THE OCEAN
GREEN SHIPPING
SUSTAINABLE ENERGY

The freight market and its interaction with the energy system

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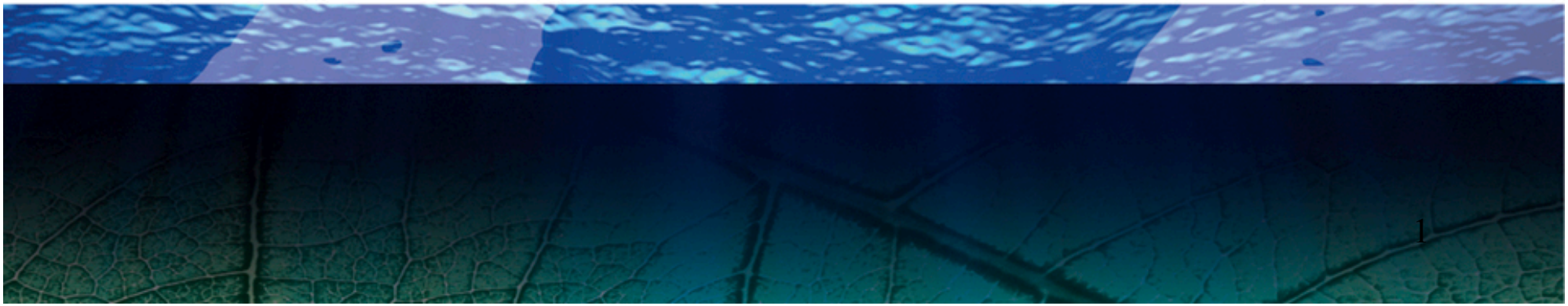


Objectives

- Financial point of view on the links between the freight market and the energy system
- Focus on derivative markets and their interactions

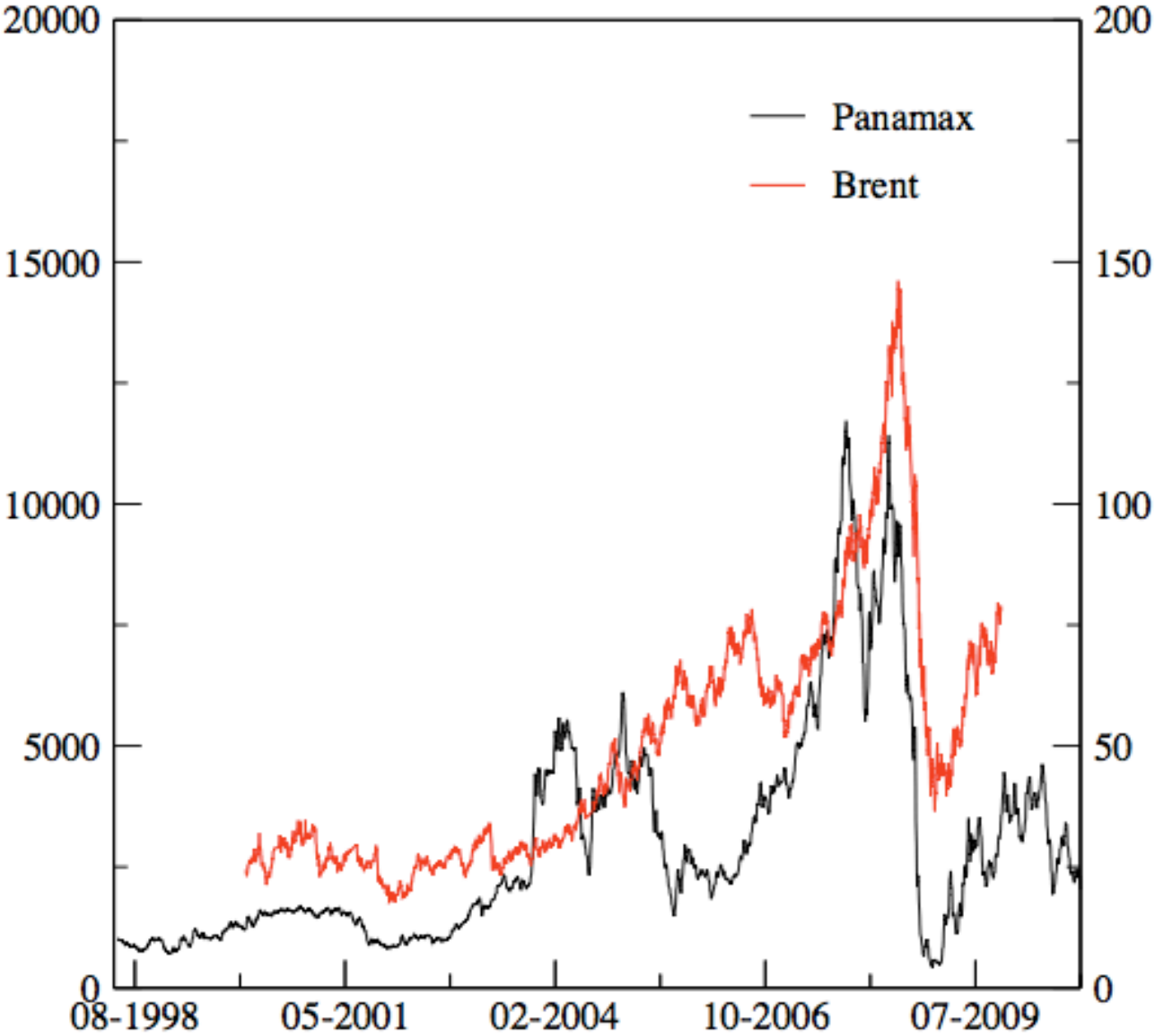
1. Questions about the energy markets:
   - Concerns about speculation
   - Portfolio management / commodities as a new class of assets
   - Development of bio fuels

2. Questions about the freight market :
   - What kind of links with other derivative markets
   - How do these links evolve since 10 years ?

Objectives

- Empirical studies on integration in derivative markets
- Co movement and cross market linkages
- Integration as a necessary condition for systemic risk to appear
- Selected markets and data :
  - Baltic Panamax Index (BPI)
  - Energy products: crude oil (US & UK), heating oil (US), gasoil (UK), natural gases (US & UK)
  - Agricultural products : soy beans, soy oil, wheat, corn
- Futures contracts with large transaction volumes, 2000-2009
- Daily settlement prices (1rst nearby) : 11 markets (more than 20 000 prices)

Prices, 2000-2009



Methodology

- Synchronous correlation of price returns as a way to measure integration / co-movement
- Huge volume of data / Complex evolving system
- Use of methods originated from statistical physic : Graph-theory
- Full connected graph :

  All possible connections between N nodes
- Filtered graph : Minimum Spanning Trees (MST)

  The shortest path between all nodes

Correlations of price returns

Prices return of asset *i*, r_i :

$$r_i = \frac{\left(\ln F_i(t) - \ln F_i(t-\Delta t)\right)}{\Delta t}$$

Synchronous correlation coefficients ρ of prices returns r :

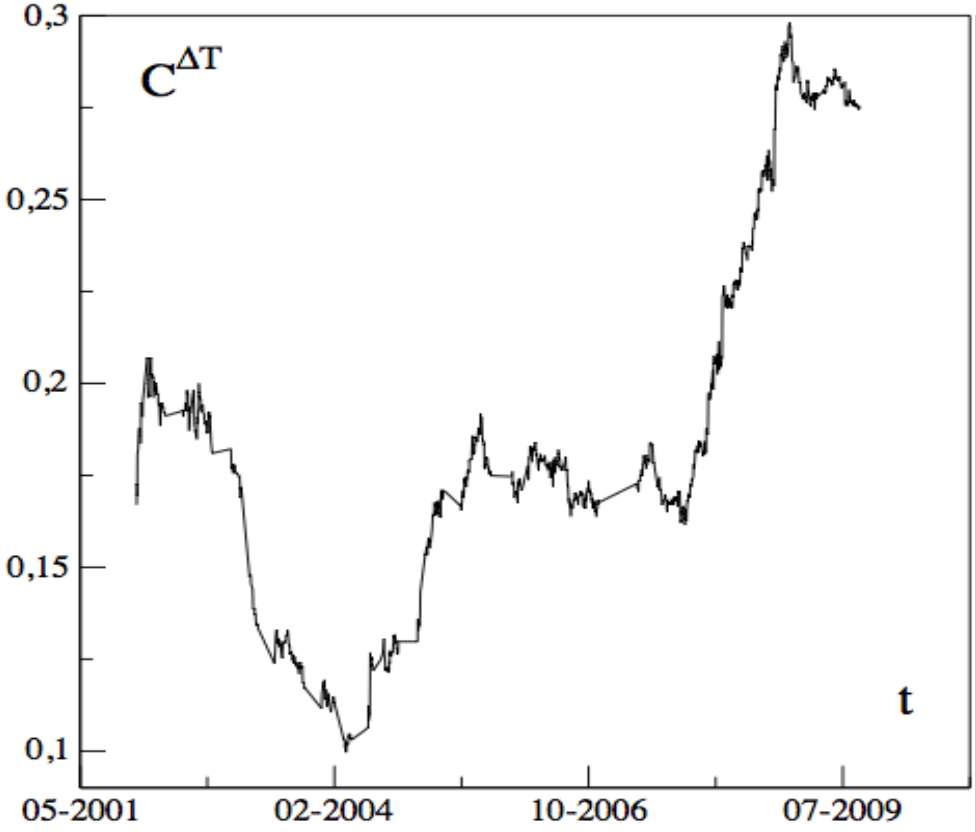
$$\rho_{ij}(t) = \frac{\langle r_i r_j \rangle - \langle r_i \rangle \langle r_j \rangle}{\sqrt{\left(\langle r_i^2 \rangle - \langle r_i \rangle^2\right)\left(\langle r_j^2 \rangle - \langle r_j \rangle^2\right)}}$$

- With: $F_i(t)$, futures prices of asset i, at t
- Correlation matrix C, (N x N)
- C symmetric

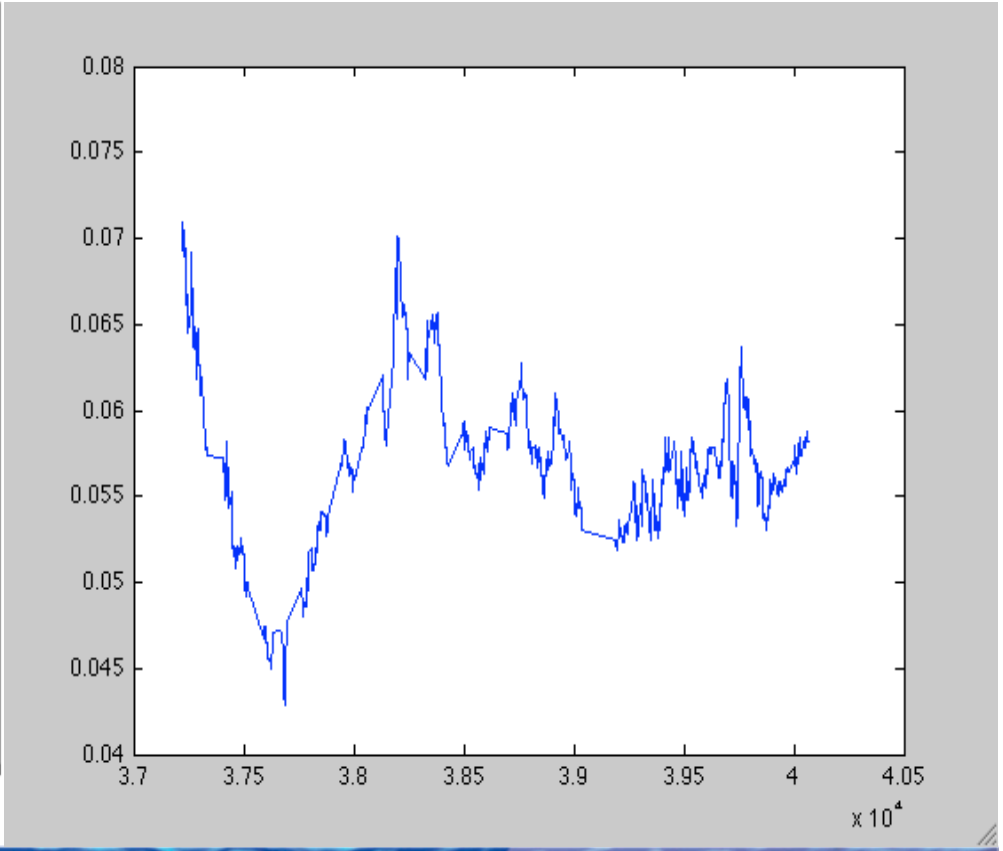
Correlations are intrinsically time dependent measures

Price returns, all markets

Mean Correlations



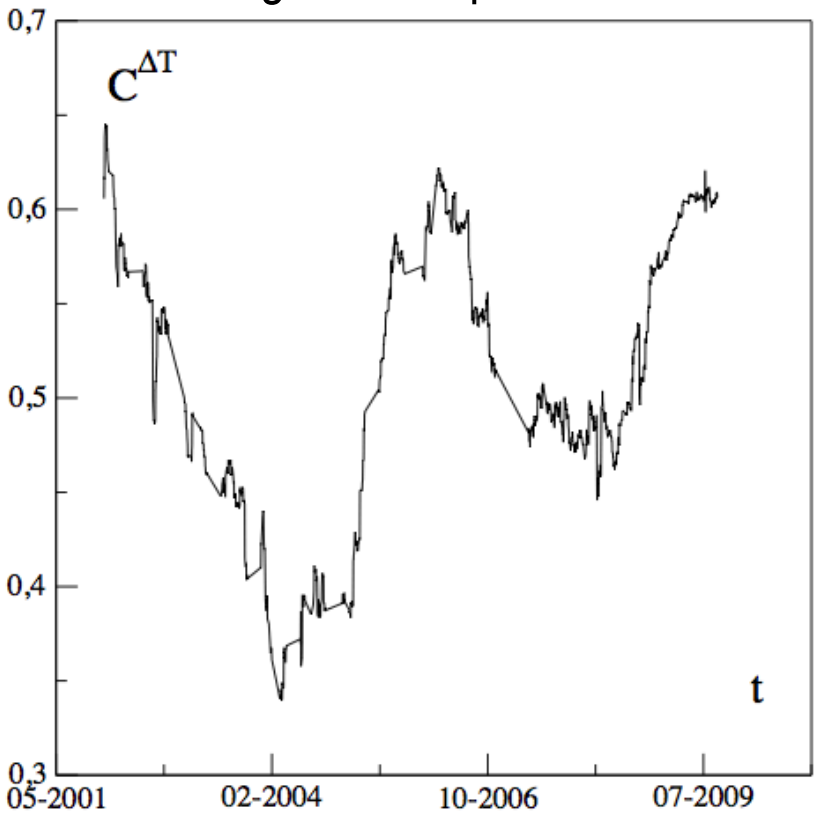
Correlations' variances



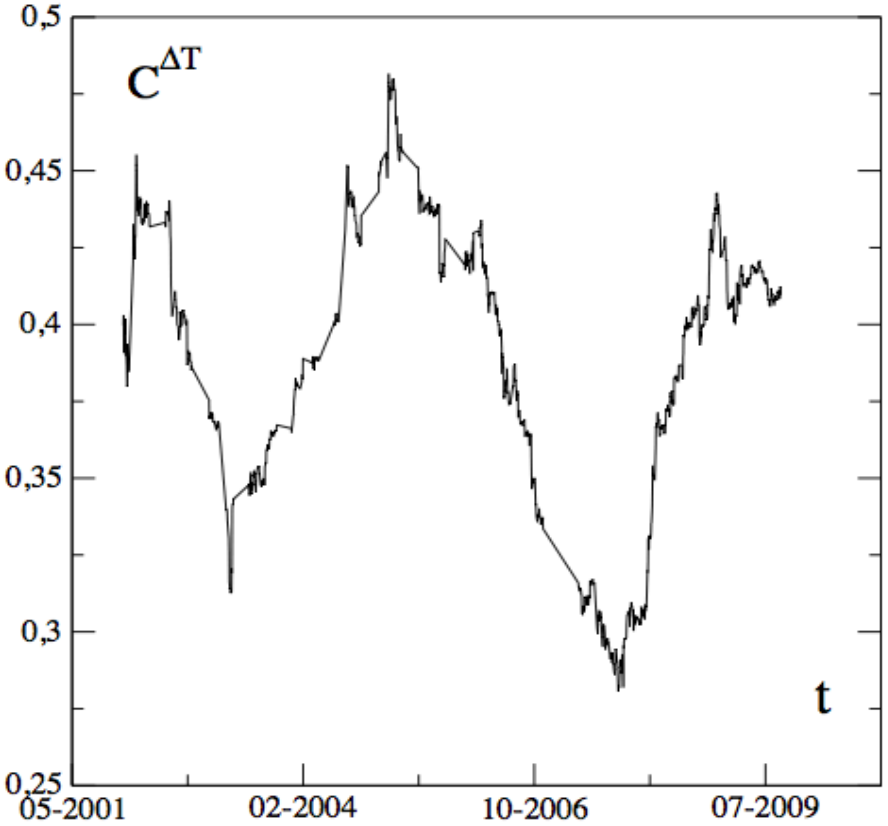
Co-movement increases

Correlations of price returns

Agricultural products



Energy products



The co-movement is more important in the sub-set of agricultural products.
The same is true for energy products

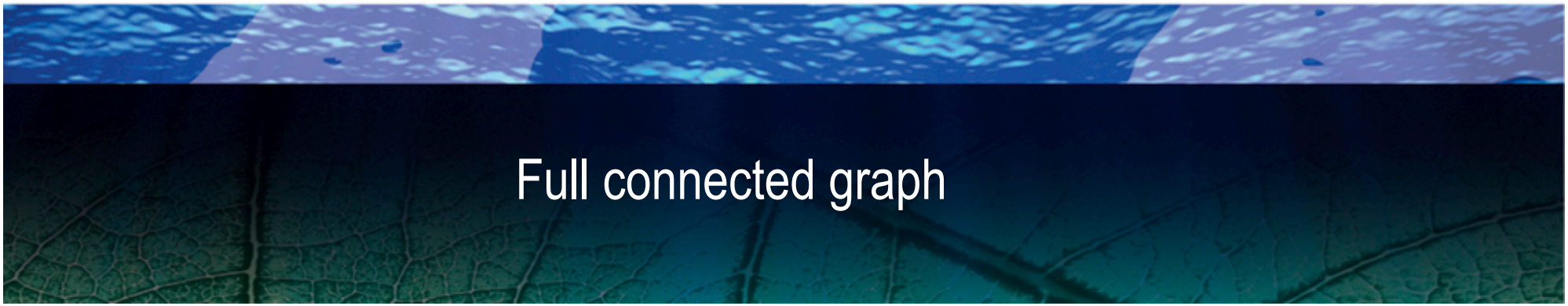
Building a graph

- The graph represents all the possible connections between N nodes
  - Node: market (time series of price returns)
  - Link: distance between 2 markets (correlations)

- Non linear transformation : from correlations to distances
- Distance d_{ij}, between node *i* and node *j*, is defined as follows:

$$d_{ij} = \sqrt{2\left(1 - \rho_{ij}\right)}$$

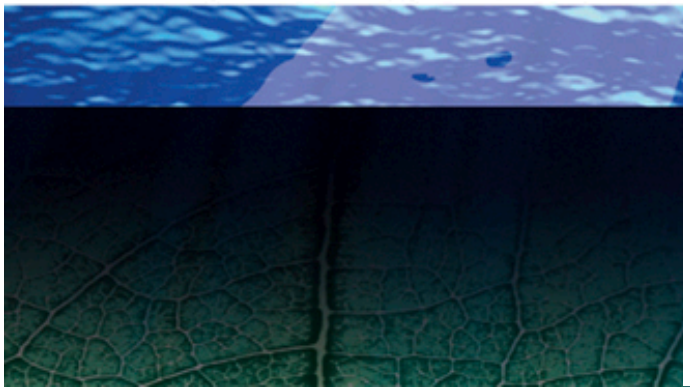
  - Distance matrix D, (N x N)

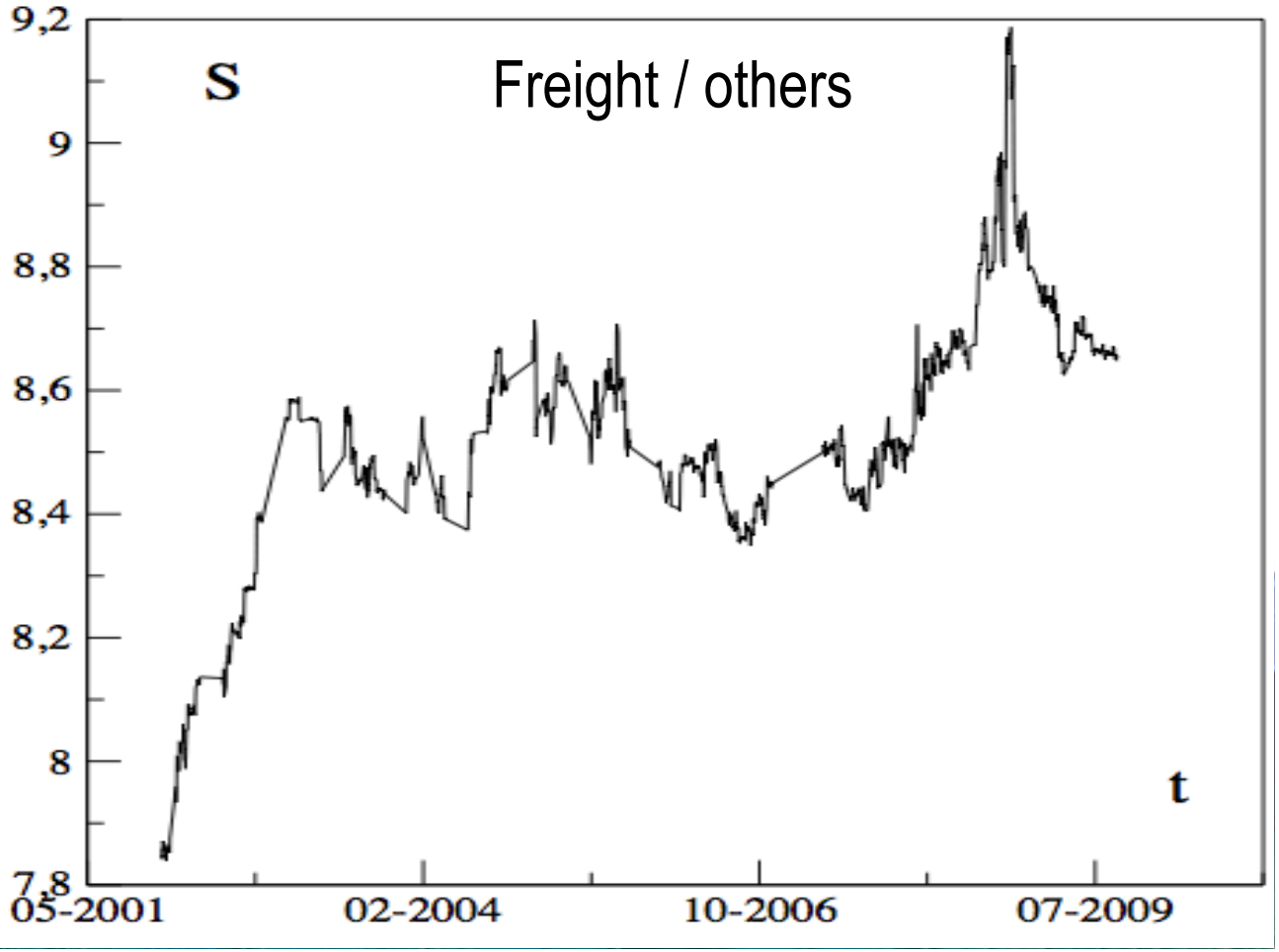


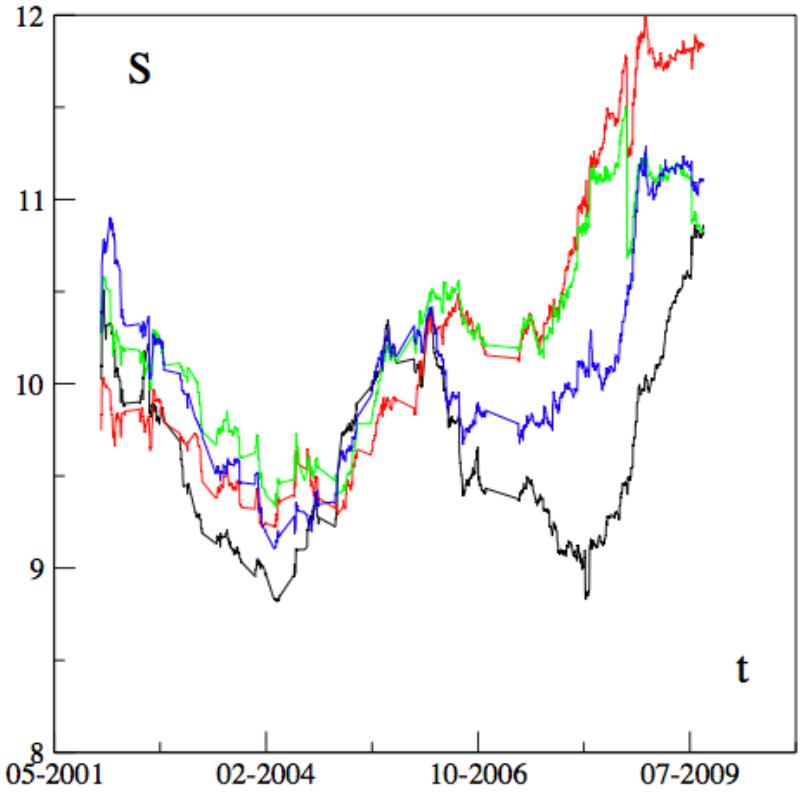
Full connected graph and node's strength

- How does markets closeness evolve ?
- Node's strength
- The node's strength S_i indicates the closeness of one node *i* to all others:

$$S_i = \sum_{i \neq j} \frac{1}{d_{ij}}$$

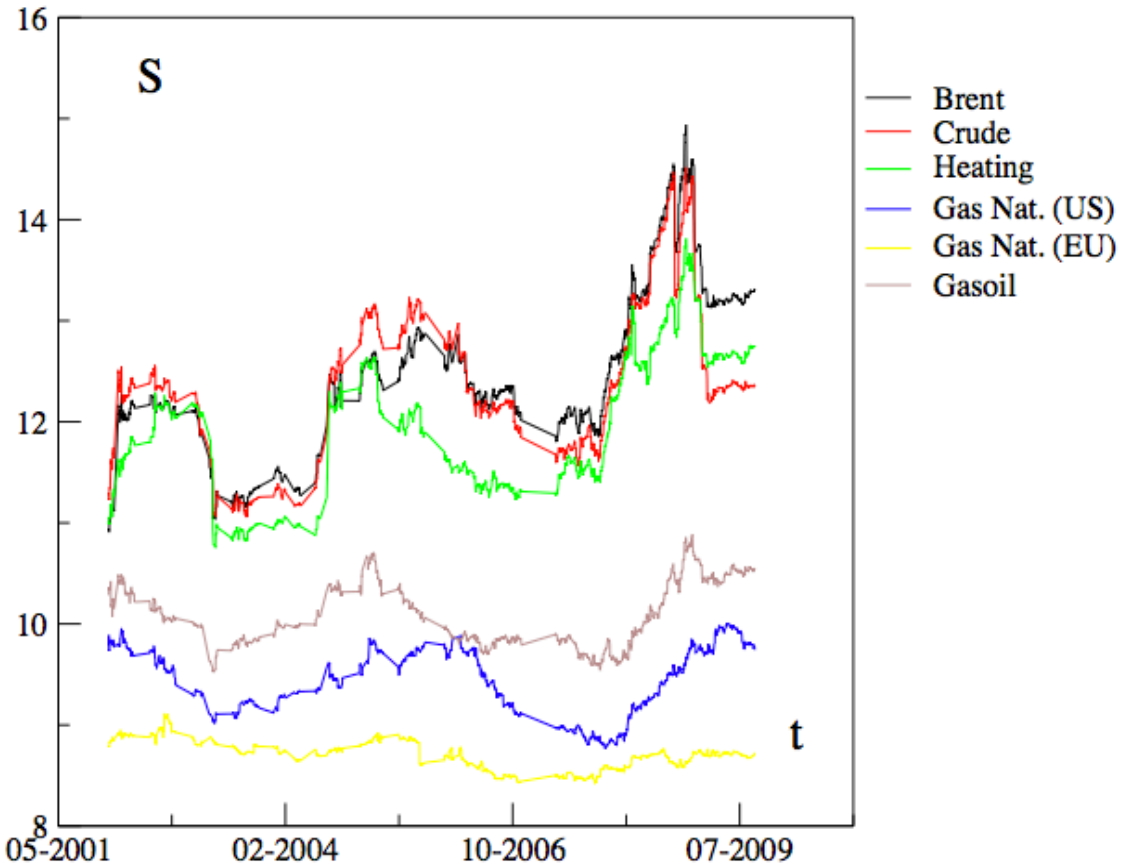


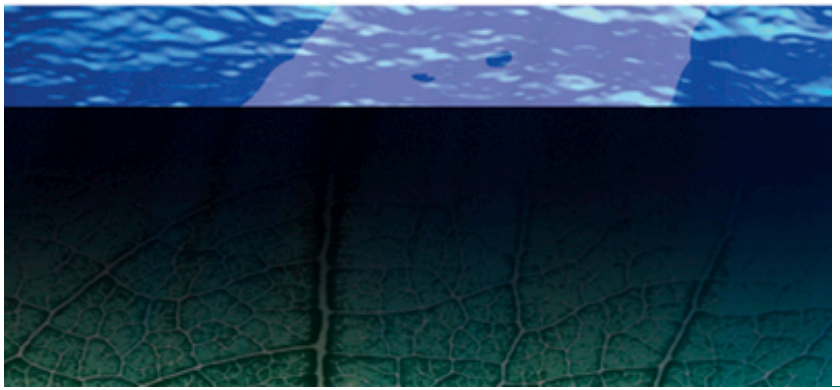




Agricultural products

Energy products



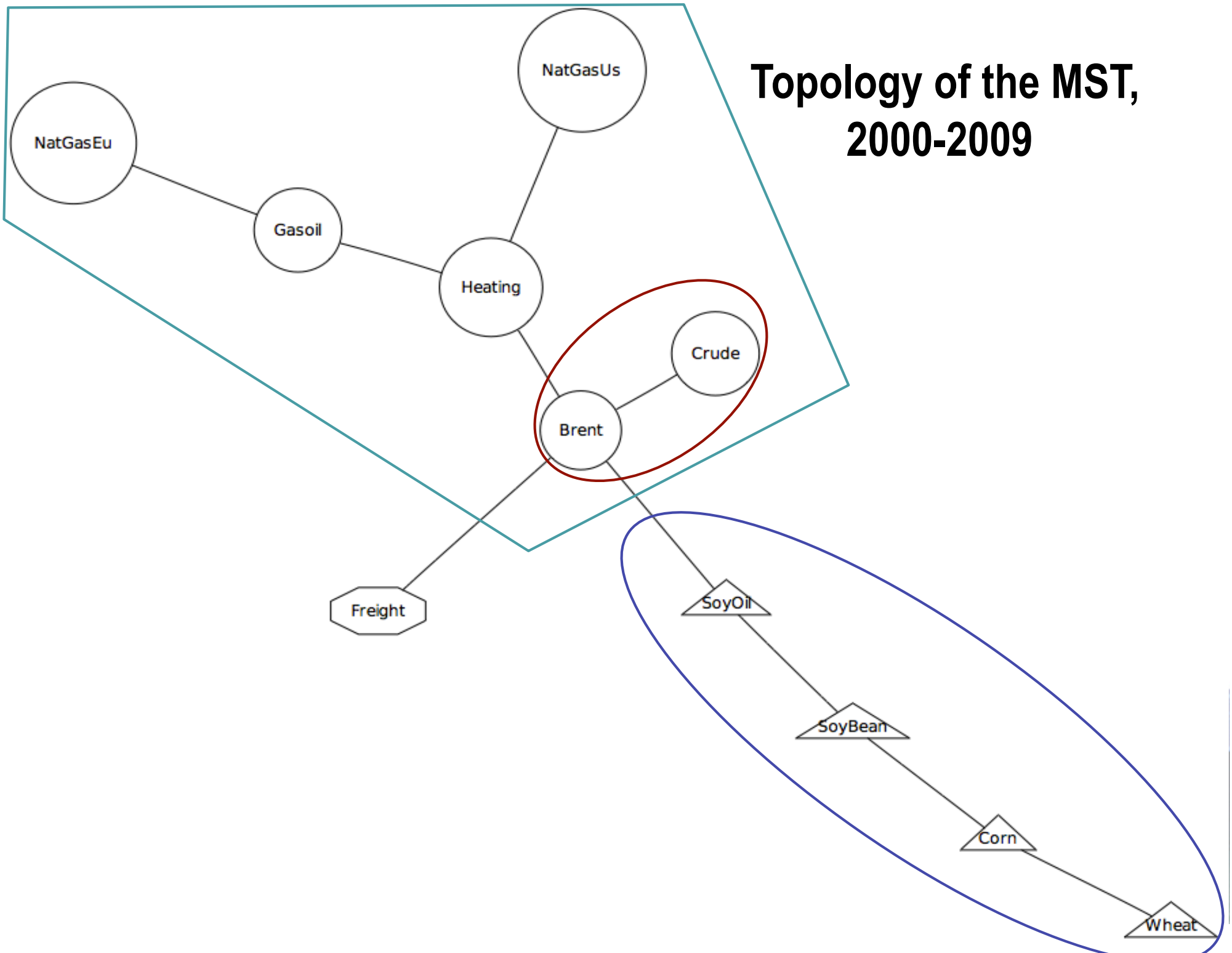


Minimum spanning trees (MST)

- Objective : filter the information contained in the full connected graph
- All the nodes of the graph are spanned, with no loops
- Result: links of the MST are a subset of the initial graph
- The information space is reduced from (N(N-1)/2) to (N-1)
- In this study : shortest path linking all nodes

  Easiest path for the transmission of prices move

Topology of the MST, 2000-2009

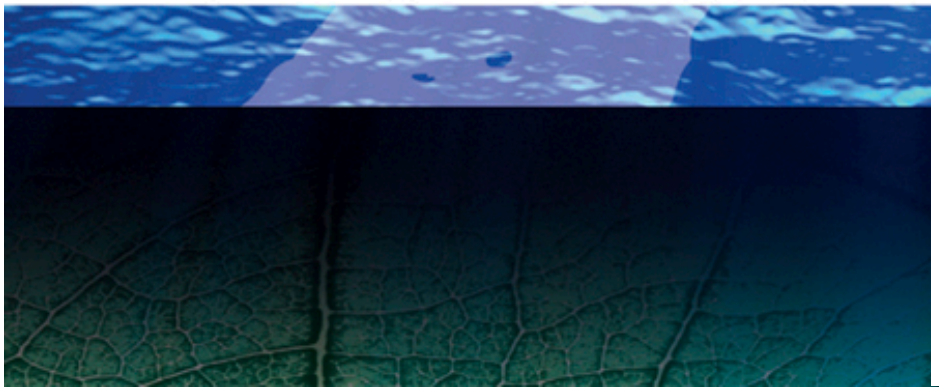


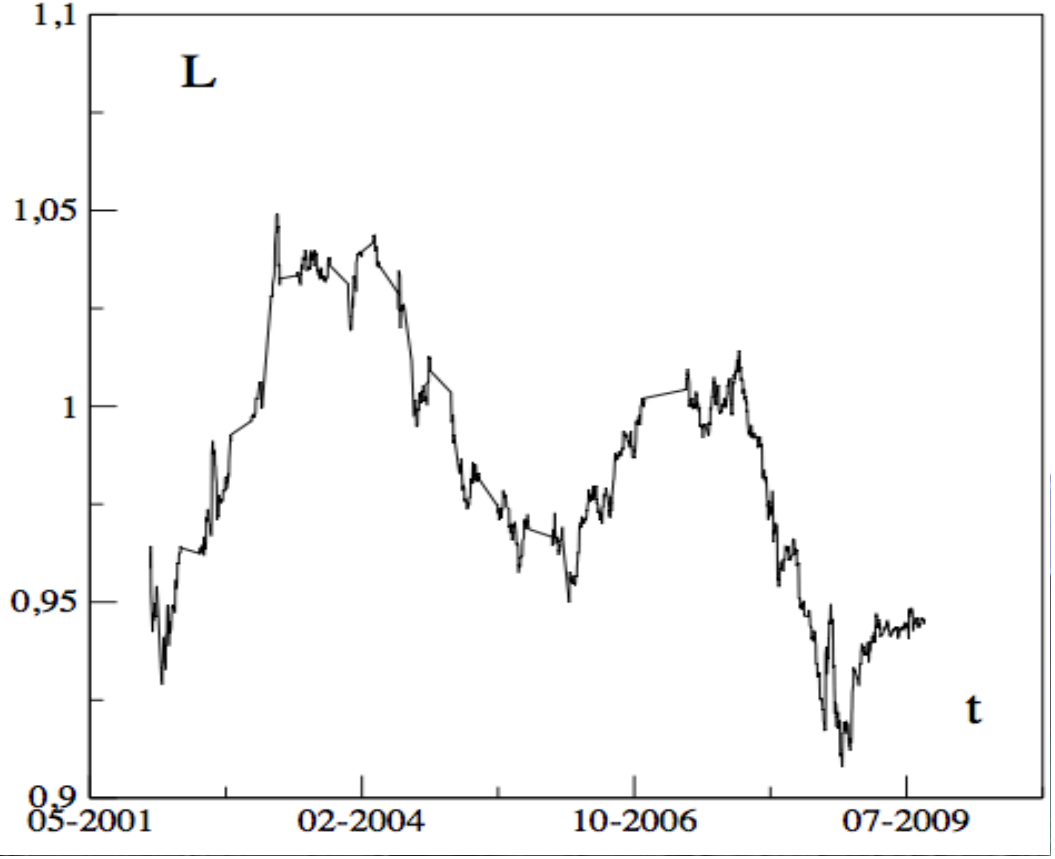
The length of the MST

- Normalized tree's length: sum of the lengths of the links belonging to the MST

$$L(t) = \frac{1}{N-1} \sum_{(i,j) \in MST} d_{ij}$$

- The more the length shortens, the more integrated the system is



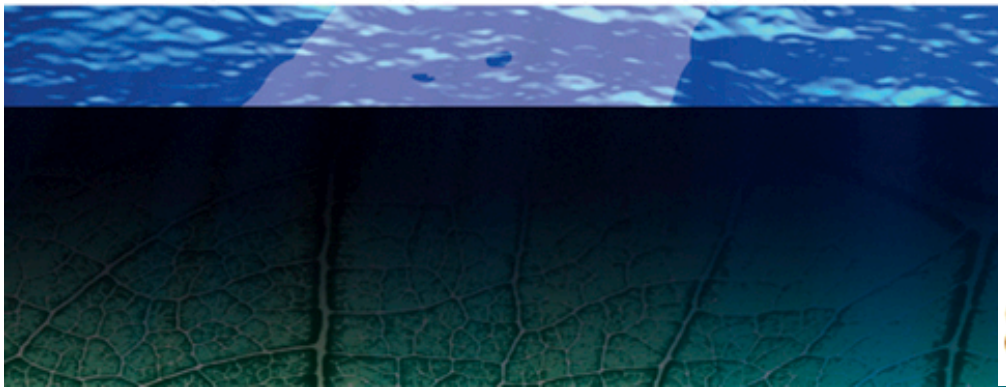


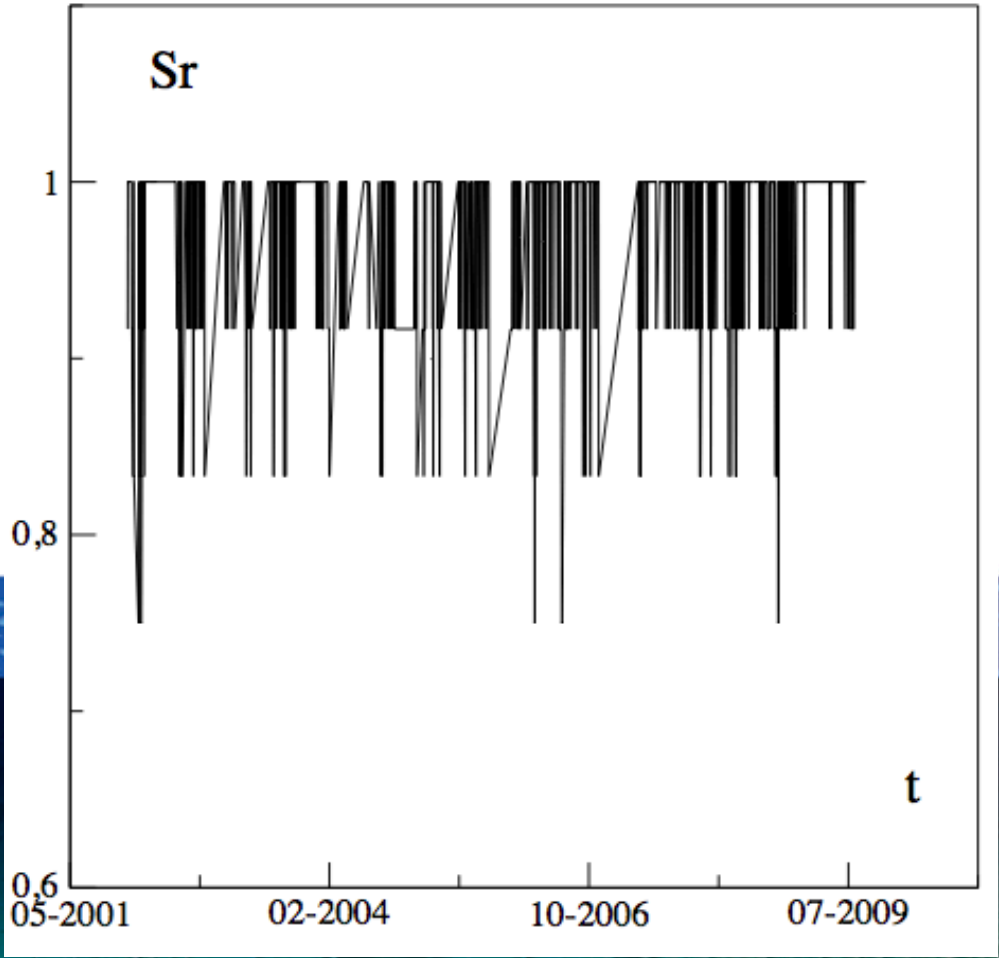
Survival ratios and the stability of the prices system

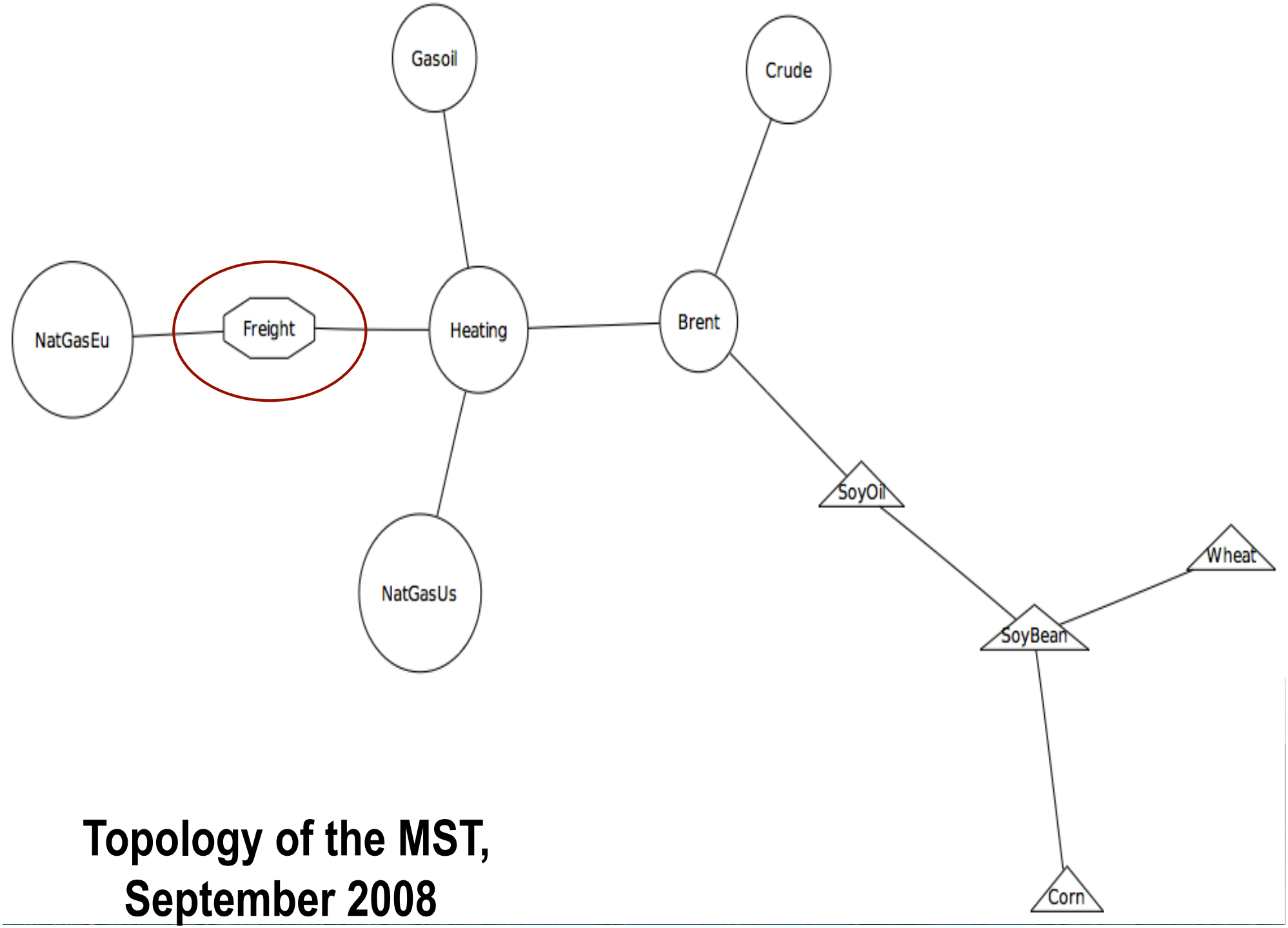
- Survival ratios on the basis of market links, in the MST
- Robustness of the topology over time
- S_R refers to the fraction of links that survives between two consecutive trading days:

$$S_R(t) = \frac{1}{N-1}\left| E(t) \bigcap E(t-1) \right|$$

E(t) : set of links at date t

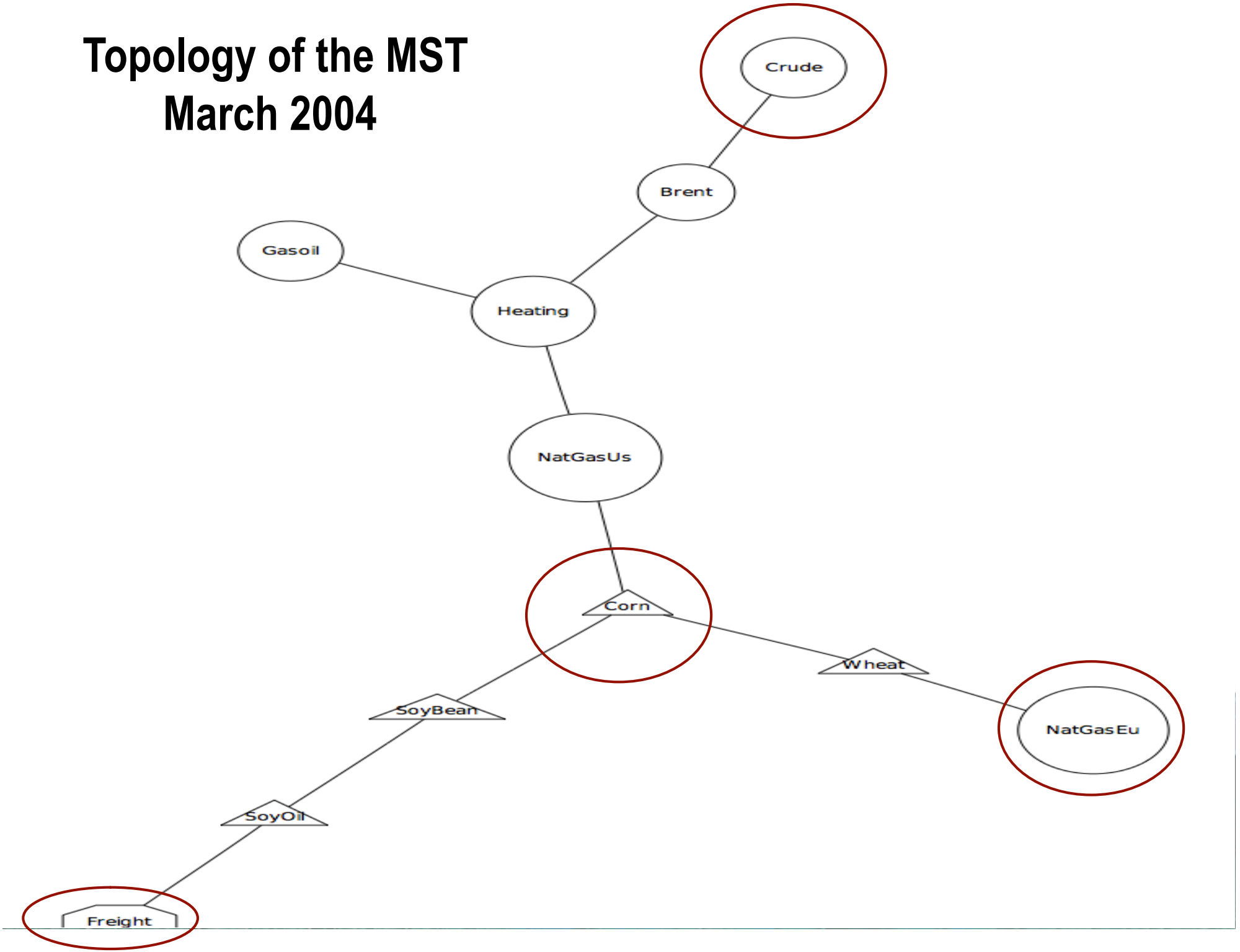






Topology of the MST, September 2008

Topology of the MST
March 2004



Where does our system stand, between order and disorder ?

- Allometric properties of the MST
- Quantifying the degree of randomness in the tree
- The root is the node with the highest connectivity
- Starting from this root, two coefficients A_i and B_i are assigned to each node i:

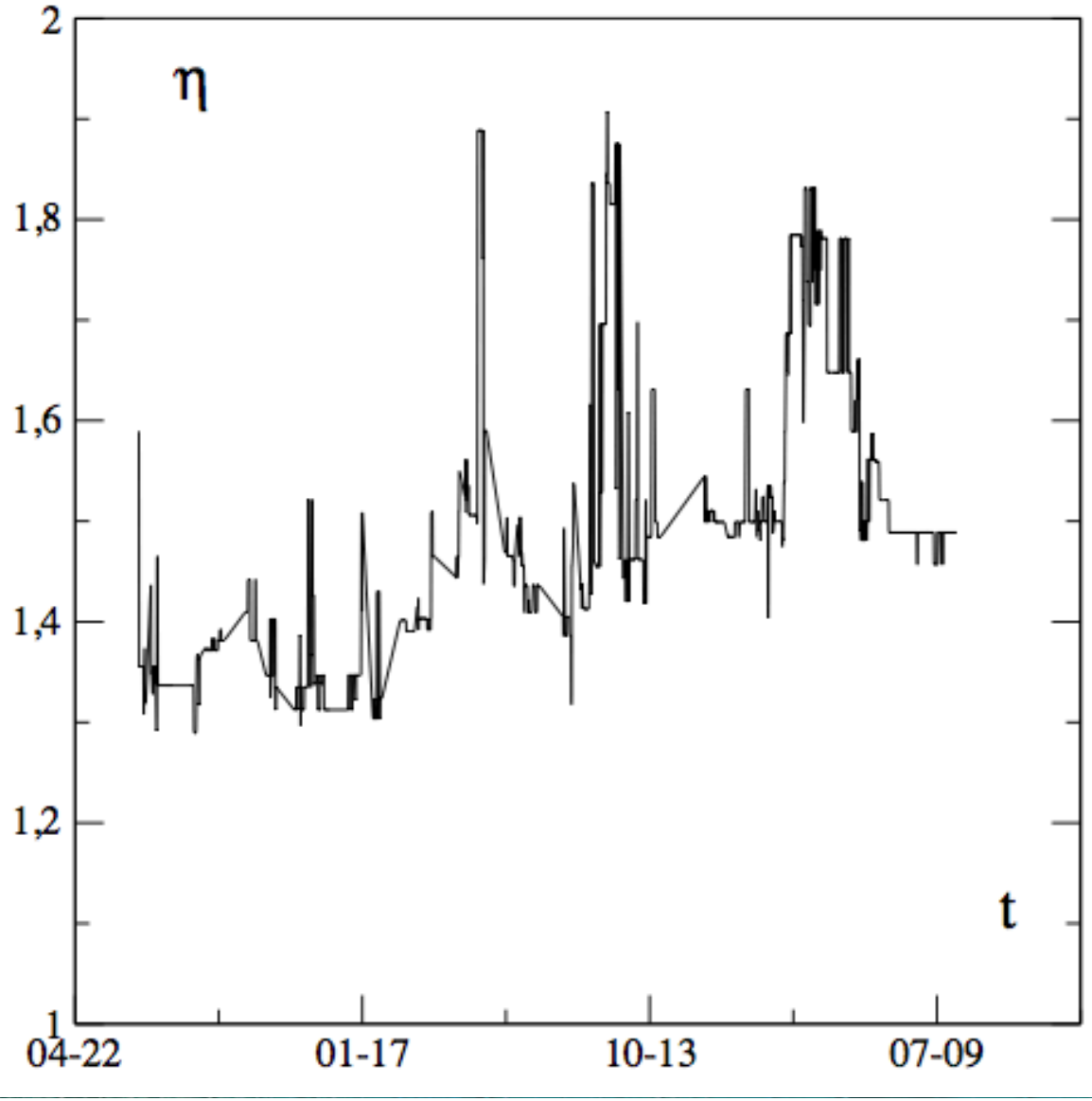
$$A_i = \sum_j A_j + 1 \qquad B_i = \sum_j B_j + A_i$$

$$B \sim A^{\eta}$$

Where η is the allometric exponent

η stands between 1+ (star-like) and 2- (chain-like)

Where does our system stand, between order and disorder ?



Main results and conclusions

- Integration
  - Increases since 10 years
  - Progresses at the heart of the system

- The prices system:
  - Is organized around the sectors of activity
  - Center of the system: two crude oils

- For the freight market, the energy prices are more important than those of agricultural products.