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

The best candidate for the propagation of prices moves
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 $\rho$ 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 $C$, $(N \times N)$
- $C$ symmetric

Correlations are intrinsically time dependent measures.
Price returns, all markets

Mean Correlations

Correlations’ variances

$C^{\Delta T}$

0.3
0.25
0.2
0.15
0.1
0.1
0.2
0.25
0.3
05-2001
02-2004
10-2006
07-2009

$t$

3.7
3.75
3.8
3.85
3.9
3.95
4
4.05

$x \times 10^4$

Co-movement increases
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
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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:

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

$E(t)$ : 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 $i$:

\[
A_i = \sum_j A_j + 1 \quad B_i = \sum_j B_j + A_i
\]

\[
B \sim A^\eta
\]

Where $\eta$ is the allometric exponent

$\eta$ 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.