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Correlations in commodity markets

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ABSTRACT

In this paper we analyzed dependencies in commodity markets, investigating correlations of future contracts for commodities over the period 1998.09.01–2007.12.14. We constructed a minimal spanning tree based on the correlation matrix. The tree provides evidence for sector clusterization of investigated contracts. We also studied dynamical properties of commodity dependencies. It turned out that the market was constantly getting more correlated within the investigated period, although the increase of correlation was distributed non-uniformly among all contracts, and depended on contracts branches.

1. Introduction

Commodity markets are, in their origins, the prime and the most basic markets rooted in times when people were exchanging goods even before money was invented. Today's commodity markets are mature and highly developed institutions, playing a very important role in the modern economy. They are not only places of goods exchange, but also a theater of speculative activity.

Nowadays, when we are used to highly sophisticated financial instruments, including credit derivatives, contracts for other contracts for some artificial underlying instruments etc., commodities seem to be rather old-fashioned. Yet, they remain important, not only due to their being primary raw materials for other stages of economic activity, but also because they can be a reliable measure of value, especially in times of crisis or other historical turbulence.

Commodities, traded at free markets, follow the rules of the efficient market hypothesis [1], the same as stocks, currencies, and others. Changes of their prices are, therefore, random and in large part unpredictable. A model which reflects this property is the geometric Brownian motion of prices, the core of the Black–Scholes theory [2]. However, real prices of financial assets deviate from the Brownian behavior, which has been clearly shown by investigations using different tools of econophysics. The autocorrelation function of the absolute returns, decays as a power law with an exponent -0.3 [3]. The returns are weakly correlated [2,4] and show persistent behavior of their sign [5,6]. All those observations for stock markets should also be, in general, valid for commodity markets, despite observed differences such as a *spatial arbitrage* effect [7], or different multifractal properties [8]. Matia et al. [9] also showed that the prices of commodity futures obey a different scaling law from the prices of spots. The former are more similar to stocks in this aspect.

It is well known that stocks of different firms are mutually correlated in a way that cannot be totally explained by the random matrix theory [10–13]. The correlation coefficients of stock price returns can be used to obtain a minimal spanning tree and, associated with it, a hierarchical tree of the subdominant ultrametric space, which was done by Mantegna [14].

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Table 1
List of investigated future contracts for commodities in the alphabetical order of their symbol.

Symbol	Name	Market	Symbol	Name	Market
AA_F	Aluminum alloy	LME	MW.F	Wheat spring	MGEX
AL_F	Aluminum	LME	NG.F	Natural gas	NYMEX
BO.F	Soybean oil	CBOT	NI_F	nickel	LME
C.F	Corn	CBOT	OJ.F	Orange juice	NYBOT
CC.F	Cocoa	NYBOT	PA.F	Palladium	NYMEX
CL.F	Crude oil	NYMEX	PB.F	Pork bellies	CME
CO_F	Copper	LME	PL.F	Platinum	NYMEX
CT.F	Cotton	NYBOT	RR.F	Rough rice	CBOT
FC.F	Feeder cattle	CME	RS.F	Canola	WCE
GC.F	Gold	NYMEX	S.F	Soybean	CBOT
HG.F	Copper	NYMEX	SB.F	Sugar	NYBOT
HO.F	Heating oil	NYMEX	SC.F	Brent oil	ICE
KC.F	Coffee	NYBOT	SI.F	Silver	NYMEX
KW.F	Wheat	KCBT	SM.F	Soybean meal	CBOT
LB.F	Lumber	CME	TI_F	Tin	LME
LC.F	Live cattle	CME	W.F	Wheat	CBOT
LE_F	Lead	LME	ZI_F	Zinc	LME
LH.F	Lean hogs	CME			

He detected grouping of firms of a similar profile in the minimal spanning tree. This effect can be reproduced neither by the random model of uncorrelated time series, nor by the one-factor model [15].

In this paper, we analyzed cross-correlations in commodity markets. We created the correlation matrix and corresponding correlation-based metric. Using the correlation metric we created a minimal spanning tree of investigated contracts, looking for sector clusterization. We also examined dynamic properties of correlations, finding out that commodity contracts were getting more and more correlated, and mean distances in a corresponding minimal spanning tree were smaller and smaller in the course of time. However, individual contracts contributed to the increase of mean correlation differently. Their idiosyncratic contribution to the correlations was characterized by an introduced quantity (strength) and its evolution.

The motivation for our research was a growing interest of investors and mass media in commodity markets. Skyrocketing oil prices were expected to reach the level of 200 USD per barrel during one week, and went down under 100 USD during another. We wanted to investigate the behavior of the commodity markets with the tools of complex system physics. We found the mirroring of the specific situation of the last years, in a time dependent picture of commodity prices correlations.

2. The data

We investigated 35 future contracts for commodities traded at different markets. Futures rather than spots were examined, as the data were more accessible.

We used data from: Chicago Board of Trade (CBOT), Chicago Mercantile Exchange (CME), IntercontinentalExchange (ICE), Kansas City Board of Trade (KCBT), London Metal Exchange (LME), Minneapolis Grain Exchange (MGEX), New York Board of Trade (NYBOT), New York Mercantile Exchange (NYMEX), Winnipeg Commodity Exchange (WCE). For today's investors in the globalized world market, a contract traded in London or in Chicago is only another financial instrument that they can buy or sell, no matter where.

Table 1 presents the list of investigated contracts, their symbols, and symbols of corresponding markets. All the contracts were quoted in USD. We took day closing prices under consideration.

3. Correlations

Let $P_i(t)$ be a day closing price of a contract i at time t. From logarithmic returns $r_i = \log(P_i(t+1)) - \log(P_i(t))$ we calculated a Pearson correlation coefficient:

$$C_{ij} = \frac{\langle r_i r_j \rangle - \langle r_i \rangle \langle r_j \rangle}{\sqrt{(\langle r_i^2 \rangle - \langle r_i \rangle^2)(\langle r_j^2 \rangle - \langle r_j \rangle^2)}}. \tag{1}$$

The correlation coefficients C_{ij} were computed for all pairs of futures from Table 1 over a span between 1998.09.01 and 2007.12.14. The average $\langle \ldots \rangle$ was calculated for the whole period, but only for days when all the contracts were traded. There were $T = 2190$ overlapping records in the mentioned period.

One could expect that due to long (compared to a number of assets) time series, the correlation matrix would have a low level of noise. According to the random matrix theory (RMT) [10], the eigenvalues spectra of a correlation matrix for N uncorrelated Gaussian time series of the length T is bounded by a maximum $\lambda_{\max}$ and a minimum $\lambda_{\min}$ value, which is equal to:

$$\lambda_{\min}^{\max} = 1 + \frac{1}{Q} \pm 2\sqrt{\frac{1}{Q}}, \tag{2}$$