Co-movements Between Financial and Commodity Markets

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Abstract—**In this paper we aim to assess the dynamics of commodities ad stock markets at time-frequency domain. Our data set consists of monthly IMF commodity price indices and sub-indices, and the Morgan Stanley Capital International (MSCI) World Stock Index between January 1993 and March 2016.**

Among others, our results indicate a significant increase in synchronization of procyclical pattern, with periodicities of one to four years, during the recent subprime and financial crisis. The results presented in the paper could help investors to design investment strategies in commodity markets.

Keywords- Comovements, wavels, commodities

I. Introduction

The relationship between commodity prices and stock markets has attracted considerable attention in the literature. The commodity dynamics impact has considerable implications for portfolio management strategies.

The empirical evidence on how the commodity price movements affect stock markets mainly concerns on oil and gold and is inconclusive (e.g., [1], [2], [3], among others).

Recently the wavelet analysis have been applied to explore the complexity and nonlinearity of commodity-stock interaction (e.g., [4], [5], among others).

Our objective is to explore the decomposition of commodities and stock markets index to analyze the influence of multiscale components on their dynamic interaction over time.

II. Methodology

Consider a real or complex function, denoted as ψ called mother wavelet.

On the basis of the mother wavelet, a family of wavelets is generated by translation and dilation (scaling) of ψ:

$$\psi_{t,s}(\tau) = \frac{1}{\sqrt{s}}\psi\left(\frac{t-\tau}{s}\right) \quad (1)$$

where τ, translation parameter leads to a shift of ψ, and s is a scaling or dilation factor that controls the width of the wavelet, reduces if $s < 1$ or increases $s > 1$ the support of ψ.

The continuous wavelet transform (CWT) of a continuous time-series $x(t)$, with respect to the wavelet function ψ is given by:

$$W_{x,\psi}(\tau, s) = \int_{-\infty}^{+\infty} x(t)\frac{1}{\sqrt{s}}\psi^*\left(\frac{t-\tau}{s}\right)dt \quad (2)$$

The wavelet power spectrum of $x(t)$ represents the local variance of $x(t)$, is obtained as:

$$WPS_{x,\psi}(\tau, s) = \left|W_{x,\psi}(\tau, s)\right|^2 \quad (3)$$

To analyze the time–frequency relationship between two time series we are going to consider the concepts of cross-wavelet power, coherence and phase-angle.

The co-movement of two series can be assessed by the cross-wavelet spectrum. Consider two time-series, $x(t)$ and $y(t)$, the wavelet cross-spectrum, interpreted as the local covariance between these time-series at each time and frequency, is defined as:

$$W_{xy,\psi}(\tau, s) = W_{x,\psi}(\tau, s)\, W_y^*(\tau, s) \quad (4)$$

Another co-movement concept is the wavelet coherence. This concept is based in the wavelet cross–spectrum and has the advantage of being normalized by the power spectrum of the time-series. For two time-series, $x(t)$ and $y(t)$, the wavelet coherence is defined as:

$$R_{xy,\psi}(\tau, s) = \frac{\left|S\left(W_{xy,\psi}(\tau,s)\right)\right|}{\sqrt{\left[S\left(W_{xx,\psi}(\tau,s)\right)\, S\left(W_{yy,\psi}(\tau,s)\right)\right]}} \quad (5)$$

where S denotes a smoothing operator in both time and scale.

Once the wavelet coherence is not able to establish the direction of co-movement nor to establish the lead–lag relation between the series, we need to use other concept, the wavelet phase angle.

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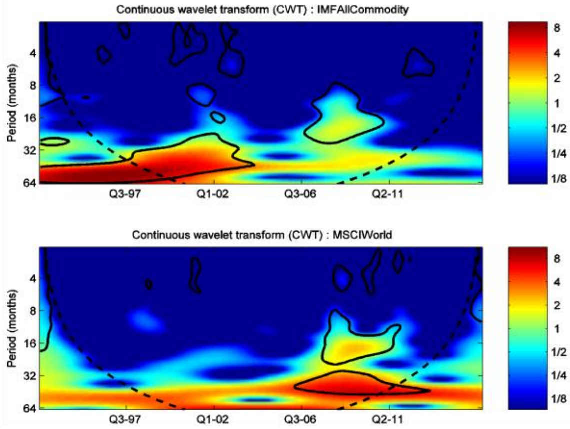

Figure 1. Continuous wavelet power spectra of monthly price index of all commodity and MSCI World index.

The wavelet cross-spectrum expressed in (4), can be written as:

$$W_{xy,\psi}(\tau,s) = \Re\left(W_{xy,\psi}(\tau,s)\right) + \Im\left(W_{xy,\psi}(\tau,s)\right) \quad (6)$$

where $\Re(.)$ and $\Im(.)$ correspond to the real and imaginary part of a complex number.

The wavelet cross-spectrum can be expressed as:

$$W_{xy,\psi}(\tau,s) = \left|W_{xy,\psi}(\tau,s)\right| e^{\phi_{xy,\psi}(\tau,s)} \quad (7)$$

where $\phi_{xy,\psi}(\tau,s)$ corresponds to the wavelet phase angle.

The wavelet phase angle is defined as:

$$\phi_{xy,\psi}(\tau,s) = arctan\left[\frac{\Im\left(W_{xy,\psi}(\tau,s)\right)}{\Re\left(W_{xy,\psi}(\tau,s)\right)}\right] \quad (8)$$

III. Data and Results

A. Data

The empirical analysis was carried out on monthly commodities index from IMF. We use the All Commodity Price Index, Non-Fuel Price Index, Fuel (Energy) Index, Crude Oil Price index, Food Price Index, Beverage Price Index, Metals Price Index, Industrial Inputs Price Index and Agricultural Raw Materials Index. The Morgan Stanley Capital International world stock index (MSCI) as the proxy the global stock market price, over the period January 1993 to March 2016. Table 1 summarizes the basic statistical characteristics of series.

TABLE I. Descritive Statistics

	Table 1 Descriptive statistics						
	Mean	***Std. Dev.***	***Max.***	***Min.***	***Range***	***Kurtosis***	***Skewness***
MSCI World	1138	328	1779	497	1281	-0,84	0,05
All Comm.	102,3	51,6	219,7	41,9	177,8	-1,06	0,64
Non-Fuel	116,1	36,3	205,8	70,4	135,5	-0,92	0,62
Energy	94,2	61,6	249,4	22,1	227,3	-0,98	0,64
Crude Oil	93,7	63,6	249,7	19,5	230,1	-0,98	0,65
Food	119,3	34,3	192,4	75,6	116,7	-0,91	0,66
Bever.	124,5	39,8	222,0	60,6	161,3	-0,94	0,32
Metals	112,7	59,0	256,2	48,0	208,2	-1,10	0,59
Indust.	112,4	40,0	217,1	64,5	152,6	-0,83	0,67
Agricult	112,0	17,5	171,4	81,4	89,9	0,30	0,77

B. Results of wavelet analysis

Figure 1 presents the wavelet power spectrum of monthly price index of all commodities and MSCI World index. The power spectrum is a measure of variance distribution at each time-frequency region represented by a color indicator, ranging from dark blue, low variability, to dark red (high power).

Both series demonstrated very high power over all sample ranging from 12 monthly periods to as high as 96 periods of scale (low frequency). The variability of all commodities index was especially high until 2013 with a three and half to five year's cycle and from 2007 to the end of 2010 by cycles of three and six years. The MSCI World market index had high power at low to medium scales (36 months cycle) between 2007 and 2012.

Figure 2 shows the estimated wavelet coherence and phase angle for each of commodity index and MSCI World index. The wavelet coherence measures the co-movement between the series, allow for identifying the dynamics of the co-movement in the time-frequency domain over the sample period.

For each pair Commodity-World Index after the identification of time-frequency location in which the coherency is statically significant (warmer colors) we analyze the direction of co-movement using the phase angle.

The coherence between All Commodities and MSCI World index shown in Figure 2(a) shows the strongest and statically significant coherence until 2003 and between 2007 and 2012. The strongest coherence occurs at periodicities of three to four years at the first sub period and for one to four years at the period started at 2007. From 2012 to 2016 this effect seems to disappear at all periodicities. The phase angle analysis of All Commodities and MSCI World index relationship reveals a procyclical pattern over the sample, although it should be referred that components with periodicities above one year are in general in-phase whereas shorter components present on average an anti-phase relationship.

The results of coherence and phase for Energy index MSCI World index (Figure 2(c)) and for Crude Oil index and MSCI World index (Figure 2(d)) show similar conclusions.

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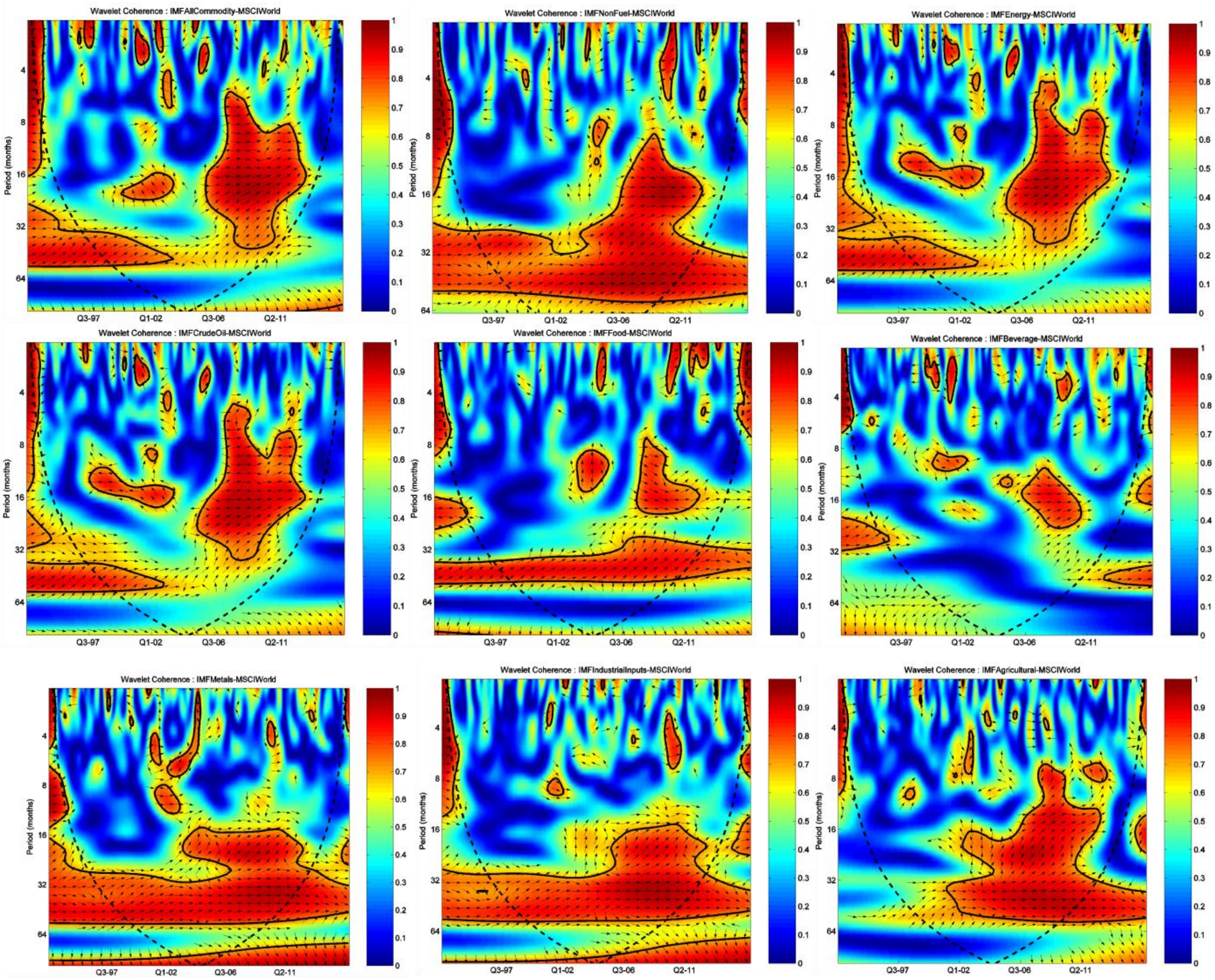

Figure 2. Cross-Wavelet Coherency between each commodity index and MSCI World index.

Figures 2(b), 2(g) and 2(h) represent wavelet coherence and phase angle between Non-Fuel index, Metals index, Industry index with MSCI World index, respectively. In the entire time interval, 1993 to 2016, a strong coherence between each of commodities indexes and the stock market is found at long-term time scale (short-term frequency) with 24–60 month scale fluctuation. Components with periodicities above one year also present a strong coherence during the period from 2003 and 2012. The results presented for significant coherencies show a positive co-movement, with few exceptions for short periods and short-time scales.

As shown in Figure 2(i) by wavelet coherence estimation the co-movement between the Agricultural index and MSCI World index none significant co-movement can be detected for the period until 2002. However, from 2003 on, and for mid and long-term time scales (1-5 years cycles), a significant and persistent positive co-movement is presented, covering the 2006–2008 period of "food crisis" and the financial and economic crisis started at 2008.

IV. Summary and Conclusions

This study presents new evidence on the complex and nonlinear interactions between commodities and stock markets.

Based on a wavelet approach, we explore in the time-frequency domain the co-movement between several commodity indexes and the MSCI World index. The dataset consists of monthly stock index and nine commodity indexes from January 1993 to March 2016.

The analysis of the coherence and phase angle shows that the co-movement between energy and non-energy indexes with stock markets present a different nature.

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The strongest and statistically significant coherence in energy index pertains to the years until 2003 and between 2007 and 2012 to medium scales. On the contrary, in non-energy case the strongest and statistically significant coherence in the entire time span (1993-2016) with slightly long cycle's periodicities.

The coherence for all pair's commodity-stock market analyzed reveal substantial changes in the co-movement pattern over time, specifically during the financial crisis, it is possible verify an increase of procycle at most cycle periodicities.

Exploring the co-movement between assets help the formulation of diversification strategies and the results presented have important implications for design strategies in the short and long terms.

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