



# How do correlations of crude oil prices co-move? A grey correlation-based wavelet perspective



Xiaoliang Jia<sup>a,b,c</sup>, Haizhong An<sup>a,b,c,\*</sup>, Wei Fang<sup>a,b,c</sup>, Xiaoqi Sun<sup>a,b,c</sup>, Xuan Huang<sup>a,b,c</sup>

<sup>a</sup> School of Humanities and Economic Management, China University of Geosciences, Beijing 100083, China

<sup>b</sup> Key Laboratory of Carrying Capacity Assessment for Resource and Environment, Beijing 100083, China

<sup>c</sup> Lab of Resources and Environmental Management, China University of Geosciences, Beijing 100083, China

## ARTICLE INFO

### Article history:

Received 1 July 2014

Received in revised form 2 March 2015

Accepted 10 March 2015

Available online 9 April 2015

### JEL classification:

P480

### Keywords:

Oil prices  
Dynamic correlation  
Grey correlation  
Wavelet

## ABSTRACT

Previous research on the oil market has focused mainly on the static relationship between bivariate oil prices, ignoring the dynamic correlation of bivariate or multivariate oil prices. This study provides a novel perspective on multivariate dynamic correlations for studying the oil market by using an optimal wavelet analysis on the basis of grey correlation. We used China-Daqing and its three reference benchmark oil prices (Brent, Dubai and Minas) as empirical data. Our main findings are as follows. First, the time–frequency phenomena of the analysis results from one-to-one and many-to-one correlation time series support the hypothesis of the regional and global characteristics of the oil market, respectively. Second, the U-shaped wavelet variance plot indicates that the fluctuation intensity of the shortest and longest time–frequency domains plays a leading role in the dynamic process of oil price correlation. For the Chinese government, the oil price adjustment strategy in the short term should reduce the reference weights of Brent, and the long-term strategy should reduce the reference weights of Minas to avoid the risk of a single reference. The investor's portfolio management should pay more attention to the leading oil price of the corresponding period to make clear market timing. Third, the significant lead–lag relationships of oil price correlations showed a time-varying spread phenomenon of benchmark oil prices' relative influence on Daqing, which provides a useful time reference when crafting an oil price adjustment strategy and intertemporal arbitrage.

© 2015 Elsevier B.V. All rights reserved.

## 1. Introduction

Crude oil is one of the most important raw materials in a modern industrial society. Because the characteristics of crude oil differ across various oil production fields, the price of crude oil is not consistent in the global oil market. Different local representative markets are formed by various crude oil trading streams, which show global and regional characteristics of the oil market. Learning how to discover the global and regional characteristics is important to understanding the oil market. Adelman (1984) suggested that we investigate the world crude oil market as a whole, representing “one great pool”. Weiner (1991) argued that we should study the transmission mechanism between crude oil prices from various production fields based on the perspective of globalization. In contrast, based on the regional market, the volatility of every oil price from a regional market can be viewed as highly interdependent with others (Gülen, 1999). Because the dynamic oil price series is a type of non-stationary and nonlinear time series, it is necessary to combine it with at least two sets of time series to reveal the global or regional volatility characteristics (Bhar et al., 2008). The complexity of

oil price fluctuations is the result of the interaction of multiple factors, each of which make correlations of oil prices more complex. Although different oil prices in the oil trade have a similar fluctuating trend in the long term, the time-varying small distance of the gap between oil price changes will make a great difference. Because of the existence of the gap, the different oil price fluctuations will create challenges in the oil price adjustment strategy for the government and in portfolio management for investors. The correlation of oil prices can reveal the difference between oil price changes. With the differences of regionalization and globalization development of the oil trade, correlations of oil prices are dynamic and uncertain, and they contain more information than the oil price itself for understanding the oil market. One-to-one and many-to-one relationships can respectively reveal regional and global characteristics of oil prices. Therefore, how to discover one-to-one and many-to-one dynamic correlations of oil prices is more helpful for understanding the oil market than only finding features of oil price fluctuations.

According to the International Crude Oil Market Handbook, there are approximately 195 crude oil traded streams in the world. Benchmark oil prices are needed for the reference price of various local representative markets, which play a crucial role in the oil market. Weiner (1991) found the significant regionalization characteristics between various benchmark oil prices. Gülen (1997) found the long-term volatility coherence of benchmark oil prices from the viewpoint of globalization.

\* Corresponding author at: School of Humanities and Economic Management, China University of Geosciences, Beijing 100083, China.  
E-mail address: [ahz369@163.com](mailto:ahz369@163.com) (H. An).

Hammoudeh et al. (2008) revealed the long-term volatility coherence between the WTI, Brent, Dubai and Maya benchmark oil prices via a cointegration analysis. Fattouh (2010) used a local unit root analysis to find the volatility difference between the WTI, Brent, Dubai and Maya benchmark oil prices. Reboredo (2011) presented the dependence structure between the WTI, Brent, Dubai and Maya oil benchmark prices with the copula approach. China is the second largest importer of crude oil in the world, and thus, the study on its crude oil price fluctuation is representative. Daqing oil price, as the local representative crude oil spot price in China, is influenced by the oil price difference across the various import sources, especially the representative global benchmark oil prices. For the Chinese government, it is necessary to find out whether the influence of its main reference benchmark oil prices on Daqing shows the global and regional characteristics for adjusting the pricing strategy. Discovering the co-movement of correlations of oil prices based on the time-varying dynamic correlations is useful in that it provides the basis for a more reasonable pricing strategy and establishes a pricing adjustment system. For investors, finding the time-varying dynamic correlations is an important market timing reference for portfolio management and hedging strategies.

How does one find a reasonable method to represent the one-to-one and many-to-one dynamic correlations to reveal the regional and global characteristics of oil prices? Grey Relation Analysis (GRA), proposed by Deng (1982), can satisfy the purpose of this study. Different from the econometric and financial models, GRA measures the relative influence of the compared series on the reference series. The one-to-one and many-to-one grey correlation time series can reveal the degree of dynamic relative influence of reference benchmark oil prices on the local representative oil price. The principle of GRA calculations is to compare the geometric relationships between time series data in the relational space. In the GRA process, time series data are not needed to satisfy a particular statistical distribution, such as a normal distribution, and there is no process of parameter estimation. Thus, GRA of time series data avoids several common analysis errors. In the existing studies of economic time series, Lin et al. (2007) used GRA to discover correlations among economic variables. Liu and Hu (2013) used GRA to improve the Support Vector regression method for stock price forecasting. GRA can capture the dynamic characteristics of time series during the development process.

However, economic and financial phenomena may exhibit various characteristics on different time scales, and the wavelet analysis tools enable us to investigate the multiscale features of these phenomena (Dajčman, 2013). Different from the Fourier transform and spectrum analysis, wavelet analysis provides a more effective and convenient process for revealing complex signal characteristics by being localized in both time and scale (Ramsey, 1999). For nonlinear time series research, wavelet decomposition reflects multi-timescale characteristics to enhance the practicality of the study results (Pinho and Madaleno, 2009). For the study of the seasonal and cyclical patterns, structural breaks, trend analysis, fractal structures and multiresolution analysis of nonlinear time series, wavelet analysis embodies the powerful ability of signal analysis (Crowley, 2005). In empirical studies, Kim and In (2007) revealed the relationship features of economic variables with wavelet correlation and cross-correlation analysis. Gallegati (2005) presented the lead/lag relationship between economic variables with wavelet cross-correlation analysis at all timescales. Other wavelet applications focused on the difference of the wavelet transform. Many wavelet families have been introduced (Benhmad, 2013). Orthogonal wavelets such as the Haar, Daubechies, Symmlets and coiflets are the most widely used in empirical studies (Daubechies and Bates, 1993). The applications of wavelet analysis for specific purposes in economics and finance are relatively recent and were initiated by Ramsey and Lampart (1998); Gencay et al. (2003); Kim and In (2007); Crowley (2005); Crowley (2010); Yu et al. (2012); Benhmad (2012) and Huang et al. (2015), among others. The existing studies on wavelet analysis applications in the field of economic time series are focused on wavelet feature analysis after wavelet

decomposition. Due to the diversity of wavelet transform methods, it is necessary to add an optimization process of the various wavelet transform methods before wavelet decomposition.

In brief, studying the characteristics of benchmark oil prices is helpful to understanding the oil market. It is necessary to use more variables and a comparative analysis from bivariate to multivariable, particularly the study of one-to-one and many-to-one dynamic correlations of oil prices, which can reveal the globalization and regionalization oil trade features of various areas. In the existing research on benchmark oil prices, the findings of the relationship characteristics are defined only at fuzzy short- and long-term time scales. If more detailed time scales were considered, it would more fully reveal the fluctuation characteristics of benchmark oil prices.

In this paper, we attempt to examine the co-movement of correlations of crude oil prices in a multivariate setting to discover the global and regional characteristics of the oil market. First, we calculate grey correlation degree time-series to find dynamic correlations of oil prices from the one-to-one to many-to-one perspective to represent global and regional characteristics. Second, we employ various wavelet methods to respectively decompose and reconstruct the grey correlation degree time-series into wavelet details and trend. Third, by comparison of the grey correlation results between the wavelet decompositions and the original time-series, we find the optimal wavelet decompositions. Finally, we employ wavelet variance, wavelet correlation and wavelet cross-correlation of optimal wavelet decomposition to respectively discover time-varying fluctuation intensity, fluctuation correlations and lead-lag relationships of oil price correlations at different time-frequency domains, which provide more evidence for oil price adjustment strategy and portfolio management. Our contributions are as follows:

- (1) We provide a novel perspective of multivariate dynamic correlation for studying the oil market by using an optimal wavelet analysis on the basis of grey correlation.
- (2) We provide a helpful time reference for oil price adjustment strategy and portfolio management.

The rest of this paper is divided into three sections. In Section 2, the wavelet transform methods and grey correlation analysis are described, and a grey correlation-based wavelet analysis framework is interpreted. Section 3 describes the data and empirical results. The last section provides the discussions and conclusion.

## 2. Methodology

### 2.1. Wavelet analysis

Wavelet analysis is proposed to cover the shortage of general econometric methods in the analysis process of economic time series. The econometric method is applied only to reflect the evolution characteristics of economic data in the time-domain. However, Spectrum analysis is used to achieve frequency-domain analysis, and the windowed Fourier transform can realize the local feature analysis. Based on the above consideration, the wavelet analysis method is improved by designing a different wavelet function (Daubechies and Bates, 1993). Multi-resolution analysis (MRA) provides reasonable wavelet decomposition and reconstruction (Fig. 1) (Mallat, 1989). Fig. 1 shows the Signal tree decomposition of a wavelet transform based on  $n$  time scales ( $n = 1, 2, \dots$ ).  $D_1, D_2, \dots, D_n$  stand for different detail sub-series that represent deviations from the trend, and  $A_1, A_2, \dots, A_n$  represent the long trend sub-series. The general function of the wavelet reconstruction for one signal is as shown in Eq. (1).

$$\text{Signal} = A_n + D_n + D_{n-1} + \dots + D_2 + D_1 \quad (1)$$

Download English Version:

<https://daneshyari.com/en/article/5064511>

Download Persian Version:

<https://daneshyari.com/article/5064511>

[Daneshyari.com](https://daneshyari.com)