Energy Economics 45 (2014) 120–133

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneco

Wavelet dynamics for oil-stock world interactions

Mara Madaleno *, Carlos Pinho

Departamento de Economia, Gestão e Engenharia Industrial (DEGEI), GOVCOPP - Unidade de Investigação em Governança, Competitividade e Políticas Públicas – linha de finanças e contabilidade, Universidade de Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal

ARTICLE INFO

Article history:
Received 30 July 2013
Received in revised form 3 June 2014
Accepted 9 June 2014
Available online 9 July 2014

JEL classification:
C22
C58
F01
O50
Q40

Keywords:
Oil price changes
Continuous wavelets
Sector stock markets
World index

ABSTRACT

A previous research ignores the distinction between short term and long term, and by decomposing financial variables (world general and stock market indexes) and the macroeconomic variable (oil prices) at various time scales, we study the relationship among series on a daily scale by scale basis. Continuous time wavelets help to circumvent the problems associated to basic linear regressions and given that stock-oil relationships are usually described as complicated we extend previous findings by providing more generalized and convincing results, in analyzing contagion and interdependence issues as well as lead and lag effects for both world general and sector stock levels between December 1992 and October 2012. The relationship between oil prices and sector stock returns is ambiguous, because results seem to show that there are both phase and anti-phase relationships, where mostly it is oil that is the lagging variable, independently of the sector under analysis. There is higher coherence among series for higher scales thus supporting the interdependence hypothesis, showing that long run market dynamics are more uncertain. Empirical results indicate a bidirectional relationship between both series for large time horizons, which can be associated to fundamentalist traders, especially fund managers and institutional investors, and which depend on the historical period under analysis.

1. Introduction and motivation

The repeated occurrence of turmoil in international financial and oil markets puts emphasis onto the analysis of the relationship between both markets. On one hand, stock markets play a significant role in capital mobilization being a significant component of the financial sector of any economy. On the other, oil price is an influential commodity to the real economy and financial markets (Reboredo and River-Castro, 2014). Still, we do not find any literature consensus about the nature and number of factors which influence stock markets. Oil price recent swings are thus an attractive factor to be analyzed deeply. In fact, oil has always played a significant role in both economic and political fields' development given that they are an important determinant of the future economic growth and stability of developing and developed countries. Oil prices affect the economy given that they are one of its most important production factors. If production costs increase due to higher oil prices, inflation, interest rates (higher discount rates lead to lower stock prices, ceteris paribus), consumer confidence and economic growth turn out to be also affected. However, rising oil prices may affect positively or negatively a firm future cash flow or an economy, depending if we have an oil producing or oil consuming one (Park and Ratti, 2008; Wang et al., 2014).

Naccache (2011) notes that oil price rises can be associated with under capacity, resource scarcity, geopolitical instability, rising costs in production, production cuts imposed by OPEC, extreme weather events and higher demand from emerging economies. Reboredo and River-Castro (2014) state that the existing empirical literature has been restricted to at most two time scales (short and long run). As expected, different impacts will have unalike consequences over different scales, as well as at different time horizons, which explains the need to separate these various contributions.

Given the oil intensity use due to rapid economic growth, economic liberalization and integration of international markets, it is important for global portfolio investors to understand the level of susceptibility of stock prices in these markets to movements in global oil prices. But, do oil prices exhibit measurable influences on stock markets? The answer to this question is inconclusive given the empirical study results which have appeared (Hamilton, 2003). Some authors state that there is a negative relationship between oil price increases (shocks) and stock returns (Driesprong et al., 2008; Jones and Kaul, 1996; Kilian and Park, 2009; Miller and Ratti, 2009; Nandha and Faff, 2008). Other studies show a positive relationship (Arouri and Rault, 2012; Narayan and Narayan, 2010; Sadorsky, 2006), but others found no relationship (Apergis and Miller, 2009; Huang et al., 1996; Reboredo and River-Castro, 2014) and also a conditional and nonlinear link (Park and Ratti, 2008; Reboredo, 2010). These inconclusive results may be due to the weakness of linear econometric tools

* Corresponding author. Tel.: +351 927 992 253.
E-mail addresses: maramadaleno@ua.pt (M. Madaleno), cpinho@ua.pt (C. Pinho).

http://dx.doi.org/10.1016/j.eneco.2014.06.024
0140-9883/

applied up to date, which do not detect asymmetries and nonlinear linkages across oil and stock market returns, and thus do not capture their complex relation. Despite this, it has been found cointegration evidence and the adjustment to the implied long-run relationship may involve nonlinearities. Another body of the literature analyses sector stock returns and oil price changes (see for example, Mohanty and Nandha, 2011). As pointed out by Akoum et al. (2012), these mixed findings may be a result of an evolving relationship between the two variables. As such, they suggest the application of methodologies which capture the possible changing relationship in oil price and stock market studies (Jawadi et al., 2010).

Some authors show that the link between oil and the economy is not linear (Cologni and Manera, 2009; Hamilton, 2003; Jawadi et al., 2010; Kilian, 2008). Fewer studies appeared which strictly look at the level of sector and regional stock returns. Most studies only care about a few industrialized countries and over the short term interaction between energy price shocks and stock markets. Arouri et al. (2010) investigate the effects of oil shocks on the stock market of GCC region (oil exporting) countries applying linear and nonlinear models, showing that stock market returns significantly react to oil price changes in most of the countries. As such, conclusions that oil prices do not affect the overall stock market performance could be due to the fact that oil prices are not any more a significant source for economic downturn (Apergis and Miller, 2009; Jammazi and Aloui, 2010).

Given that wavelets provide out of sample forecasts for oil prices, we use them to better understand the underlying dynamics of this oil price variability over sector stock returns, but for a world perspective. The idea is to subdivide the price data or signal in its low and high frequency parts. While the coarse scales reveal the trend, finer scales might be related to seasonal influences, singular events and noise. As pointed out by Aguiar-Conraria et al. (2008, pp. 646) wavelets offer a huge advantage in terms of its ability to perform "natural local analysis of a time series in the sense that the length of wavelets varies endogenously: it stretches into a long wavelet function to measure the low frequency movements, and it compresses into a short wavelet function to measure the high frequency movements". The authors use cross-wavelet analysis to decompose time-frequency effects of oil price changes on the macroeconomy. In both economic and financial fields we can find wavelets applied to study the relationship between stock returns and inflation (Kim and In, 2005), business cycles (Yogo, 2008), financial market contagion (Gallegati, 2012), oil price cycles (Naccache, 2011), to forecast crude oil prices (Jammazi and Aloui, 2012) and to relate oil prices to exchange rates (Reboredo and Rivera-Castro, 2013).

We can also find some attempts in the literature that use wavelets to analyze the relationship between oil prices and stock markets. Jammazi and Aloui (2010), combine wavelet analysis and Markov Switching Vector Autoregressive models to explore the impact of crude oil shocks over stock returns for UK, France and Japan from January 1989 to December 2007. They show that crude oil shocks do not affect the recession stock market phases except for Japan. Akoum et al. (2012) examine the short and long term dependencies between GCC stock market returns and OPEC basket oil returns using wavelets. Their empirical results show that oil and stock returns are not strongly linked in the short term. They also suggest that there is a variation in the dependence between oil prices and stock markets across countries and an increasing strength in the market dependencies after 2007, meaning there are more diversification benefits for investors in the short term compared with the long term. They show a lack of dependence in the short term between the MSCI global index and oil prices, using weekly data from January 2002 until May 2011. Jammazi (2012) uses wavelet analysis to show that wavelet variance decreases with increasing scales, exploring the relationship between crude oil changes and stock returns for developing countries (USA, Canada, Germany, Japan and UK). The author suggests that the study's results vary depending on the oil-stock market linkages' sensitivity to the degree of improvement in energy efficiency of a given country, the degree of oil shock persistence and if the country is an oil importer or exporter. Also, he argues that investors try to profit from short term price reactions (the co-movement of series at higher frequencies) and that from a long term portfolio diversification perspective, investors seek to explore long term price reactions (lower frequencies), using monthly data. Reboredo and River-Castro (2014) examine the relationship between oil and stock returns just for Europe and the USA at both the aggregate and sectorial levels using wavelets, finding no evidence of lead and lag effects in the pre-crisis period and rejecting the underreaction hypothesis.

The present work tries to add to the existing literature by studying these dynamic effects between oil and stock markets but using a general world perspective, not just by putting emphasis onto these effects before and after the onset of the financial crisis, but by analyzing several different historical episodes related to this relationship during almost twenty years of data and by using the continuous time Morlet wavelet transform (CWT) technique that expands a time series into a time frequency space where oscillations can be seen in a highly intuitive way. As such, this technique exposes regions with high common power and further reveals information about the phase (lead or lag) relationship. As noted by Naccache (2011), many times the analysis is done in the time domain and the frequency domain is completely forgotten although some appealing relationships may exist at different frequencies. The oil price may act like a supply shock at high and medium frequencies, therefore affecting the macroeconomy, whereas in the long run (lower frequencies) it is the macroeconomy, through a demand effect that affects the oil price. Moreover, Gallegati (2012) proposes the wavelet methodology to identify contagion and interdependence between crude oil and stock markets. Reboredo and River-Castro (2014) also use this concept stating that since shock transmission due to contagion is rapid and quickly fade in a matter of days, those changes associated to higher frequencies can be related to contagion and those occurring at lower frequencies are due to interdependence or co-movement. However the authors only apply wavelets in the context of Europe and USA and using its discrete version for signal decomposition.

The present work tries to find intrinsic characteristics of world stock market sector indexes where the cross-coherence-phase-wavelet technique is applied to study the comovement between oil prices and world representative stock market and sector indexes. A previous literature using wavelets to study this relationship was only applied to general country or specific regional stock and global indexes. We use continuous cross-wavelet coherence and phase analysis to show how the relation among these sector indexes has changed and evolved with time. Results show that these are not homogeneous across the different frequencies. Moreover, very few studies have looked at the impact of oil price changes on the stocks of individual sectors and most of these studies are country specific and thus do not provide a global world perspective, despite the fact that oil is a commodity used by all, with an evident macroeconomic impact and with economic consequences all around the world.

Studying the effects of oil price fluctuations sector by sector is important for several reasons (Arouri, 2011), because any market-wide consequence may mask the not necessarily uniform performance of any sector; due to the fact that sector sensitivities to changes in the price of oil may be asymmetric (once more affected than others; Arouri, 2011); and finally, it is interesting to analyze different sector markets in order to see how oil price changes may impact these attending to their inherent characteristics. The present article extends the understanding of this proved existent relationship between oil prices and stock returns in two different manners: first, by testing for nonlinear linkages and second, by using an industry/sector focused view, in order to provide a broad range of conclusions. With this purpose in mind this study investigates whether nonlinear relationships, due to common behavior, exist in the selected sector stock markets and oil price series.

Another useful contribution of the present study is the fact that we try to provide investors advantages to make their own suitable