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The nexus between geopolitical uncertainty and crude oil markets: An entropy-based wavelet analysis[☆]

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HIGHLIGHTS

- We utilize an entropic mixed discrete-continuous multiresolution approach.
- We explore the dynamics between geopolitical, economic uncertainty & oil markets.
- A novel time-scale method is applied to detect business cycle (a)synchronization.
- A strong heterogeneity is revealed over time and across scales.

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ABSTRACT

The global financial crisis and the subsequent geopolitical turbulence in energy markets have brought increased attention to the proper statistical modeling especially of the crude oil markets. In particular, we utilize a time–frequency decomposition approach based on wavelet analysis to explore the inherent dynamics and the casual interrelationships between various types of geopolitical, economic and financial uncertainty indices and oil markets. Via the introduction of a mixed discrete-continuous multiresolution analysis, we employ the entropic criterion for the selection of the optimal decomposition level of a MODWT as well as the continuous-time coherency and phase measures for the detection of business cycle (a)synchronization. Overall, a strong heterogeneity in the revealed inter-relationships is detected over time and across scales.

1. Introduction

The financial crisis and the subsequent growing geopolitical uncertainty in crude oil markets, continue to stress the business cycle of the global economy. Over the past decade, the crude oil price fluctuations can exclusively be explained by several factors including macroeconomic, financial and market conditions. The recent oil market uncertainties are also connected to the global demand for oil, which is strongly linked to the oil demand of industrialized countries and the

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supply of oil exporting countries. Recently, these markets have become more sensitive to external information including macroeconomic uncertainty [1,2], uncertainty in financial markets [3,4], market sentiment [5], financial speculation [6,7], and so on so forth. These uncertainties influence the economic decision-making process through several economic channels of price shocks mostly via production or consumption functions [8]. Importantly, price shocks are connected with quantity responses, which in turn lead to recession in real economy. In general, uncertainty influenced by macroeconomic factors has short-run adverse effects on economic growth [9]. In an earlier study, the geopolitical uncertainty in crude oil markets was observed to be a potential driver during the 2007–2009 economic recession period [10]. Therefore, uncertainty is of paramount importance vis-á-vis the predictability of the real economy [1]. Moreover, it is fundamentally vital for oil dependent and interdependent countries, wherein crude oil is the primary input driving the economy through the production process [11].

A large and growing body of literature, both theoretical and empirical, has documented the impact of uncertainty on oil prices using mainly four different perspectives. Firstly, the United States and the European Union economic policy uncertainty were recognized by Baker et al. [12]. Earlier studies found that the real oil prices are linked to significant increases in economic policy uncertainty [13–15] and oil price volatility [16]. The application of the news-based economic policy uncertainty analysis in crude oil market is more recently discussed in numerous works, such as in [17] wherein oil market predictability is examined with the Please check the following cross-citation (similar cases), and correct if necessary. use of a quantile causality approach, in [18,19] on oil price forecasting via a Time-Varying Parameter VAR model, and in [20] using a Structural VAR approach on US and Non US oil production.

The second important factor in determining the oil price is financial uncertainty; Cheng et al. [21] attributes this type of uncertainty (VIX) having effects on both trader positions and commodity prices, while Sari et al. [22] drew attention to the fact that the VIX, had a significant suppressing effect on oil prices in the long run and a less important role in explaining the forecast error variance of oil prices in the short run. Thirdly, crude oil prices are also influenced by market sentiment as inferred by traders' positions [23]. Fourthly, oil price oscillations can be often attributed to pure speculation. However, the empirical evidence is inconclusive. For example, some studies conclude that speculative shocks are relevant determinants of oil price differentials [6,24], whereas others show that the strength of the relation between speculation index and oil price is rather weak [25,26].

In this study, we investigate the relationship between crude oil markets and several sources of uncertainty including economic, financial, sentiment, and speculation uncertainty for different business cycles utilizing a time–frequency framework both in the discrete and continuous time-scale domain, over the period April 1990–December 2015. We contribute to the relevant literature in two important ways: firstly we capture the nonlinear and nonparametric aspects in the relationship between crude oil prices and uncertainty, which is characterized by a multi-scale structure caused by asymmetries in the business cycles. Secondly, we introduce wavelet coherence and phase difference measures in an attempt to capture significant second order moments (volatility) over time and across the spectrum, and reveal the strength of the co-movements between crude oil markets and various types of economic/financial uncertainty. Our time domain-based lag–lead linkages and frequency domain-based coherence and phase results, confirm that economic and financial uncertainty play a stronger role than market sentiment and speculation in global crude-oil markets.

The paper is structured as follows: the next section describes the novel entropic discrete multiresolution methodology introduced, while Section 3 presents the data and a preliminary analysis. Section 4 analyzes the continuous time–frequency measurement approach followed to detect co-movements and interrelationships between uncertainty indices and oil markets. Section 5 demonstrates the empirical results, and Section 6 concludes.

2. Entropic MODWT

The introduction of the wavelet multi-resolution analysis (MRA) in finance and economics is widely discussed in previous literature as in the works of Ramsey et al. [27] for US stock prices, Ramsey and Lampart [28,29] for money, income and expenditure, of Gençay et al. [30,31] for growth and inflation, of Bekiros and Marcellino [32] for currency markets, Bekiros et al. [18,19] for EU business cycles and Bekiros et al. [33–35] for equity and commodity markets. More recent empirical works employing the wavelet time-scale analysis include Bekiros et al. [34,35] wherein money supply and inflation dynamics in the Asia-Pacific economies are investigated, Mensi et al. [36] for BRICS, emerging and major developed stock markets, Shahzad et al. [37] where the authors apply this method on Greek and other EU equity markets, Shahzad et al. [38] in case of industry-level US credit markets and Jammazi et al. [39] in which six major oil-importing countries are analyzed.

The maximal overlap discrete wavelet transform (MODWT) acquires some innovative properties when compared to the classical discrete wavelet transform (DWT). In our work, we implement the MODWT on oil and uncertainty series [30,31]. Technically, in wavelet analysis any function$f(t)$ in $L^2(R)$, can be decomposed into different components, which are associated with different scales of resolution. The wavelet representation of a signal$f(t)$ is given by

$$f(t) = \sum_k s_{J,k}\phi_{J,k}(t) + \sum_k d_{J,k}\psi_{J,k}(t) + \sum_k d_{J-1,k}\psi_{J-1,k}(t) + \cdots + \sum_k d_{1,k}\psi_{1,k}(t) \quad (1)$$

where ϕ is the scaling function – also known as the father wavelet – and ψ the wavelet function known as the mother wavelet. The terms $\phi_{J,k}$ and $\psi_{J,k}$ are scaling and translation filters corresponding to ϕ and ψ. Furthermore, the $s_{J,k}$ and $d_{J,k}$