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Do all sectors respond to oil price shocks simultaneously?☆

Shupei Huang[a,b,c,d,*], Haizhong An[a,b,c], Xuan Huang[e], Yue Wang[a,f]

[a] School of Humanities and Economic Management, China University of Geosciences, Beijing, China
[b] Key Laboratory of Carrying Capacity Assessment for Resource and Environment, Ministry of Land and Resources, Beijing 100083, China
[c] Key Laboratory of Strategic Studies, Ministry of Land and Resources, Beijing 100083, China
[d] Department of Science and Technology, Parthenope University of Naples, Centro Direzionale-Isola C4, 80143 Napoli, Italy
[e] School of Economics, Xi'An University of Finance and Economics, Shaanxi, China
[f] Strategic Research Center for Oil and Gas Resources, Ministry of Land and Resources, Beijing 100034, China

HIGHLIGHTS

- Multiscale lead-lag relations among impacts of oil prices on sectors are explored.
- The number of oil-stock nexuses involved with lead-lag effects grows as length of time scales.
- In the short term intensive fluctuations lead to the complexity of oil-stock nexuses.
- In the long term significant lead-lag relations with longer time lags are found.

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ABSTRACT

Sector stock indices respond to oil price fluctuations with temporal heterogeneities based on their oil dependence and multiple transmission mechanisms. Additionally, such heterogeneities may not persist across time scales due to their inherent multiscale features. Aiming to explore the lead-lag effects among oil-stock nexuses at sectoral level and further identify the transmission path of oil price shocks to different stock sectors chronologically across time scales, we propose an integrated research framework combining the wavelet transform, cross correlation coefficients and the network analysis together. We take the Brent oil price and Morgan Stanley Capital International (MSCI) world sector stock indices (Materials, Industrials, Consumer Discretionary, Consumer Staples, Health Care, Financials, Telecommunications, Utilities, Transportation and Metals & Mining) from January 2000 to January 2016 as data samples. We find that the number of oil-stock nexuses involved in lead-lag effects and the maximum time lags grow as the length of the time horizon. Each sector may lead or lag behind other sectors in different frequencies to move with an oil price shock, but Transportation, Utilities and Consumer Discretionary are sectors have higher probability to lag behind other sectors, while Materials and Telecommunications are the sectors with higher possibility to lead other sectors. In addition, The oil-stock nexuses of Utilities, Telecommunication and Consumer Staples work as key points in the frequencies of 8, 64, and 128 days, whereas the Brent-Transportation nexus control more information in the frequency of 256 days. Finally, we infer that the complexity of the interaction between oil price and the stock market is triggered by different causes across time scales. In the short term, such complexity is caused by high fluctuations of the oil-stock nexuses happening simultaneously because there are fewer lead-lag relationships among nexuses. In the long term, the relationships of oil-stock nexuses are more stable, but the time lags among nexuses become longer, which could overlap the impacts of oil price from different time points.

1. Introduction

Compared with the obvious negative effect of the oil price increase on the real economy[1] [1], influences of oil prices on the stock market display mixing types, namely insignificant, positive and negative ones [2–8]. Such mixing results could be triggered by two main reasons. The

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* Corresponding author at: School of Humanities and Economic Management, China University of Geosciences, Beijing, China.
E-mail address: hspburn@163.com (S. Huang).

[1] In recent decade, the relationship between the oil price and the stock market become 'reverse causality'. More precisely, the economy boom becomes to affect the oil price fluctuations.

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multiscale nonlinearity could be the first one [9]. More specifically, the international oil market and stock markets consist of a variety of stakeholders with objectives rooting in heterogeneous time horizons [10], for instance investors are interested mainly in the short investment horizons, while the policy makers pay more attention on the long term equilibrium. Hence, the time series of oil prices and stock indices are formed by the combination of components associating with different time scales [11,12], which complicates the oil-stock analysis. Moreover, another contributor is that aggregate stock indices are composed of numerous listed companies that can be classified into different sectors [13,14]. The impact of the oil price on each sector may have temporal differences based on transmission paths and the various oil dependence of different sectors [15]. It is expected that oil related sectors are more sensitive and respond much more rapidly to oil price shocks than other sectors. Due to the temporal heterogeneities, the impacts of oil price shocks on different sectors from the same or different time points could be overlapped together and obscure the entire interaction between the oil price and stock market [16,17]. Therefore, closer observations considering the multiscale and lead-lag effect among impacts of the oil price on each sector stock index could favor a more comprehensive picture of the transmission path and mechanism of influences of the crude oil price on the stock market.

The literature focused on the oil-stock nexus pays more attention to whether the aggregate stock index responds to oil price fluctuations at first. To be more specific, part of the literature did not find any evidence proving that fluctuations of the oil price could shock the stock market [2,18–21], whereas the other part of the literature found that stock markets could respond to the oil price in a positive or negative manner [4,5,22,23]. Additionally, some studies find the impacts of oil prices on the stock market are time varying [24–28]. Then, Confronting the mixing impacts of the oil price fluctuations on the aggregate stock indices, the research shifted to the non-linear issue of the oil-stock nexus that partially explains why there are fewer consensuses among previous research studies [29–31]. From the multiscale point of view, researchers prove that relationships between oil prices and stock indices vary according to time scales; these heterogeneities of relationship between oil prices and stock markets across different time scales increase the complexity of the oil-stock nexuses [3,30,32–36]. Besides the multiscale issue, researches extend to the sectoral level for more detailed and comprehensive understanding for the oil-stock nexus [37]. El-Sharif et al. found insignificant relationship between the oil price and Oil & Gas stock sector in UK [38]. Hammoudeh and Li argue that the oil price exert significant effect on US transportation sector [39], which are confirmed by Nandha and Brooks [40]. Nandha and Faff prove that the oil price have negative influence on all global sectors except Mining and Oil & Gas industries [41]. Degiannakis et al. find different relationships between oil price and sectors in Europe [15]. Arouri et al., prove that not only the oil related sectors but also the non-oil related sectors are sensitive to the oil price shock [42]. Huang et al., examine the influence of the oil price on stock sectors within multiple time scales [43]. Bouri et al. explore the time-varying relationship between the oil prices and sector stock indices [44]. Phan et al. find that asymmetric effect of oil prices on most of sub-sector stock indices [45]. Kristjanpoller and Concha's work displays strong positive influence on the airline stock returns [46]. All these researches confirm the fact that each stock sector may respond to the oil price diversely in terms of directions (positive or negative) in single or multiple time horizons. More interestingly, recent works find that the impacts of the oil price on the stock market are not only diversify in the direction (positive or negative) but also display asynchronization. Reboredo and Rivera-Castro find that there exist lead-lag relationships between the oil price and different stock sectors and each temporal relationship vary in different time horizons [35]. And Peng et al. find little immediate impact of oil price shocks on Chinese firms' stock synchronicity; but the lagged effect is evident from the cumulative aspect [47]. Both works find evident hint that the spread of the oil price fluctuations among the sector stock indices have significant time differences. However, the examination of lead-lag relationships between the oil price and stock markets is limited to each single pair of sectoral oil-stock nexus through the bivariate model. There is no quantitative and systematical consideration of accurate lead and lag relationships among multiple oil-stock nexus with multiple variables. Hence, it is difficult to understand how the impact of the oil price shocks spread along different sectors in the stock market chronologically. In other words, the specific transmission path of the oil price along stock sectors involving time differences information is still hidden. To clarify this hidden information could deepen the understanding of the interaction between the international oil market and world stock market with precise time differences.

Previous studies confirm that sectoral and multiscale sensitivities of the stock market to the oil price shock, which could associate with various transmission paths. The stock price could be calculated from the discounted value of the expected future cash flow. In theory, the oil price fluctuation could influence the future cash flow of the company in negative or positive manner (depends on the oil is input or output of that firm) and also could affect the cash flow discount elements, namely exchange rate, interest rate and inflation [35]; all these discount elements are associating with the macro economic conditions and need more time to changes. Simultaneously, the stock market is efficient and could receive any market related information and reflect it with the stock price fluctuations, which is primarily rely on the expectations and behaviors of market stokeholds and could be immediately reflected through the dealing behaviors [48]. These transmission paths through the discount elements and market expectations enhance the linkage between the oil price and sector stock indices in different time horizons. In addition, concerning different sectoral indices, the cost side effect of the increasing oil price enhance the relationship between the oil price and stock sectors with directly association with the oil, whereas sectors having indirectly relationship with the crude oil depend on the demand-side effect of the aggregate demand [42,49]. Thus, based on various transmission mechanisms, the linkage between sector stock indices and the oil price are closed from multiscale and sectoral aspects. However, as our best knowledge, there are no further considerations of the time differences among multiple sectoral oil-stock nexuses from a system perspective involving precise lead-lag estimation since the existing explorations of the relationship between the oil price and sector stock indices are limited to the bivariate models. With the bivariate models, the attention is paid more on the time difference between oil prices and sector stock indices rather than the time difference happens during the spread of the oil price fluctuations among sector stock indices. Through clarifying the transmission of the oil price fluctuations among sector stock indices systematically with consideration of chronological order, we could forward a further step to an improved understanding about the dynamic relationship between the oil market and the stock market from the sectoral and multiscale perspectives. Furthermore we could answer following questions that are still covered in the previous studies, do sector stock indices respond to oil price fluctuations with significant time differences? Do the oil sensitive sectors always lead other sector? Do oil-indirect related sectors have higher possibility lag other sectors? Do these lead-lag relationships of oil price fluctuations spreading among sector stock indices persist across all time scales?

Hence, we formally explore lead-lag relationships among different sectoral oil-stock nexuses across time scale considering the oil price and multiple stock sectors as a system for a comprehensive picture. For this purpose, we proposed a synthesis research framework. First, the wavelet transform offers an effective solution to obtain the multiscale information of financial time series [50]. The main idea of wavelet transform is to use different resolutions to observe the original time series and to track the details and trend of a given time series in the time and frequency domains simultaneously [51–54]. In particular, we implement wavelet coherence to capture the coherence between the oil