Applied Energy xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Applied Energy

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

Do oil price asymmetric effects on the stock market persist in multiple time horizons?

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HIGHLIGHTS

- There are no asymmetric effects of oil prices on stock return across the multiscale.
- Oil price increase and decrease both have significant influence on stock returns.
- The effect on stock returns of oil price changes is greater than the exchange rate.
- The responses of the stock market to the oil price changes increase in the long term.

ARTICLE INFO

Article history:
Received 17 August 2015
Received in revised form 13 November 2015
Accepted 30 November 2015
Available online xxxx

Keywords:
Oil price
Stock
Asymmetric effects
Multiscale

ABSTRACT

The oil price could exert asymmetric effects on the stock market. Does this effect persist in various time horizons? To answer this multiscale puzzle, we combine the wavelet transform and the vector autoregression model to examine the dynamic relations between the oil price increase or decrease and stock returns at various time horizons. This paper finds evidence that for each time horizon, both the oil price increase and decrease have significant effects on the stock returns; in addition, the stock market has a reverse influence on the oil price. Further examination proves that the response amplitude of the stock market to the oil price changes ascends as the time horizon lengthens and the response direction varies across different time horizons. Moreover, compared with the exchange rate, the oil price changes could exert a greater effect on the stock market. Overall, based on the influence direction and the extent of the oil price increase and decrease vary with the time scale, there is no persistent asymmetric effect of the oil price on the stock market across time scales. However, the impacts in the longer time horizons deserve more attention from the policy-makers and investors.

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1. Introduction

Dramatic crude oil price increases could depress national economies and lead to recessions [1]; however, minimal evidence proves that an oil price decrease could foster economic booms. This phenomenon is academically defined as the asymmetric effect of oil price shocks [2–4]. Because the stock market is generally considered as the bellwether of the economy and their linkage builds upon the interest rate, inflation, bonds and cash flow [5], a large body of literature examines whether the asymmetric effect of the oil price is also exists in stock markets. Sadorsky proves the asymmetric effect of oil prices on the stock market using the vector auto-regress model [6], and then Basher and Sadorsky confirm these phenomena for emerging countries [7]. Recently, Salisu and Oloko pronounced a significant own asymmetric impact during the world economic slowdown period [8]. In contrast, Cong et al., find minimal evidence for an asymmetric effect on the aggregated stock index [9]. The works by Nandha et al., and Park et al. confirm that no asymmetric issues with larger data sample size, and they recommend to hedge the oil price risk [10]. Obviously, it is difficult to derive a consistent conclusion for the asymmetric issue with increasing literature [8,11–18]. Because of the reputedly complicated oil and stock markets as the influences of many exogenous factors, such as policy changes, new technology improvement and environmental concerns, the oil–stock issue is

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http://dx.doi.org/10.1016/j.apenergy.2015.11.094
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highly complex and difficult to attain conclusive results [19,20]. Therefore, by involving more nonlinear considerations, Ramos and Veiga show evidence that the asymmetric effect is solely significant for oil-importing when the distinction among countries and oil volatility are considered [21]; this proves that more elaborated examinations involving nonlinear factors could offer more convincing results.

However, in addition to these obvious nonlinear factors, there remains an important hidden factor for considering the asymmetric effect of oil price changes. As we know, there are a variety of stakeholders with markedly different investment horizons [22]. The investors who prefer long-term trading rely in part on the trend analysis at quarterly and yearly time horizons. In monthly and weekly time horizons, the investors often rely on a computational finance strategy. The daily and intra-daily frequency is the ideal choice for speculators [23]. Thus, the markets combine all investors from various time horizons, which means that all the investment classes may exert different influences on the entire market [24]. Moreover, a strand of literature provides a convincing evidence for multiscale characteristics of the relationships between the oil price and stock market such as the study by Jammazi [19], Khalfaoui et al. [25], Reboredo and Rivera-Castro [26] and our previous research [27]. However, the existing literature that focuses on the oil–stock interaction examines this nexus in a general manner and ignores the asymmetry effect of the oil price, which may omit crucial and specific reference information for the stakeholders in the markets. Therefore, whether the asymmetric effect of the oil price persists in multiple time horizons remains a nascent problem.

Encountering this issue in multiple time horizons, we choose the wavelet transform to attain a multiscale analysis. The economic and financial research of the past decade provides evidence of the effectiveness and efficiency of the wavelet [28–30]. The researches proved that there are multiscale features in the stock markets [31–34], energy commodity markets [35–39] and their interactions [22,27,40]. Hence, using a wavelet transform, we can examine whether the asymmetric effect of the oil price on the stock market exists across various time horizons, which has been a gap in the literature. Based on the analysis in different time horizons, we can answer the following questions: Could the oil price increase and decrease cause changes in the stock market across different time horizons? Does the stock market respond to the oil price increase or decrease in the same direction, and do these response directions persist across time horizons?

With the objective of exploring the asymmetric puzzle across various time horizons, we combine novel and traditional approaches, the wavelet transform and the vector autoregression model (VAR). First, we use dummy variables to separate the oil price time series into an increase and a decrease series. Second, we implement the wavelets to decompose the oil price increase/decrease series and stock returns into various time horizons. Third, we construct the VAR model involving the oil price changes and stock return variables for each time horizon. Finally, the analysis examines the asymmetric puzzle for each time horizon using the Granger causality test, the impulse response function and variance decomposition.

2. Methodology and data

To test the asymmetric effects of oil price variations on the stock market in multiple time horizons, we first need to transform the original time series into different time horizons with the discrete wavelet transform. Based on the decomposition results, we construct the multiple variables vector autoregression model to explore the dynamic interaction between the oil price and the stock index.

2.1. Discrete wavelet transform

First, the Haar à trous wavelet transform is used to decompose the oil price changes and stock index in different time scales. Generally, in the existing economical literature using the discrete wavelet transform, most have adopted the maximal overlap discrete wavelet transform (MODWT) [38,41]. However, MODWT has a boundary effect that could omit information at the beginning or end of the time series. The Haar à trous wavelet transform (HTW) solves the boundary effect and effectively retains the information by abandoning the sampling and interpolating processes [42]. In addition, for the wavelet transform always needs to find a balance between the time and scale because in the high frequency band, the time resolution is better, and in the low frequency band, the frequency resolution is better. The Haar à trous wavelet transform (HTW) has a better tradeoff between the most desirable wavelets' properties (time alignment of the Haar and non-decimation of the à trous), which could retain the entire information of the original time series effectively and also offer precise construction and observation [43].

In detail, the Haar à trous wavelet transform can be represented as an equation involving a series of wavelet coefficients and scale coefficients. First, given the scale, coefficient c_{i+1} is defined as follows:

$$c_{i+1}(k) = \sum_{l=-\infty}^{+\infty} h(l) c_i(k + 2^i l) \tag{1}$$

where $h(*)$ is the filter (1/2, 1/2).

Then the wavelet coefficient d_i can be obtained from the difference in the successive scale coefficients:

$$d_i(k) = c_{i-1}(k) - c_i(k) \tag{2}$$

Finally, the original time series is composed into j scales, namely D1, D2, D3,. . ., Dj and Aj. Among these scales, D1, D2, D3, . . ., Dj represent the details of the changes in the time series. The HTW of one time series can be represented as follows:

$$X(k) = c_j(k) + \sum_{j=1}^{J} d_j(k) \tag{3}$$

Hence, according to the decomposition of the HTW, we can obtain the wavelet and scale coefficients for different scales, which reveal richer fluctuation information at each scale.

2.2. Econometric model

Based on the wavelet decomposition results, we establish a multiple vector auto-regression model to further explore the dynamic relation between the oil price changes and stock market. Furthermore, the impulse response function uncovers the direction of the response of the stock index to oil price changes, and the variance decomposition can estimate the level of impact of oil price changes.

2.2.1. Vector auto-regression model

Sims [44] presented the vector auto regression model (VAR) for the dynamic analysis of the economic system. The VAR model treats all of the variables as endogenous, and evaluates the estimation of the dynamic interaction between the economic variables. The VAR model can be expressed as follows:

$$y_t = \Phi_1 y_{t-1} + \cdots + \Phi_p y_{t-p} + \varepsilon_t, \ t = 1, 2, \ldots, T \tag{4}$$

where y_t is a k-dimensional endogenous variables column vector, p is the lag length, and T is the number of samples.

Please cite this article in press as: Huang S et al. Do oil price asymmetric effects on the stock market persist in multiple time horizons?. Appl Energy (2016), http://dx.doi.org/10.1016/j.apenergy.2015.11.094

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