Applied Energy 179 (2016) 272–283

Contents lists available at ScienceDirect

Applied Energy

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

Oil price and exchange rate in India: Fresh evidence from continuous wavelet approach and asymmetric, multi-horizon Granger-causality tests

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HIGHLIGHTS

- We assess the relationship between the oil price and India-US real exchange rate.
- We use a wavelet approach and asymmetric, multi-horizon Granger-causality tests.
- Co-movements are noticed in the post-reform period, especially for 2–4-years bands.
- The Granger-causal relationship between variables is non-linear and asymmetric.
- The short run oil price movements are important for the exchange rate stabilization.

ARTICLE INFO

Article history:
Received 5 January 2016
Received in revised form 21 June 2016
Accepted 29 June 2016

JEL classification:
C40
E32

Keywords:
Cyclical and anti-cyclical effects
Wavelet coherence
Oil price-exchange rate
Granger causality
India

ABSTRACT

We use a continuous wavelet approach and deploy asymmetric, multi-horizon Granger-causality tests between the return series of the oil price and the India-US exchange rate, over the time-span 1980M1–2016M2. The results highlight important co-movements in the post-reform period, especially for the 2–4-years band. The wavelet Granger-causality tests show that the exchange rate Granger-causes the oil price in the long run, while the opposite applies in the short run. Moreover, we find that the Granger-causal relationship between variables is non-linear, asymmetric and indirect, which will help policymakers and traders to make better strategic and investment decisions.

1. Introduction

The effectiveness of energy policies are of vital importance for the macroeconomic environment due to supply-side shocks which might generate. After the 1973 oil crisis many researchers have empirically examined the relationship between oil prices and various macroeconomic issues, underlining the link between oil shocks and recessions [1]. The empirical literature has blossomed again after the remarkable fluctuations recorded by international oil prices in 2008–2009, but especially after the 2014 free-fall in oil prices, highlighting the impact of energy policies in general and of oil prices in particular, on business cycles and inflation [2–4], on stock prices [5–7], on non-energy commodity markets [8], or on other monetary issues like the exchange rate [9,10]. However, because the oil represents one of the most traded commodities, assessing the impact of oil price shocks on the exchange rate deserve a special attention.

There is a well-established theoretical link between the international oil price and the US Dollar exchange rate. On the one hand, Golub [11] and Krugman [12] document how the oil price explains exchange rate movements. In brief, according to these authors an

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http://dx.doi.org/10.1016/j.apenergy.2016.06.139
0306-2619/

oil-exporting (oil-importing) country may experience a currency appreciation (depreciation) when oil prices rise and depreciation (appreciation) when oil prices fall. On the other hand, Bloomberg and Harris [13] provide an explanation on the potential impact of exchange rates on oil price movements. In short, relying on the law of one price for tradable goods, they show that, since oil is a homogeneous and internationally traded commodity priced in US Dollars, a depreciation of this currency reduces the oil price to foreigners relative to the price of their commodities denominated in US Dollars. Thereby, as their purchasing power and oil demand increases, the crude oil price in US Dollars is pushed up. Further, as the US Dollar is the major billing and settlement currency in international oil markets, the domestic currency exchange rate with the US Dollar is the key channel through which an oil price shock is transmitted to the real economy, with different effects for oil-exporting and oil-importing countries [14]. Consequently, the response on monetary policies to oil price fluctuations can amplify the shocks in the oil price [2].

The empirical investigation of the oil price – exchange rate nexus shows mixed evidence. The dominant view in the literature, represented by Amano and van Norden [15], Chaudhuri and Daniel [16], Bénassy-Quéré et al. [17], Chen and Chen [18], Coudert et al. [19], Lizardo and Mollick [20] and more recently by Basher et al. [21], reports a unidirectional Granger causality from the oil price to the exchange rate. Another view argues that movements in the US Dollar exchange rate Granger-cause crude oil prices, showing thus the opposite phenomenon (see for example [22]). Most of these studies use cointegration techniques and one-shot measures of Granger-causality.

However, recent studies show that the relationship between the oil price and the exchange rate is time-frequency dependent and bidirectional at the same time [10,23,24]. In line with these studies, our paper aims to analyze the lead-lag relationship between the return series of the oil price and the Indian Rupee exchange rate against the US Dollar, applying continuous wavelets. This method allows to see if the direction and the strength of the Granger causality and the lead-lag relationship between variables vary in time and over different frequencies. In addition, by applying Continuous Wavelet Transform (CWT) we are able to identify cyclical and anti-cyclical relations, as well as periods of volatility/jumps and structural breaks.

Different from the works mentioned above, the present paper brings forward several contributions to the existing literature. First, the CWT methodology used in previous studies is largely based on Torrence and Compo [25], who use a parametric bootstrap approach to assess the significance of areas. However, the pointwise testing approach, especially for the phase difference, is questionable (for a discussion, see [26]). Therefore, in order to avoid this bias, we employ the bootstrapping method advanced by Cazelles et al. [27], who compare the consistency of different resampling techniques, and take into account the key components of a time series (i.e. mean, variance and distributions of values, in both time and frequency domains). Second, different from previous studies, the present paper explores the oil price – exchange rate relationship, applying a wavelet Granger-causality test, recently proposed by Olayeni [28]. This method circumvents the need for minimum-phase transfer functions and is able to identify causality in both time and frequency.

We also contribute to the literature by employing a battery of newly proposed time-series based tests to disclose the Granger-causal relationship between the variables in question, and we compare them with frequency-domain and regime-switching based Granger-causal tests, in order to check the robustness of the wavelet Granger-causality test. All these tests allow to estimate the non-linear Granger-causal relationships between the oil price and the India-US exchange rate. In this line, we first use time-series tests, as multi-horizon Granger-causality tests [29], non-linear Granger-causality tests [30,31], and asymmetric Granger-causality tests [32]. Second, we employ the frequency-domain Granger-causality test proposed by Lemmens et al. [33], and the Markov regime-switching VAR (MRS-VAR) to account for regime-switching in the Granger-causal relationship. Finally, we combine the Hatemi-J [32] and Dufour et al. [29] methodologies, in order to see if the asymmetric Granger-causal relationship is instantaneous or gradual.

Another contribution of the present paper resides in the analysis of the particular case of India, which had in place a managed float exchange rate regime starting with 1975 (the pre-reform period), and introduced the Liberalized Exchange Rate Management System (LERMS) in March 1992 (the post-reform period). According to the Energy Information Agency (EIA) statistics, India recently became the fourth largest consumer of oil and petroleum products, and also the fourth largest importer. Between a wide range of oil suppliers, Nigeria stands as the main supplier at the moment, followed by the Saudi Arabia. India's crude oil imports cover a basket of three varieties – Brent, Dubai and West Texas Intermediate (WTI). Given this composition, even if one of the three varieties experiences sharp increases in prices, the overall price of the basket does not get affected to the same extent. Consequently, when studying the oil price – exchange rate nexus, it is useful to refer to all the benchmarks, as we do in this paper, using the International Monetary Fund (IMF) statistics. We also focus on India because its dependence on oil imports has been growing rapidly in the recent years, creating a huge trade deficit. At the same time, the trade deficit can also widen due to the Rupee's appreciation vis-à-vis other major currencies (i.e., the US Dollar). In this context conducting adequate energy policies is highly important for the Indian government.

Finally, the results we obtain represent by their own a distinct contribution of this paper to the existing literature, as they allow the comparison of the oil prices – exchange rate nexus over two exchange rate regimes. Different from other studies with a focus on India, we discover a significant Granger-causality relationship between oil prices and the Rupee-US Dollar exchange rate, which is non-linear and bidirectional. In addition, this relationship manifests differently in the short and long run, and exists only in the post-reform period.

The remainder of the paper is organized as follows. Section 2 presents a brief review of the literature on the oil prices – exchange rate nexus. Information about the wavelet methodology and Granger-causality test in the CWT is given in Section 3. Section 4 describes the data. Section 5 presents and discusses the results while Section 6 concludes and draws policy implications for policymakers and traders.

2. The oil price – exchange rate relationship: literature review

There is a voluminous body of literature analyzing the causal relationship between the oil price and the exchange rate. A first strand finds evidence of unidirectional causal relationships, usually running from the oil price to the exchange rate [17,18,34]. Different from these studies, Zhang et al. [22] find that causality is running from the US Dollar exchange rate to the oil price and documents that the US Dollar depreciation is a key factor in driving up the international crude oil price. A second strand of research finds evidence of bidirectional Granger-causality between the oil price and exchange rates [35,36].

However, most of the previous studies analyze the oil price – exchange rate nexus in the case of developed countries, leaving small open economies and emerging countries outside the main research arena, with few exceptions (i.e., [37–40]). In line