



Nonlinear causality between crude oil price and exchange rate: A comparative study of China and India



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ABSTRACT

While several studies have examined the linear causal relationship between oil prices and exchange rates, little is known about the nonlinear causality between these two variables. The present paper tries to fill this research gap in the context of India and China. By applying the Hiemstra and Jones (1994) nonlinear Granger causality test to the VAR residuals, the study finds a significant bi-directional nonlinear Granger causality between oil prices and exchange rates in both countries. The findings suggest that the nonlinearity of oil price influences the exchange rate irrespective of the exchange rate regimes. Further, to check robustness, the persistence in the variance of oil price and exchange rate is taken into account using a GARCH (1, 1) model. While the results consistently hold in the case of India, with respect to China, a unidirectional causality runs from exchange rate to oil price. However, the oil price in China does not Granger cause exchange rate.

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1. Introduction

Oil, which is a vital form of energy, plays a significant role in the economic development of countries all over the world. The increasing demand for oil in developed and developing countries has led to a rapid increase in the price of oil. The growing demand for oil creates a pressure on the current balance of payments, particularly for oil-importing countries. The fluctuations in oil prices have both direct and indirect effects on the economy. The direct effect of rising oil prices impacts the production of goods and services. An increase in oil price increases the costs to produce goods and services in the economy, thereby increasing inflation. In turn, this higher level of inflation has a negative impact on the financial market through an insidious effect owing to the higher input prices as consumers can now purchase fewer goods, which leads to a decline in revenue and profit. Conversely, an increase in oil price also affects the wealth of the nation through the transfer of income from oil-importing countries to oil-exporting countries in the form of trade balance. The disequilibrium in trade balance then leads to fluctuations in exchange rates.

The sharp increase in oil prices and in their volatility are closely linked with the exchange rates in oil-exporting and oil-importing

countries, and the emerging countries, such as China and India, are exposed to this linkage. One-third of the world's incremental oil demand was consumed by China between 1995 and 2004, and China's consumption is expected to grow nearly threefold over the next 20 years.¹ Similarly, India is the fourth largest consumer of oil in the world. The Integrated Energy Policy (IEP) report, prepared by the planning commission of India, highlights that more than 70% of their demand for crude oil is met through imports. Thus, any fluctuation in the international oil price influences the real exchange rate and, in turn, affects other key macroeconomic variables. Similarly, the real exchange rate shock could lead to a variation in international oil prices. By avoiding large fluctuations in the exchange rate, both China and India maintain a stable, trade-weight effective exchange rate system to operate a high level of international trade and smooth the financial market. The effective exchange rate of India is based on the currencies of 36 countries. Similarly, with respect to China, the basket of currencies included in the effective exchange rate is the Australian dollar, Canadian dollar, Euro, Japanese yen, Korean won, Malaysian dollar, Russian ruble, Singapore dollar, Thai baht, GBP, and USD. The chief currencies that have been given the highest weight are the US dollar, the Euro, and the Japanese yen (Zhang et al., 2011).

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¹ See the US Energy Information Administration website.

There are a number of studies that document various channels through which the oil price significantly affects macroeconomic variables, such as gross domestic product, interest rates, money supplies, stock prices, and exchange rates (see, for example, Hotelling, 1931; Fried and Schultze, 1975; Dohner, 1981; Narayan and Sharma, 2011; Hayat and Narayan, 2011; Narayan et al., 2013; Narayan and Sharma, 2014). Hotelling (1931) finds that changes in interest rates alter oil prices through producer extraction decisions if oil in the ground has value. Dohner (1981) examines the linkage between energy prices, economic activity, and inflation and finds that higher oil prices have significant impact on inflation. Similarly, voluminous studies on the impact of oil price volatility on stock returns have been conducted by Narayan and Sharma (2011), Hayat and Narayan (2011), Narayan et al. (2013), and Narayan and Sharma (2014). Narayan and Sharma (2011), using the NYSE firm level data, show that the oil price has different effects on firm returns depending on the sector to which the firm belongs. Hayat and Narayan (2011) examine whether the demand and supply shocks explain the fluctuations in the oil stock in the USA. Narayan and Sharma (2014), using daily data from the NYSE, investigate whether the oil price affects stock return volatility. The result indicates that the effect of the oil price on firm return volatility is sector-specific and that for the majority of the firms, an increase in the oil price generally reduces stock return volatility.

Several studies also investigate the existence of a causal relationship between oil prices and exchange rates, but their findings are mixed. On the one hand, studies by Amano and Norden (1998), Chaudhuri and Daniel (1998), Chen and Chen (2007), Zhang et al. (2008), Lizardo and Mollick (2010), Benhmad (2012), and Tiwari et al. (2013) have reported that oil prices Granger cause exchange rates, while others (Benassy-Quere et al., 2007; Huang and Guo, 2007; Reboredo, 2012; Sadorsky, 2000; Zhang and Wei, 2010) have found that the movements in the exchange rates may Granger cause a change in the crude oil prices, thus explaining oil price movements. The pioneer studies by Krugman (1983a, 1983b) and Bloomberg and Harris (1995) have provided a thorough description of the movements of exchange rates and oil prices. According to their studies, the weakening of the US dollar relative to other currencies, *ceteris paribus*, encourages international buyers to pay more US dollars for oil, thus supporting the contention that changes in exchange rates impact oil prices.

On the basis of the findings from the literature, this paper examines whether there is a nonlinear causality between crude oil price and exchange rate in two of the leading emerging economies—India and China. Although most empirical studies dealing with causality focus on a linear relationship, given the growing evidence on the nonlinear dynamic of oil prices and exchange rates along with other financial time-series indicators, there has been an increasing interest in nonlinear causality based on time series. There are several prominent studies where some authors argue that the traditional Granger causality test, designed to detect linear causality, is ineffective in uncovering certain nonlinear causal relationships and thus recommend the use of nonlinear causality tests (Baek and Brock, 1992; Bell et al., 1996; Benhmad, 2012; Chen et al., 2004; Diks and Panchenko, 2005; Hiemstra and Jones, 1994; Hiemstra and Kramer, 1997; Li, 2006; Péguin-Feissolle and Teräsvirta, 1999; Péguin-Feissolle et al., 2008; Skalin and Teräsvirta, 1999; Wang and Wu, 2012).

There are four important factors presented in this paper that are worthy of attention. First, both countries are leading emerging economies, and the demand for crude oil in these countries has increased sharply in comparison to that of the United States, which is also ranked in the field of global oil consumption. The statistics show that the demands for oil in China and India have been continuously rising. In China, the demand for oil increased from 4795.715 barrels per day in 2000 to 10,276.83 barrels per day in 2012, and in India, it increased from 2127.438 barrels per day in 2000 to 3621.751 barrels per day in 2012. On the other hand, in the United States, the demand for oil

decreased from 19,701.08 barrels per day in 2000 to 18,490.21 barrels per day in 2012 (reference EIA database).

Second, though both China and India show similar patterns of overall growth performance, the two countries follow different exchange rate regimes. Both countries have attempted to benefit from the exchange rate by fostering exports-led growth. While India clearly moved away from fixed exchange rates as evidenced by the Reserve Bank of India (RBI) actively trading on the market to contain the volatility, China adopted the strategy of currency pegging. After being fixed to the US dollar for many years, China announced a shift from a fixed rate to a basket peg in July 2005. However, the renminbi remained *de facto* pegged to the US dollar (Patnaik and Shah, 2009; Shah et al., 2005). Therefore, it could be interesting to examine the causal relationship between oil prices and exchange rates of the two countries.

Third, though a large number of studies examine the causal relationship between oil price and exchange rate, only a minimal number of studies examine the nonlinear causal relationship between the two variables in the cases of China and India. Further, this study uses Hiemstra and Jones (1994) nonlinear causality test in the context of crude oil prices and exchange rates of India and China. The advantage of this test is that it has good size and power properties and does not require a specified *a priori* model. Hence, this test is widely applied in economics and financial literature (Abhyankar, 1998; Ajmi, 2013; Asimakopoulos et al., 2000; Huh, 2002; Li and Shukur, 2010) for exploiting the nonlinear causal relationship in the time series analysis.

Last, earlier studies that used Granger causality test for examining the causal relationship between the two series observed the ignorance of a common informational factor—the volatility effect—that leads to misleading results (Asimakopoulos et al., 2000). Similarly, the studies by Benassy-Quere et al. (2007), Amano and Norden (1998), Chaudhuri and Daniel (1998), Chen and Chen (2007), Olomola and Adejumo (2006), and Lizardo and Mollick (2010) have assumed that the relation between oil price and exchange rate is linear. This study examines nonlinear causality between oil price and exchange rate using a GARCH (1, 1) model for capturing the common informational factor.

The remainder of this paper is structured as follows. Section 2 presents the importance of linkage between oil price and exchange rate. Section 3 briefly describes the methodology used in the study, while Section 4 presents the data and Section 5 discusses the results obtained from the data analysis. Section 6 offers the conclusion.

2. Linkage between oil price and exchange rate

It is essential to study the linkage between oil price and exchange rate for two reasons. First, the price of oil is one of the major determinants for terms of trade. Amano and Norden (1998) specify a simple model by identifying two sectors for tradable and non-tradable goods. Both the tradable input (oil) and a non-tradable input (labour) are used in each sector. The output price is fixed internationally, and the real exchange rate is identified in relation to the output price in the non-tradable sector. A fall in the labour price would lead to a rise in the oil price to meet the requirement for competition in the tradable sector. If the tradable sector is less energy intensive than the non-tradable sector, its output price rises and so does the real exchange rate. The opposite applies if the tradable sector is more energy intensive than the non-tradable sector. Therefore, the oil price shock depends on the oil intensiveness of both the tradable and non-tradable sectors in all countries under review.

The second strand is noted by Krugman (1980) and Golub (1983) through balance of payment. They posit that an increase in oil prices leads to a shift in wealth from oil-importing countries to oil-exporting countries, and the impact of this shift on the exchange rate depends on the portfolio preferences of oil-importing countries in the short run. However, in the long run, the exchange rate depends on the countries' import preferences. They further find that oil-exporting countries, typically OPEC countries, have a strong preference for dollar

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