Resources Policy 51 (2017) 219–224

Contents lists available at ScienceDirect

Resources Policy

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

On the nonlinear relation between crude oil and gold

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ARTICLE INFO

Keywords:
Oil
Gold
NARDL
India

ABSTRACT

We examine the causal relation between oil and gold prices in the Indian context using the Hiemstra and Jones (1994) nonlinear Granger causality tests and nonlinear ARDL tests. The oil prices linearly Granger causes the gold prices in both short- and long-run. The results of Hiemstra and Jones (1994) nonlinear Granger causality test show a strong evidence of bidirectional nonlinear relation between oil and gold prices. The results of the nonlinear ARDL test reveal that positive shock in oil prices has more pronounced effect than negative shocks on gold prices. In the long-run, the relation between oil and gold prices is stickier towards upper side which emphasizes that gold prices are relatively more sensitive to increasing oil prices. We therefore conclude that the interactive mechanism between oil and gold prices is nonlinear and asymmetric.

1. Introduction

Recent co-movements in oil and gold prices have attracted the attention of academicians and practitioners given that these two are considered to be strategic commodities (Jain and Biswal, 2016). The price movements of oil and gold have important implications for financial markets and the economy as a whole due to their huge tradability and high liquidity (Tiwari and Sahadudheen, 2015). The volatility and impact of oil and gold prices has become invariably crucial for the economic development of all countries across the globe. The increase in the demand of oil in both developed and emerging countries has made it an indicator for all price trends and essential for production processes (Bildirici and Turkmen, 2015). Moreover, price changes in gold and crude oil market influences the price trends of the commodity markets. Therefore, it is important to understand the relationship between oil prices, gold markets and the overall economy (e.g., see, Herrera and Pesavento, 2009; Basher et al., 2012; Bal and Rath, 2015).

The positive co-movement between oil and gold prices can be explained through various channels, firstly, inflation channel (Narayan et al., 2010). They argue that the rising oil prices increase the cost of production of goods and services in the oil-importing economy, hence, increasing inflation. Moreover, gold has been identified as an effective and unique tool against inflation, such that an increase in oil prices lead to increase in gold demand (Bampinas and Panagiotidis, 2015; Van Hoang et al., 2016). Therefore, gold prices move up in an inflationary environment, and a positive relation between oil and gold prices is observed (Tiwari and Sahadudheen, 2015). A second explanation involves how oil prices affect the economic growth and asset values (Reboredo, 2010). Rising oil prices negatively impact the economic growth and lead to reduction in asset prices, forcing investors to buy gold as an alternative at least to store some asset value (Reboredo, 2013). A third explanation for the oil gold relation was given by Melvin and Sultan (1990) who show a strong correlation between oil and gold through the export revenue channel. When the oil prices, hence revenues, rise, the oil-exporting countries increase the proportion of gold in their portfolio for diversification benefits. Such an increase in demand for gold during rising oil prices leads to increase in gold prices. All these explanations support the argument that oil and gold prices follow similar behavioral patterns.

In this paper, we aim to analyze the cointegration and causal relation between oil and gold prices in India. Our study would extend the literature in several ways. *First*, in contrast to the studies mentioned above, we argue that the relation between oil and gold may be mis-specified since the traditional causality tests assume a linear relation between the variables (Hiemstra and Jones, 1994; Benhmad, 2012; Wang and Wu, 2012). Such models may no longer be suitable due to the increasing tendency of commodity prices to behave like financial assets (Jain and Biswal, 2016). Moreover, in the post 2008 global financial crisis period, the oil and gold prices have shown extreme fluctuations (see Fig. 1). The nonlinear relation between gold and oil could arise due to the effects of economic

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http://dx.doi.org/10.1016/j.resourpol.2017.01.003
Received 19 August 2016; Received in revised form 3 January 2017; Accepted 3 January 2017

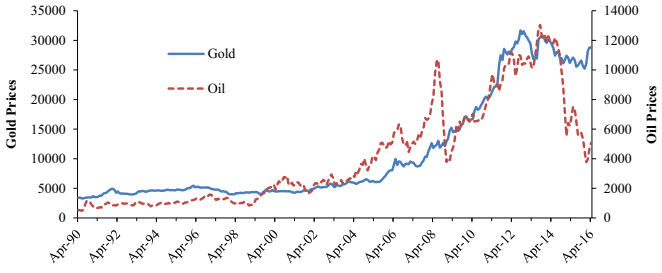

Fig. 1. The time-series of oil and gold prices.

conditions which lead energy commodities and other precious metals to exhibit a nonlinear behavior over time[1] (Bildirici and Turkmen, 2015). All these factors may lead to structural breaks causing unexpected and asymmetric behavior of macroeconomic variables, thereby violating the linear trends. Therefore, the prices of oil and gold are expected to exhibit a nonlinear and more complex behavior than otherwise assumed in other studies.

Secondly, to achieve our objective of studying the nonlinear relation between oil and gold prices, we make use of Hiemstra and Jones (1994) and a novel nonlinear autoregressive distributed lags (hereafter, NARDL) model. The advantage that Hiemstra and Jones (1994) test offers is that it contains good size and power properties, and does not depend upon *a priori* specified model. This test has been widely used in financial and economics literature to examine the nonlinear relationships in time-series analysis (Asimakopoulos et al., 2000; Huh, 2002; Ajmi et al., 2015). We also incorporate the NARDL to examine the causality between oil and gold prices as a measure of cross checking the robustness of the results. NARDL is a bound testing approach developed by Shin et al. (2014) which allows testing the long-run and short-run asymmetries in the variables and is robust to small sample sizes. Additionally, unlike standard cointegration techniques, NARDL is flexible to different orders of integrations in the time-series (Shin et al., 2014).

Thirdly, unlike most of the previous research, which mainly concentrate on the United States or the European countries, we analyze this relationship in the Indian context. The case of India is unique in that India has been an important player in the world oil and gold market. Recently, India has replaced Japan to become the third largest oil importer after the United States and China.[2] Moreover, India is the largest consumer of gold, with 642 t of gold consumption in first nine months of 2015.[3] In 2013–14, the import of crude oil and gold in India accounted for almost 44% of the total import bill. In effect, gold is the second commodity after crude oil which contributes significantly to worsening the current account deficit (CAD) in India (Kanjilal and Ghosh, 2014). Given such a large and significance presence of India in the international oil and gold markets, it seems pertinent to understand the effects of crude oil price movements on the gold prices in the Indian context.

Finally, our next important contribution is that we consider gold prices in terms of Mumbai gold prices instead of those from London converted to Indian rupee (INR). Most of the studies mentioned above have considered gold prices from London or New York which are quoted in the US dollars. For studies which consider other countries (e.g., Japan and Germany), gold prices in London converted into the local currency are used (Wang et al., 2011). This choice of gold prices data may provide misleading results since gold prices quoted in London do not necessarily reflect the actual situations of the local gold markets (Van Hoang et al., 2016). In our data, we observed huge spreads in the gold prices between those in Indian rupees and those converted to Indian rupees from the London market.

The rest of the paper is organized as follows: Section 2 discusses the data, Section 3 provides the methodology used in the paper, and Section 4 presents the main empirical results for the linear and nonlinear relation between oil and gold prices. Section 5 concludes the paper.

2. Data description

The data on oil price is obtained from International Monetary Fund (IMF) database (Series Code: POILAPSP Index) with 2005 as the base year. The crude oil (petroleum) is the simple average of three spot prices; Dated Brent, West Texas Intermediate, and the Dubai Fateh. The crude oil price is measured in terms of dollars per barrel. Therefore, to convert the oil price in Indian rupee (INR), USD-INR exchange rate has been used, which is taken from the Reserve Bank of India (RBI). The gold price has been taken from RBI in terms of Rupees per 10 g (Mumbai gold price). We use the monthly data from April 1990 to April 2016. The choice of the sample period is dependent upon the data availability. All time-series data have been converted in log returns as $R_t=ln\ (p_t/p_{t-1}) \times 100$, where R_t is the return, p_t is the current price and p_{t-1} is the price one period before for both the variables considered.

Fig. 1 shows the movement of monthly gold prices and oil prices. Until 2003–04, the ups and downs in the oil prices were fairly stable. The oil prices reached a peak just before the global financial crisis and fell down rapidly soon after. However, the prices started rising again after the crisis and have been falling heavily in the recent times. The gold prices have been showing a consistent increase 2004–05 onwards with minor downward movements in the latest part of the sample.

3. Methodology

3.1. Nonlinear Granger causality test - Hiemstra-Jones test

Prior to examining the nonlinear evidence, we first look into the linear causality between oil prices, and gold prices in India. Granger (1969) introduced a causality test through which this paper examines whether oil prices and gold prices have forecasting ability for each other. We estimate the following bivariate vector autoregression (VAR) model based on the error-correction approach:

$$X_t=\alpha_0+\sum_{i=1}^{n}\alpha_{1,i}Y_{t-i}+\sum_{i=1}^{n}\alpha_{2i}X_{t-i}+\alpha_3 ECT_{t-1}+\varepsilon_t \quad (1)$$

$$Y_t=\beta_0+\sum_{i=1}^{n}\beta_{1i}X_{t-i}+\sum_{i=1}^{n}\beta_{2i}Y_{t-i}+\beta_3 ECT_{t-1}+\mu_t \quad (2)$$

where, X_t and Y_t are the proxies for changes in crude oil prices (ΔOIL), and changes in the gold prices (ΔGOLD). ECT_{t-1} is the error correction term lagged one period. The Granger causality method tests the hypothesis H_0: $\alpha_1=0$ which means Y_t does not linear Granger cause X_t. Similarly, another hypothesis is H_0: $\beta_1=0$ according to which X_t does not linear Granger cause Y_t.

The Granger-causality approach assumes that the relations are linear such that it fails to capture the nonlinear causal relations. Therefore, to test for nonlinear Granger causality between oil and gold prices, we use a modified version of the Baek and Brock (1992) nonparametric technique developed by Hiemstra and Jones (1994). For further illustration of the test, we consider the following two time series X_t and Y_t (as defined above) which are strictly stationary and weakly dependent. Assume that l-length lead vector of X_t is shown by

[1] Such macroeconomic conditions could include economic crises (for example, the 1970s crisis, OPEC decisions, the balance of payment crisis in India in 1991, the burst of the dot-com bubble in 2001, exchange rate mechanism crisis, 1997–1998 Asian crisis and the recent 2008 global financial crisis), wars and other extreme geopolitical events (such as ISIS emergence) involving the oil exporting and importing nations, oligopolistic behavior in oil production and distribution, or the structure of oil market competition.

[2] The International Energy Agency predicts that India will burn through 4.1 million barrels per day (mb/d) in the second quarter of this year, edging out Japan's 3.8 mb/d.

[3] GFMS Gold Survey Q3, 2015 Review and Outlook.