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# Nonlinear causality between oil and precious metals

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ABSTRACT

This work aims to analyze the cointegration and causality relationship among oil and precious metals of gold, silver and copper by using nonlinear ARDL and two popular nonlinear causality tests; Hiemstra and Jones (1994), and Kyrtsou and Labys (2006) test for the period from 1973:1 through 2012:11 monthly. According to the asymmetric Kyrtsou and Labys test (2006) results, an interesting finding emerges; precious metal prices returns respond nonlinearly to shocks to changes in crude oil prices only at earlier lags. Symmetric case results imply that there is evidence for bidirectional causality between pairs of oil and gold price and oil and silver price. Moreover a unidirectional relationship emerge for oil and copper prices for the asymmetric positive case and no causality for other cases. According to Hiemstra and Jones causality test, bi-directional causality between gold and oil and copper and oil and a unidirectional Granger causality running from oil price to silver price have emerged. In this way, asymmetric Kyrtsou and Labys (2006) results and Hiemstra and Jones (1994) results are different. Although the tests do not provide consistent results for the considered commodities, it can be concluded that, our models grasped the nonlinear nature in the price discovery process, hence partially captured the nonlinearity between oil and gold markets and their important role in macroeconomy.



## 1. Introduction

Oil and precious metals like gold, silver and copper are strategic commodities which volatility of their price has received much attention. Crude oil is maybe the most strategic commodity, probably is an indicator for all price trends and vital for production processes. On the other hand, the price movements in gold and crude oil have an impact on changing the price trends of the whole commodity markets. In this way, investigating their relationship over price discovery helps to provide some information for both forecasting the crude oil price, the gold price and the potential effects on commodity markets.

The volatility and influence of oil and gold price has become increasingly crucial for world economic development. The volatility of the precious metal prices depends on the rise-and-fall of the oil and gold price and sudden increase of oil price causes economic slowdown and increases of other commodity prices. Moreover, increase of oil price can be thought as a tax levied from oil exporting countries to oil consumers.

Additionally, gold has been an important precious metal for many centuries, and it plays a role as a means of store of value especially in periods of political and economic instability. There is an evident advantage and outstanding position of gold. The role of the gold market in the large commodity market has received increasing attention by both academic world and real sector. As it will be mentioned in detail at subsequent sections, gold remains as a safe haven especially considering the remarkable fluctuations in oil price, such as first and second oil price crisis and 2006 oil price shock. During I. and II. oil crisis, gold prices have increased significantly, followed a relatively flat pattern till 2005 and began to rise afterwards[1]. It should be noted that, oil prices has also faced with price increases at that period.

This work aims to analyze the cointegration and causality relationship between oil and precious metals by using nonlinear ARDL (NARDL) and two causality tests, namely; Hiemstra and Jones test (1994), and Kyrtsou and Labys (2006) test by Mackey Glass model. The main reason beneath using two different

[1] The main difference between 2006–2007 oil price shock and earlier oil price shocks lies in the cause of the shocks. While the previous shocks are caused by physical supply limitation, the 2006–2007 crisis was caused by strong demand due to "Global Modernation Era". In 1970s energy crisis, the major industrialized countries faced with oil shortages caused by interruptions in oil exports from Middle East due to political reasons such as the oil embargo against Israeli military or the Iranian revolution. Although the causes were different, the economic results were similar, such as decreases in consumption spending and demand in automobile and related industries.

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nonlinear causality tests, as it will be brought up in subsequent sections, is for a cross check for the results.

This study primarily focuses on the use of nonlinear models; the main reasons for this can be stated as follows. Due to the effects of economic circumstances, energy commodities and most of precious metals exhibit a nonlinear behavior over time, like an economic or financial variable. Hence, their interaction among them is also nonlinear. The theoretical and empirical roots of this nonlinear behavior may rely upon the fragibility of macroeconomic variables may possibly be caused by economic crises (e.g., 1970s crisis, OPEC decisions, ERM Crisis, 1994 Russian Crisis the 1997–1998 Asian Crisis, the 2008–2010 global financial crisis), wars and other geopolitical extreme events effective in supplier or demander nations (e.g. first and second oil price shock and 2006 oil price shock, the Arab Spring, increasing ISID terrorism), oligopolistic behavior in refinery and redistribution, production lags, and the structure of market competition. All the aforementioned factors may generate structural breaks, cause unexpected and asymmetric responses in the behavior of economic agents, hence distorting the "linear" world. Under these circumstances, the prices of the strategic economic commodities, namely oil and precious metals, are expected to exhibit a more complex behavior than a simple and stable relationship.

According to the linear ARDL model and the traditional Granger causality testing procedure; series are assumed to be linear. As stated in Anoruo (2011), one of the shortcomings of the linear causality tests is that they are unable to detect non-linear relationships whether it exists. As mentioned above, macroeconomic data in the real world follow a pattern with breaks and in addition to this, oil and gold prices follow a nonlinear pattern. Combining this structure with the additional reasons mentioned above, we will use nonlinear models; ARDL and non-linear causality tests.

The second part of the work is comprised of literature, the relationship among variables is given in the third part. Fourth section is devoted to the data and econometric methodology. While econometric discussion is the fifth section of the paper, the last part is the conclusion.

## 2. Literature

Baur and Tran (2012) and Escribano and Granger (1998) analyze the long run relationship between gold and silver prices. Baur and Tran (2012) analyzed a sample period from 1970 to 2010 and examine the existence and stability of a long run relationship by following Escribano and Granger (1998). Escribano and Granger (1998), by using monthly data from 1971 to 1990, found cointegration has occurred during some periods and especially during the bubble and post bubble periods. In addition to that, Baur and Tran (2012) studied the role of bubbles and financial crises for the relationship between gold and silver.

Morales and Andreosso-O'Callaghan (2011) found that gold dominates precious metals for volatility spillover. Sensoy (2013) investigated the dynamic relationship among four precious metals, namely; gold, silver, platinum, palladium, between 1999 and 2013. According to his findings, gold shows a unidirectional shift contagion effect on other precious metals, in addition to this; silver has a unidirectional shift contagion effect on platinum and palladium.

Cochran et al. (2012) found that, following the 2008 crisis, the volatility of gold platinum and silver returns have increased. Their finding is inconsistent with the study by Vivian and Wohar (2012) who did not find any exceptional volatility increase during the crisis.

Cashin et al. (1999), Hammoudeh and Yuan (2008), Lescaraoux (2009) Soytas et al. (2009), Sari et al. (2010), Narayan et al. (2010), Zhang and Wei (2010), Šimáková (2011), Wo and Hui (2012), Hsiao et al., (2013) and Naifar and Dohaiman (2013) are other studies that examine the relationship among gold and oil.

Cashin et al. (1999), by using the data of seven commodities among 04.1960 and 11.1985, found a significant correlation between oil and gold.

Hammoudeh and Yuan (2008), by examining the volatility behavior of three metals: gold, silver and copper; found that oil shocks had calming effects on precious metals excluding copper. Lescaroux (2009), investigating the correlations among crude oil and precious metals, states, most studies report that they tended to move together.

Sari et al. (2010) particularly concentrates on the impact of oil price shocks over gold, silver, platinum and palladium by using the data of U.S. over 01.1999-10.2007. He found a weak asymmetric relationship among gold and oil prices. On contrary to this result, Soytas et al. (2009) investigated the long run and short run impacts of gold and silver prices on oil price. The linear causality approach of Toda-Yamamoto is applied to the data between 05.2003- 03.2007 but no causal relationship can be found.

Narayan et al. (2010) examine gold and oil spot and future markets, concluding that; gold is a hedge against inflation and oil market can be used to predict gold market bi-directionally.

Zhang and Wei (2010) investigated the causality between crude oil and gold market over the period January 2000 and March 2008. They found out a consistent trend between crude oil and gold price. Oil price linearly Granger causes the volatility of gold price but changes in gold price do not linearly cause oil price volatility.

Šimáková (2011) focuses on the relationship between oil and gold prices. The existence of long run relationship between variables is shown by using Granger causality test, Johansen cointegration test and VECM.

Wo and Hui (2012) examine the nonlinear dynamic relationship among USD/yen, gold futures, VIX, crude oil and several stock indexes. According to their findings, the role of gold is determined according to crude oil price. From this aspect; as the price of crude oil is low, gold exhibits the hedging function; when price of oil is high, gold is both a hedge and safe haven for developing countries.

Hsiao et al., (2013) investigated the correlation among oil prices, gold prices and exchange rates over the period between 09.2007 and 12.2011. They conclude that the variables are considerably independent.

Naifar and Dohaiman (2013) tested the nonlinear structure of oil prices by using several econometric methods and stressed the explanatory power of linear models. They compare and contrast linear models with regime switching models over the criteria of linear models' stationary distributions versus regime switching models' combinations of parametric distributions whose probabilities depend on unobserved state variables.

Shortly, most of the studies explaining the link between gold and oil prices use inflation channel. As oil price rises, it leads to an overall increase in prices. The overall uncertainty at financial markets leads economic agents to buy gold as a hedging instrument. Hence, this explains the safe haven motivation.

## 3. Co-movement of oil and precious metals

Volatility of oil and gold prices are important due to both their impact on each other and other metals. Oil prices, as stated in the introduction, fluctuate depending on many variables. Fluctuations in oil prices affect precious metals. In this context, gold can be ascribed a special place in precious metals.

Gold is one of the most important precious metals that contain all the roles as a store of value and means of exchange. With these characteristics, gold is seen as a safe haven, especially in times of