Gold, Oil and the Euro: Are These Markets Inter-Related?

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Abstract. This paper offers first a rapid review of the markets for oil, gold and the euro prior to the last eight years. During this time oil and gold markets had limited inter-relationships. Since the euro did not exist prior to 1999, it did not play any role. During the past eight years, the three markets have moved together. This paper analyzes the inter-relationships among these using standard time series methodology to conclude that the US dollar weakness as measured by the euro and fears of future inflation as measured by the price of gold both have influenced the price of oil.

JEL Classification: C12, C22, F33
Keywords: Gold, Oil, Euro, Time series, Commodity markets, Currency markets.

1. Introduction

This paper studies the inter-relationships between three important markets: gold, oil and the euro. Numerous studies have analyzed the relationships between oil and its impact upon the U.S. economy. The traditional line of argument goes like this: crude oil prices influence several energy related products such as gasoline, heating oil and natural gas that in turn impact the producer price index, the consumer price index and other inflation indexes. Since inflation is a fundamental topic, economists have studied extensively not only how to control inflation via monetary and fiscal policies but also how to hedge against it. A long standing hypothesis claims that gold is a potential hedge against inflation.

In section 2 we briefly review some of the key lines of research, primarily for gold and oil since these two markets have a long history. We also present a graph of a synthetic euro. This brief review offers a contrast to recent developments. Past evidence suggests that gold has played the longest and most influential economic role in economic history during the last 150 years since it anchored the British pound as a global currency. Oil emerged as a significant economic force in the early and mid-1970s and its influence remains substantial to date. In contrast to both gold and oil that have played significant economic roles for a long period, the euro was created on January 1, 1999 and, in a relatively short period of nine years since its creation, is challenging the U.S. dollar for global currency leadership. Of course, one can synthetically create a euro by assigning appropriate weights to the German deutschemark, French franc and the other currencies that were replaced by the euro and thus study the role of these currencies since the end of World War II. This we do in a graph to follow to give some perspective of the euro.

In section 3 we introduce the hypotheses of this paper, namely that the relationship between gold, oil and the euro has changed during the recent eight years. In particular we observe that the depreciation of the US dollar against the euro has generated fears of global inflation for countries that peg their currency to the dollar and induced oil producing countries to demand compensation for their resources in general and for oil in particular. In turn, such appreciation of commodities, and oil in particular, fueled increases in the price of gold.

Section 4 describes the data used. Section 5 reports the results of tests for randomness and cointegration. Then in section 6 we discuss the inter-relationships of the three variables in a forecasting and neural network framework. Section 7 summarizes the key findings.

2. Brief Review of the Literature

Eichengreen (1992) and Bordo, Dittmar and Gavin (2007) have presented various aspects of the role of the gold standard as a global monetary system. These studies document the role of gold in preserving price stability. When economists discuss the classical gold standard as a monetary system that has been associated with price stability, the emphasis is always in the long run. Figure 1 illustrates this property of the gold standard. Short-term price variability occurred very often, mostly due to real shocks to the economy but the advantage of adhering to the gold standard with the slow growth of gold output ensured overall long-run price stability. The main disadvantage of the gold standard was its cost in terms of constraining real economic growth.

Independent of anchoring the global monetary system on gold, after August 15, 1971, the metal ceased its association with global monetary matters but maintained its property as an indicator of inflation. Diba and Grossman (1984) have investigated empirically whether the price of gold exhibits rational bubbles. They concluded that the empirical analysis finds a close correspondence between the time series properties of the relative price of gold and the time series properties of real interest rates. Theoretically, real interest rates are a proxy for the fundamental component of the relative price of gold. The authors conclude that the evidence is consistent with the combined hypothesis that the relative price of gold corresponds to market fundamentals, that the process generating first differences of market fundamentals is stationary, and that actual price movements do not involve rational bubbles.

Figure 2 illustrates the price of gold since 1982. We can observe that from 1982 to 2005, which is most of this period, the price fluctuated between $250 and $500. However, during the past 3 years the price of gold has skyrocketed to over $1,000. Can we say that such an increase foretells great future inflation or has gold's property of being a hedge against inflation been replaced by some other property?

With regard to oil, we are here interested in the price fundamentals. Elekdag, Lalonde, Laxton, Muir and Pesenti (2008) develop a five-region model of the global economy and consider various scenarios to study the implications of different shocks driving oil prices worldwide. The model introduces significant real adjustment costs in the energy sector, making both the demand and supply for crude oil extremely inelastic in the short run, thus requiring large movements in crude oil prices to clear the energy market.

Figure 1:

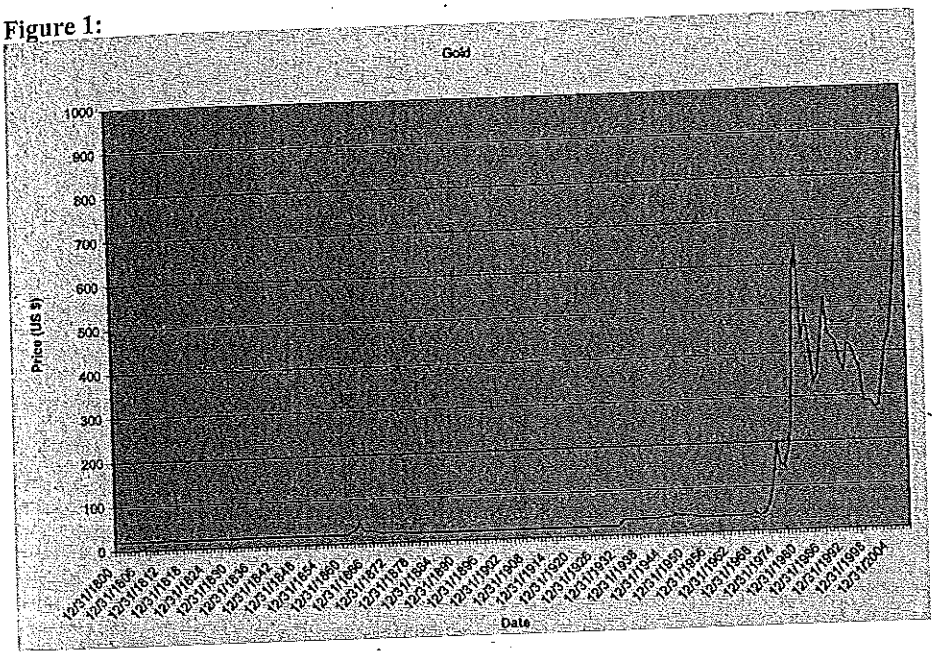
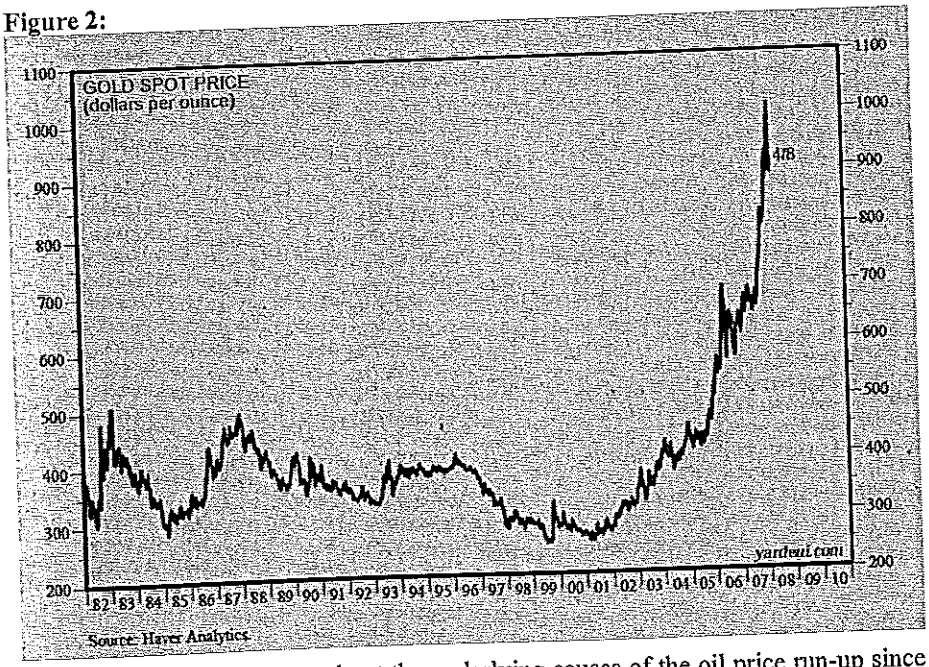


Figure 2:



To answer the question about the underlying causes of the oil price run-up since 2003, the authors offer a story based on stronger productivity growth in oil importing regions coupled with shifts in oil intensity in production (emerging Asia), and (to a much lesser extent) pure price increases by oil producers. Oil price shocks stemming

from higher growth in the oil-importing regions are accompanied by wealth transfers through terms-of-trade movements, leading consumption to grow slower than output in the oil-importing regions. In the medium term, high investment rates in the high-growth regions crowd out investment in the oil-exporting regions. These results need not hold if higher oil prices bring about expectations of a larger availability of oil reserves in the future. Moreover, the positive effects of higher oil prices on consumption need not translate into reduced current account surpluses in the oil-exporting regions, to the extent that they are accompanied by an upward shift in the desired net foreign asset positions. The conclusions about the role of increased productivity in the oil-importing regions can be reinforced by considering emerging Asia in particular, with its increased intensive use of oil in the production of tradable goods.

In this paper we consider the question: Are increases in the prices of oil related to the appreciation of the euro and/ or gold? With respect to the euro, in a matter of a few years, a very large bibliography has emerged that describes the creation of this new global currency and its relative success. Portes and Rey (1998) offer a comprehensive background of the monetary history of the emergence of the euro while Chinn and Frankel (2005) and Eichengreen (2007) speculates on euro's future emergence as a competitor to the U.S.dollar. Figure 4 shows the Euro exchange rate from 1980 through 2007. A line demarcates the introduction of the Euro in 1999. Data from 1980 to 1999 are artificial. This graph illustrates how the euro initially weakened from 1999 to 2001, but since 2003 has strengthened considerably against the U.S. dollar. The same graph illustrates that if an artificial euro were to be constructed primarily based on the performance of the German mark, the current strength of the euro could be put in a much better perspective.

3. Hypothesis

This rapid review of the literature illustrates that gold and oil have played important roles and have been studied essentially independent of one another. Gold has served as the anchor of the Global Monetary System known as the Gold Standard. Since the introduction of the euro and in particular during the past few years, the euro, gold and oil appear to be interrelated. We claim here that the weakness of the U.S. dollar as measured by the appreciation of the euro from about $.80 per euro to $1.55 per euro has partially driven both the price of oil from about $20 per barrel to $110 and the price of gold from about $300 to over $1,000.

Figure 3:

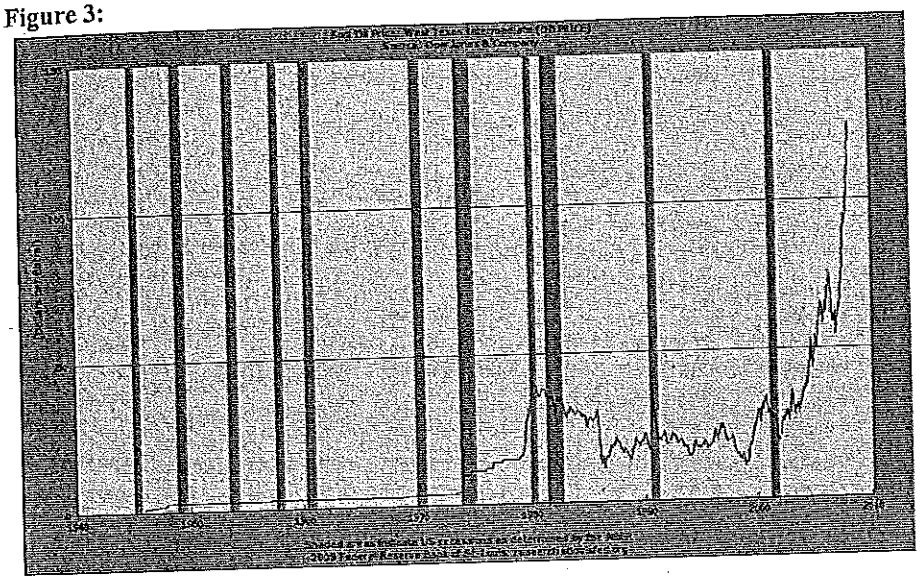
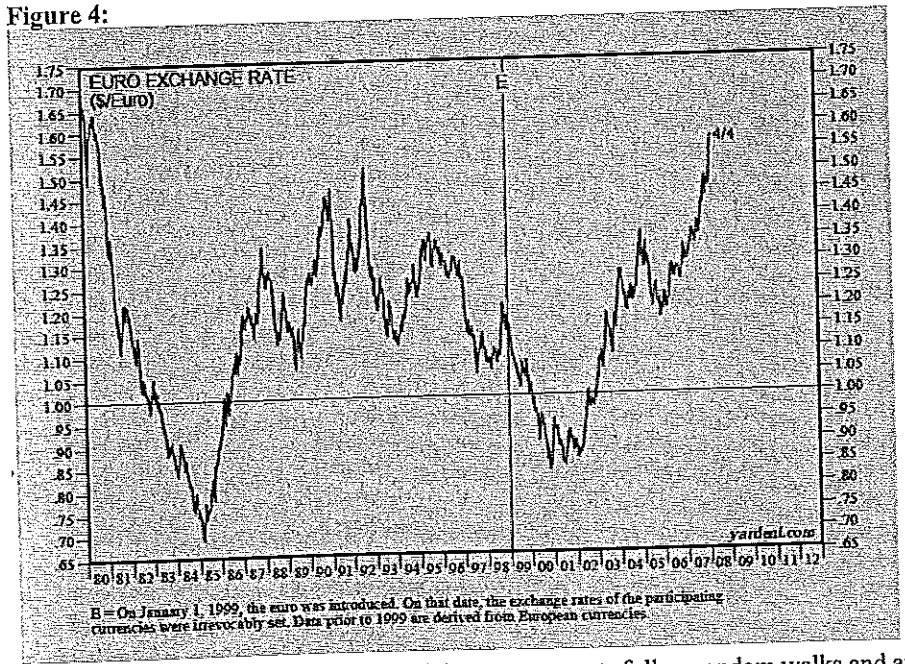


Figure 4:



E = On January 1, 1999, the euro was introduced. On that date, the exchange rates of the participating currencies were irrevocably set. Data prior to 1999 are derived from European currencies.

In particular we argue that oil, gold and the euro as assets follow random walks and are cointegrated.

4. Data and Methodology

We use daily cash prices for gold, oil, and the euro. The data sample covers the time period from January 4, 2000 through December 31, 2007 and was downloaded from BarChart. There are a total of 1,991 observations for prices for each of the three daily closing prices.

The hypothesis stated above is tested with augmented Dickey and Fuller tests of stationarity and tests of cointegration. Brief descriptions of these methods follow. Figure 5 shows the natural logarithm of the three data series.

4.1 Test of Stationarity

The stationarity of price is tested with the augmented Dickey and Fuller (ADF) (1979), test:

$$X_t - X_{t-1} = b_0 X_{t-1} + \sum_{i=1}^{T} b_i \left(X_{t-i} - X_{t-i-1}\right) + \varepsilon_t \quad (4)$$

where X_1 represents the logarithm of the price of the appropriate variable and is called the level of the variable. The null hypothesis of non-stationarity is $b_0 = 0$. If the null hypothesis cannot be rejected for the level of the variable but is rejected for the first difference, then the variable is stationary in the first difference and it is said that the variable is integrated of order 1, denoted by I(1). Model (1) can be extended to include a constant and/or a trend as described in Table 1.

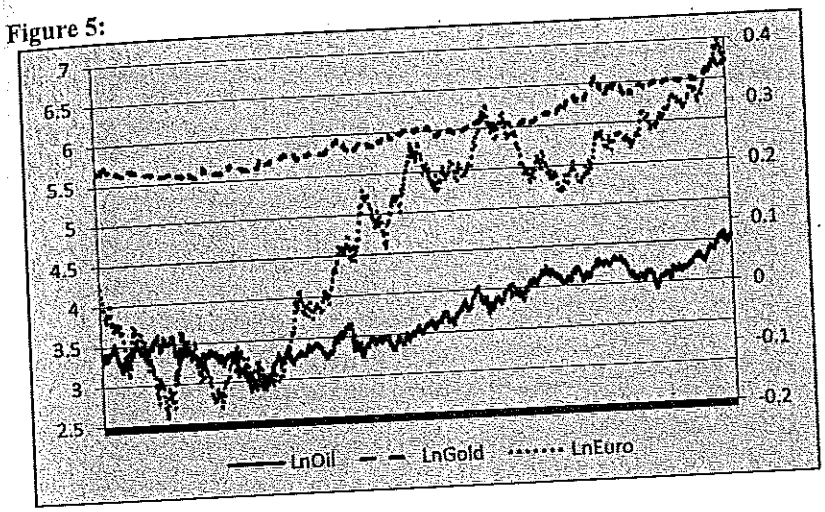
4.2 Tests of Cointegration

The idea that a variable in integrated can be extended to two variables and if both variables are integrated one may ask if they are cointegrated. Specifically, if two time series, Xt and Yt, are both nonstationary in levels but stationary in the first difference, it is said that variables, Xt and Yt, are I(1). If two variables, Xt and Yt, are both I(1), their linear combinations, $Zt = Xt - \alpha Yt$, are generally also I(1). However, if there is an α such as that Zt is I(0), then Zt is integrated of order 0 or stationary in level. If Zt is I(0), then the linear combination of Xt and Yt is stationary and it is said that the two variables are cointegrated. Cointegration represents a long-run equilibrium relationship between two variables. The intuition behind cointegration is that beyond the random walk followed by each variable such randomness preserves a relationship between the two variables.

Engle and Granger (1987) propose several methods to test for cointegration between two time series. This study follows the approach of first running the cointegration regression:

$$X_t = \alpha_0 Y_t + \varepsilon_t \quad (5)$$

Figure 5:



and then running the ADF regression

$$\varepsilon_t - \varepsilon_{t-1} = b_0 \varepsilon_{t-1} + \sum_{i=1}^{T} b_i \left(\varepsilon_{t-i} - \varepsilon_{t-i-1}\right) + \mu_t \quad (6)$$

on the residuals of (2). The null hypothesis of no cointegration is H0: b0 = 0. If the null hypothesis is rejected, then the variables, Xt and Yt, are cointegrated and there is some long-term relationship between them.

5. Analysis of Empirical Results

The results of our empirical testing are presented in Tables 1, 2 and 3. More specifically we have found the following.

First, the natural logarithms of the prices of oil, gold and the euro follow random walks. These random walks are of three types: a random walk with no constant and no time trend, random walks with a constant and a random walk with a constant and trend. We have also tested these three models with only one lag or several lags, the length of these lags having been decided by the Akaike criterion. While the log price levels of gold, oil and the euro follow three types of random walks, the hypotheses that their differences are also random walks is rejected in the lower level of Table 1. Thus we conclude that oil, gold and the euro are integrated of order one written as I(1).

In Table 2 we find that there is a long-term relationship between any two of the variables. In other words we find that the logarithms of the variables are cointegrated. The t-statistics indicate that in order of significance the relationship

Table 1[2]. Augmented Dickey-Fuller Tests of Stationary 2

Price Level (LN(X))

		Only Lags	Lags and Constant	Lags, Constant, and Trend
Gold				
	No lags	2.361111	0.667188	-2.836540
	5 lags	2.363708	0.693961	-2.843861
	20 lags	2.373704	0.766124	-2.862830
Oil				
	No lags	1.191509	-0.626496	-2.759707
	5 lags	1.313748	-0.461972	-2.541877
	20 lags	1.368074	-0.235474	-2.456710
Euro				
	No lags	0.631741	-0.079099	-3.034661
	5 lags	0.659061	-0.049944	-3.063701
	20 lags	0.521473	-0.293593	-2.657669

First Price Differences (LN(Xt) - LN(Xt-1))

		Only Lags	Lags and Constant	Lags, Constant, and Trend
Gold				
	No lags	-46.65579	-46.77877	-46.81729
	5 lags	-18.68709	-18.86720	-18.93417
	20 lags	-9.389532	-9.698579	-9.833956
Oil				
	No lags	-45.22329	-45.25046	-45.24871
	5 lags	-19.52137	-19.57521	-19.58983
	20 lags	-10.21073	-10.31103	-10.35710
Euro				
	No lags	-46.05127	-46.07716	-46.10367
	5 lags	-17.92471	-17.97228	-18.02022
	20 lags	-9.111516	-9.214248	-9.259299

between gold and oil is the strongest. This means that although the two markets appear to move together there is evidence that oil adjust to gold rather than vice versa. Secondly, oil and the euro have a longrun equilibrium relationship and each market adjust quickly to the other without any one market being the driving force. The weakest relationship is between gold and the euro with some minor evidence that increases in gold generate decreases in the value of the dollar which equivalent to increases in the euro. Combining these results we conclude that gold, oil and the euro follow longrun relationships in such a way that gold influences the price of oil and also oil is influenced by the value of the euro.

Table 2[3]. Engle and Granger Test of Cointegration of LN(Price) 3

Dependent Variable (X)	Independent Variable (Y)	b_0	t-stat
Gold	Oil	-0.009211	-2.920998
Oil	Gold	-0.010399	-3.122336
Gold	Euro	-0.003219	-1.723030
Euro	Gold	-0.003753	-1.950192
Oil	Euro	-0.006973	-2.584827
Euro	Oil	-0.006324	-2.512779

7. Conclusions

In this paper we first offer a review of the markets for oil and gold prior to the last eight years. This analysis demonstrates that the oil and gold markets had limited inter-relationships between them. Since the euro did not exist prior to 1999, it did not play any role. In contrast during the past eight years, the gold, oil and the euro markets have moved together. What appears to be significant is the impact of both gold and the euro in determining the price of oil with a further feedback from the price of oil to both gold and the euro.

8. Notes

1 Professor Mary Malliaris and A.G. Malliaris are professors at Loyola Univeristy of Chicago, Chicago, IL. We are thankful to Joko Mulyadi for data collection, bibliographical search and valuable computational assistance. An earlier version of this paper was presented at the Joint Athenian Policy Forum and the Indian Institute of Management Kozhikode Conference, Calicut, India, December 18-20, 2008. We are thankful to the Conference organizers and participants for their helpful comments and encouragement.

2 In Table 1, the model is:

$$\Delta X_t = a_0 + a_1 \cdot t + a_2 \cdot X_{t-1} + \sum_{i=1}^{T} c_i \cdot \Delta X_{t-i}$$

The null hypothesis is H0: a2 = 0 (variable is not stationary). The MacKinnon critical values for rejection of the null hypothesis of only lags are 1% critical value = -2.58, 5% critical value = -1.95, 10% critical value = -1.62. The MacKinnon critical values for rejection of the null hypothesis of lags and constant are 1% critical value = -3.43, 5% critical value = -2.86, 10% critical value = -2.57. The MacKinnon critical values for rejection of the null hypothesis of lags, constant, and trend are 1% critical value = -3.96, 5% critical value = -3.41, 10% critical value = -3.12.

[3] In Table 2, the model is

$$\Delta X_t = a_0 + a_1 \cdot t + a_2 \cdot X_{t-1} + \sum_{i=1}^{T} c_i \cdot \Delta X_{t-i}$$

The null hypothesis is H0: b0 = 0 (variable is not stationary). The MacKinnon critical values for rejection of the null hypothesis are 1% critical value = -2.58, 5% critical value = -1.95, 10% critical value = -1.62.

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