Oil prices and the US dollar exchange rate

Correlation or Causality

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Abstract: Because the U.S. imports large amounts of oil, many contend that higher oil prices cause a weaker dollar. Yet others maintain that the dollar exchange rate causes changes in oil prices. This paper will employ time-series regression techniques and add controls for energy conservation as well as the demand for oil in developing countries to determine whether the U.S. dollar exchange rate causes changes in oil prices, or whether changes in oil prices cause exchange rate changes. Our study indicates that there is no conclusive proof of relationships among these variables.

I. Introduction

In the past few months (early-mid 2009), oil prices have risen while the dollar continued to plummet. Before oil's recent surge, the dollar was strong. Many believe that the two are inversely correlated, because oil is driving down the value of the dollar. However, prior to 2007, oil and the dollar were believed to be positively correlated. Oil is bought and sold in US dollars, therefore as oil prices climbed, so did the global demand for dollars. During recurrent oil shocks the demand for dollars continued, this prompted a flight to safety in US Treasury securities by investors as a result of rising risk aversion. Higher oil prices result in a higher cost of oil imports for the US, which will lead to higher current account and trade deficits. This higher strain on the economy would lower U.S. growth prospects and reduce capital inflows.

In contrast, others contend that it is the dollar which is driving the price of oil because we are not sure how much oil will be demanded globally. Investors appear to be more concerned with the signal of oil's stronger growth, than they are with the effects higher oil prices will have on trade (Lien, 2009). Since oil is priced in dollar terms and the US has a large deficit, any unexpected oil shocks will have a negative effect on the US economy. Therefore investors are concerned with how much oil will be demanded not only in the US, but globally.

This paper will examine exchange rates and oil prices over time to determine the direction of causation (oil prices to exchange rates or exchange rate to oil). In addition, it will estimate the direction (positive or negative) and the magnitude of the link.

II. Background on oil prices and the US dollar exchange rate

Oil is priced in US dollars and is used as the invoicing currency of international crude oil trading. Hence, the fluctuation in US dollar exchange rate is believed to underlie the volatility of crude oil price and especially its forecasting accuracy (Zhang, et al., 2008). In world markets most primary products are priced in dollars. The role the dollar plays in the world markets tends to have a biased effect on the price of imports as well as the inflation rate in the US. (Gray, 1998). The development of the BRIC countries played a pivotal role in the international oil markets.

It is not realistic for The Organization of the Petroleum Exporting Countries (OPEC) to even think about pricing oil in any currency other than the US dollar. The dollar is the currency of the largest importer of OPEC oil. The US, and most currencies of other oil importing countries are dollar related or linked. It is, by far, the most prominent currency of pricing for internationally-traded commodities, goods and services.

During the period of set prices, OPEC often adjusted prices to compensate for the loss in the purchasing power of the barrel due to US dollar depreciation against other currencies as well as inflation. When the dollar was fluctuating and adjustment for it could be positive or negative, inflation and correction for it was not reversible because of its cumulative nature. To illustrate this effect, look at the effects of the exchange rate and inflation since 1973 (appendix table 12) when OPEC first dealt with the issue of price correction to compensate for their losses (Salman, 2004).

III. Review of Existing Literature

a. Literature showing a positive correlation

Bénassy-Quéré, et al. (2007) use cointegration and causality tests to determine the relation between the real price of oil and the real price of the dollar over a period from 1974-2004. The results showed that causality ran from oil prices to the exchange rate and in the long run an oil price increase of 10 percent caused the dollar to appreciate 4.3 percent. However, subsequent research suggests that the relationship in the future could be reversed due to the emergence of China.

Since the emergence of China in the world economy as a major player, it holds the ability to have a positive or negative effect on the US dollar. In particular, its impact on oil and foreign exchange markets could strengthen the positive causality of oil to the dollar in the short run and reverse it in the long run. China's emergence in the markets has brought energy intensive economic development, in China driven by ballooning exports and a fixed exchange rate of the Yuan to the US dollar. These two factors could have a negative reverse causality of the dollar to oil. Because of China's increased demand for oil and its fixed rate of the Yuan to the dollar the perceived notion is that dollar depreciation has a positive impact on China's economic activity (Penot, et al, 2007).

Amano and Van Norden (1998) use similar econometric techniques as Penot, et al. Their study finds similar results that oil and the exchange rate are cointegrated and causality runs from oil to the exchange rate. The study also shows that post-Bretton Woods exchange rate shocks were the result of oil prices. They also conclude that energy prices may have future implications on exchange rate behavior (Amano and Van Norden, 2008).

Roach (2008) explains that the trend, for the most recent period of economic activity (1992-2008) and in economic models, is for the dollar to lead the price of oil. Higher oil prices were correlated with a stronger dollar from the beginning of this period until roughly 2003. This was the trend because for the most part, petrodollars were recycled back into the US economy and it was dominant in terms of attractiveness of exports and assets. However, this correlation was non-existent in 2004 and turned negative in 2006 (Roach, 2008).

b. Literature showing a negative correlation

Recently many analysts are saying that oil and the dollar are showing a strong negative correlation because of interest rate cuts. The interest rate cuts cause an inflow of cash into the commodities market. This raises commodities prices and results in inflation. Setser (2008) notes in terms of oil prices directly affecting the valuation of the dollar, that the US is the world's largest oil importer. The US economy is more susceptible to rising oil prices than other countries, because the US economy is very energy intensive. Since the US is such a large importer of oil and has such a large deficit, any oil price shock will have a larger impact.

A report published by the Interagency Task Force on Commodity Market (2008) on crude oil explains that the causality can run from both exchange rates to oil prices and oil prices to exchange rates. Empirical studies do not show a clear relationship between oil prices and the exchange rate of the US dollar. The evidence suggests that oil price will behave approximately proportionately to changes in the dollar, considered all economic factors are held constant. A ten percent depreciation of the dollar would lead to a ten percent appreciation in the price of oil. The depreciation of the dollar since 2002 will explain the increase in oil prices, but only explains part of the over-all increase in oil prices. In early to mid 2008 the dollar was stable but oil prices appreciated steadily (Interagency Task Force on Commodity Markets, 2008).

Most of the goods that the US exports is not sold to oil exporters, this has a negative effect on the US due to the fact that most of these oil exporters have money to spend abroad and does not allow the US to capitalize on the excess money.

Setser also notes in terms of the dollar's fall affecting oil prices, that higher oil prices are a result of the weakness of the dollar, even if compared to a basket of other currencies, and oil prices remain at a constant level. Speculators look to take advantage of the US interest rate cuts that were used in order to stabilize the economy. Investors look to the commodities market or other assets that due not bear interest. The investors turned to the commodities market because confidence in the US dollar is falling.

Verleger (2008) also notes the negative correlation link between rising oil prices and the falling dollar is due to the Federal Reserve’s inability to control inflation expectations. Interest rate cuts forced investors to shy away from the dollar and move into inflation resistant assets (Verleger, 2008).

To further support this negative correlation a study was done by members of the IMF which found when the real price of oil rose ten percentage points, an Organization for Economic Co-operation and Development (OECD) country’s real exchange rate would depreciate by two percentage points (Chinn, 1997).

Different time periods tend to show different results. Many of the recent studies tend to show a negative correlation. Many recent studies show a negative correlation for which there are several possible explanations. First, oil exporters rely less on the US then ever and generally tend to purchase European manufactured goods. During the 1970’s approximately 19 percent of imports were from the US. This number has dropped to nearly 9 percent while imports from the EU are on the rise. A simple conclusion is that the higher the oil price, the more goods are purchased in Euros as opposed to dollars. Another explanation is that commodity prices tend to benefit from a weaker dollar because declining US currency tends to make dollar-based commodities cheaper for non-US buyers (Coull, 2009).

IV. Data

Data was collected on the daily price of NYMEX crude oil futures (CL) and the US Dollar Index (DXY). To further the study data was also collected on the price of gold. The data was obtained from a Bloomberg terminal using daily closing prices from January 1989 through September 2009. It has more than 5200 observations.

An index shows a change in an economy or securities market through statistical analysis. A futures contract is an agreement made on the floor of a futures exchange to buy or sell a commodity or financial instrument at a predetermined price. When you purchase a futures contract you are agreeing to pay the pre-determined price for future delivery. When you purchase the contract, the item for future delivery has not yet been produced.

The US Dollar Index

The US Dollar index is a calculation of six currencies that have been averaged against the US dollar. It was listed on November 20th 1985 as a futures contract. The US Dollar Index contains six component currencies: the euro, Japanese yen, British pound, Canadian dollar, Swedish krona and Swiss franc. In 1973 it was created by the US Federal Reserve following the Bretton Woods agreement. The Bretton Woods agreement established a system of fixed exchange rates.

The US Dollar Index as explained by ICE futures US, was created as a way to provide external bilateral trade weighted average of the US dollar as it freely floated against global currencies. The formula for the calculation of the US Dollar Index is 50.14348112 multiplied by the product of all components raised to an exponent equal to the % weighting ((EURUSD ^ - 0.576) * (JPY ^ - 0.136) * (GBP ^ - 0.119) * (CAN ^ - 0.091) * (SEK ^ - 0.042) * (CHF^ -.036)) All currencies are expressed in units of currency per U.S. dollar (ICE, 2009).

Currency Weights

Euro = 57.6% Canadian dollar = 9.1%

Japanese yen = 13.6% Sweden krona = 4.2%

British pound = 11.9% Swiss franc = 3.6%

NYMEX Crude Oil

Crude oil is the world's most actively traded commodity. The NYMEX Division light, sweet crude oil futures contract is the world's most liquid forum for crude oil trading and also the world's largest-volume futures contract trading on a physical commodity and therefore is used as a principal international pricing benchmark. Because of its standard on pricing, additional options are available on the futures contract, including trading opportunities, risk management, calendar spread options, crack spread options (on pricing differentials), and average pricing options.

This futures contract is traded in units at 1000 barrels to an international delivery point, Cushing, Oklahoma, and provides several grades of domestically and internationally traded crude oil. However, light sweet crudes are preferred for their low-sulfur content and high yield of viable products for transportation and heating.

Gold

Gold futures are hedging tools for producers and users of gold. They provide several amenities: global price discovery, portfolio diversification, continuous trading opportunities, and are alternatives to gold bullion, coins, and mining stocks. In addition gold futures contracts are physically delivered, block-trade eligible, American-style options, and can be traded off-exchange for clearing.

Gold is such a valuable commodity because it's a precious metal, meaning it is somewhat rare and has other desirable qualities like conductivity, malleability, and luster. Because of these qualities it is an international medium of wealth and a constant in markets. It is used as insurance in unstable markets because it will remain a valuable commodity.

V. Statistical Analysis

The statistical model being used for this study is the vector autoregressive (VAR) model which is useful in studying the relationships among multivariate time series. It is also very helpful in forecasting and describing the dynamic behavior of economic and financial time series. After analyzing four different models VAR(1), VAR(2), VAR(3) and VAR(4), the VAR(3) was found to be the best fit model as shown in table 2.

The VAR(3) model is described as:

$$Y_{it} = \rho_{11}\, Yi_{1t\text{-}1} + \rho_{12}\, Yi_{2t\text{-}1} + \rho_{13}\, Yi_{3t\text{-}1} + \rho_{21}\, Yi_{1t\text{-}2} + \rho_{22}\, Yi_{2t\text{-}2} + \rho_{23}\, Yi_{3t\text{-}2} + \rho_{31}\, Yi_{1t\text{-}3} + \rho_{32}\, Yi_{2t\text{-}3} + \rho_{33}\, Yi_{3t\text{-}3} + \varepsilon_{it}$$

where Yi_t is the variable of interest, t is the time index, ρ is a coefficient, and εit is the error term.

The estimated model is:
(*t-values are shown in parentheses.)

$$\mathbf{er}_t = .98221(er)_{t-1} - .00739(oil)_{t-1} - .00246(gold)_{t-1}$$
(68.25) (-1.08) (-1.85)
$$+ .00790(er)_{t-2} + .00911(oil)_{t-2} + .00002(gold)_{t-2}$$
(0.39) (0.97) (0.01)
$$+ .00989(er)_{t-3} - .00152(oil)_{t-3} + .00242(gold)_{t-3} + \varepsilon_{1t}$$
(0.69) (-0.22) (1.82)

$$\mathbf{oil}_t = .06775(er)_{t-1} + .93532(oil)_{t-1} + .00618(gold)_{t-1}$$
(2.19) (63.62) (2.17)
$$- .06613(er)_{t-2} - .00218(oil)_{t-2} - .00163(gold)_{t-2}$$
(-1.53) (-0.11) (-0.41)
$$- .00173(er)_{t-3} + .06462(oil)_{t-3} - .00433(gold)_{t-3} + \varepsilon_{2t}$$
(-0.06) (4.40) (-1.52)

$$\mathbf{gold}_t = -.32869(er)_{t-1} + .04849(oil)_{t-1} + 1.00221(gold)_{t-1}$$
(-2.00) (0.62) (66.19)
$$+ .24337(er)_{t-2} - .17550(oil)_{t-2} - .02236(gold)_{t-2}$$
(1.06) (-1.64) (-1.05)
$$+ .08506(er)_{t-3} + .12944(oil)_{t-3} + .02029(gold)_{t-3} + \varepsilon_{3t}$$
(0.52) (1.66) (1.34)

Next, we will examine these time series follows a unit root process, which will tell if the time series is stationary or non-stationary. Non-stationary data typically will have means, variances, and covariances that change over time. The Dickey-Fuller (DF) test is used to determine this. The vector autoregressive (VAR) model as described above will be used to capture the evolution and the interdependencies between multiple time series. The Johansen test is used to check for cointegration which means that one variable is related to another in a long term, and the Granger Causality test will be used to determine if one time series is useful in forecasting another. The Stock-Watson test will examine for common trends that may exist between the series. We will also examine the impulse response function (IRF) which refers to the reaction of any dynamic system in response to some external change. Finally, the Forecast error variance decomposition will indicate the amount of information each variable contributes to the forecast error variance of other variables in our Vector autoregression (VAR) models.

1. Dickey-Fuller Test is setup as follows:

$$\nabla y_t = (\rho - 1)y_{t-1} + u_t = \delta y_{t-1} + u_t$$

where ∇ is the first difference operator and $\delta = \rho - 1$. This model can be estimated and testing for a unit root is equivalent to testing $\delta = 0$. Since the test is done over the difference term rather than raw data it is not possible to use standard t-distribution to provide critical values. Therefore, this statistic τ has a specific distribution simply known as the Dickey–Fuller statistic.

2. Johansen cointegration rank test examine the existence of multiple cointegrating vectors in the VAR system:

3. Granger Causality Test examine the causal realtionships

4. Stock-Watson Test for common trend

5. Impulse Response Function measures dynamic effect of the change in one variable over the others

6. Forecast Error Variance Decomposition also measures how forececast error variance are realted to othe change in other variables

All five tests (2 to 5) examine the existence of long run equilibrium relationships among these macrovaraibles.

VI. Statistical Results

Descriptive Statistics

Descriptive statistics are displayed in table 1 of the appendix for the variables used in this study. We see a mean of 92.78686 for the exchange rate, a mean of 34.20716 for oil, and a mean of 426.44866 for gold.

Dickey –Fuller Test

The results of the Dickey-Fuller test are displayed in table 4. With reference to equation 1, the DF test is set up as follows.

H*o:* δ=0 (a unit root exists) not stationary

H*a:* δ< 0 (the data are stationary around a zero mean)

Since the p values are larger then the significance value of 5%, we do not reject the null hypothesis (for zero mean case) .and conclude that unit roots do exist and that the data is nonstationary. For Gold data it always nonstationary, however, for oil and exchange rate, they are stationary for single mean and deterministic time trend.

Cointegration Rank Test Using Trace

Since original time series data are nonstationary, to capture the long term relationship among themselves, we consider the case of cointregration. For this, we have used Johansen methodology of rank and trace test for cointegration. The results are displayed in table 5. The null hypothesis is that exchange rate, oil price and gold price are not cointegrated, and the alternative hypothesis will be that they are cointegrated. The results show the test statistic is less than the critical value for all three orders. Therefore we do not reject the null and conclude that all the processes are not cointegrated.

Granger Causality Test

The results for the Granger causality test are displayed in table 6. Test 1 shows oil is not influenced by the exchange rate at a 5% or 10% significance level. Test 2 shows that oil is not influenced by gold at the 5% significance level, but it is at the 10% level. Test 3 shows that the exchange rate is not influenced by oil at the 5% or 10% level. Test 4 shows that the exchange rate is influenced by gold at the 5% and 10% level. Test 5 shows that gold is not influenced by the exchange rate at the 5% or 10% level. Finally, test 6 shows that gold is not influenced by oil at the 5% or 10% level.

Univariate Model ANOVA Diagnostics

From the Vector autoregression (VAR), table 7 shows Univariate Diagnostic Checks. This provides diagnostic checks for the univariate form of the equations. The output in table 4 describes how well each univariate equation fits the data. The results show a very high R-square meaning that each univariate model is significant.

Stock-Watson test for Common Trends Using Differencing Filter

The results for the Stock-Watson test for Common Trends using differencing filter are displayed in table 8. The null hypothesis is that k-dimensional time series y_t has m <_ k common stochastic trends, and the alternative is that it has s < m common trends. The results show that all the test statistics are less than the critical value,therefore we will reject the null and conclude that the series does not have a single common trend.

Simple Impulse Response by Variable

Table 9 displays the results and figures 1-3 shows a graphical interpretation of the impulse response function. A one unit increase in the current value of the US exchange rate value will result in an increase in the current value of oil of 0.00018 and a-0.00003 decrease in gold. At lag 2 we will see an increase of 0.00037 in oil and a decrease of -0.00006 in gold. Al lag 19 we see an increase in oil of 0.00342 and a decrease in gold of -0.00052. And at lag 20 we see an increase of 0.00360 in oil and a decrease of -0.00054 in gold.

We will se at lag 1 that a one unit increase of the current value of oil will result in a decrease in the exchange rate of -0.00016 and an increase in the current value of gold 0.00027. At lag 2 we see a decrease in the exchange rate of -0.00032 and increase of gold of 0.000053. At lag 19 we see a decrease in the exchange rate of -0.00301 and an increase in gold of 0.00495. At lag 20 we see a decrease in the exchange rate of -0.00316 and an increase in gold of 0.00520.

At lag 1 we see that a one unit increase in the current value of gold will lead to a decrease of -0.00028 in the current value of the exchange rate and an increase in the current value of oil of 0.00225. At lag 2 we will see a decrease in the exchange rate of -0.00056 and an increase of 0.00450 in oil. At lag 19 a decrease in the exchange rate of -0.00542 occurs and an increase of 0.04189 in oil. At lag 20 we see a decrease in the exchange rate of -0.00571 and an increase of oil of 0.004404.

Decomposition of Prediction Error Covariances by Variable

Variance decomposition will determine how much of the forecast error variance of each variable can be explained by an exogenous shock to the other variables. The results are displayed in table 10. The exchange rate with a lead of one and lead of two, show for both oil and gold 0.00000. At a lead of 20 is the results show 0000005.

Oil, with a lead of one shows 0.01774 for the exchange rate and 0.00000 for gold. At a lead of two it shows 0.03552 for the exchange rate and 0.00000 for gold. At a lead of 19 it shows 0.34337 for the exchange rate, and 0.000402 for gold. At a lead of 20 we see a result of 0.36181 for the exchange rate, and 0.00469 for gold.

Gold, with a lead of one, shows 2.28456 for the exchange rate, and 2.97244 for oil. At a lead of 2 it shows 4.57113 for the exchange rate, and 5.95414 for oil. At a lead of 19 we see an increase to 43.75380 for the exchange rate, and 58.05595 for oil. At a lead of 20 the results show 46.07707 for the exchange rate, and 61.20372 for oil.

Proportion of Prediction Error Covariance by Variable

The output in table 11 explains that 100% with a lead of one, one step ahead of prediction error covariances of the exchange rate is accounted for by its own innovation and 0% is accounted for by oil and gold. The percentages are similar even in the long-term forecasts, with a lead of twenty, 99.998% of the exchange rate is accounted for by its own innovation while oil accounts for 0.00001 and gold 0.00001.

For oil, with a lead of one, 98.489% is accounted for by its own innovation, while the exchange rate accounts for 1.511%, and gold accounts for 0%. In the long-term forecasts, with a lead of twenty, 98.376% of oil is accounted for by its own innovation, while the exchange rate accounts for 1.603%, and gold accounts for 0.00021.

For gold, with a lead of one, 6.924% is accounted for by its own innovation, while the exchange rate accounts for 9.009%, and oil accounts for 84.067%. The long-term forecasts with a lead of twenty shows that 6.943% of gold is accounted for by its own innovation, while the exchange rate accounts for 9.222%, and oil accounts for 83.835%.

VII. Conclusion

This study was done from a period of January 1989 to September 2009 to determine whether the U.S. dollar exchange rate causes changes in oil prices, or whether changes in oil prices cause exchange rate changes. The study also included tests to see if there is any type of relationship between the two, a third variable, gold, was also added to further the study.

The results show that no cointegration exists between the variables meaning that a long term relationship does not exist between the exchange rate, oil, and the price of gold. Subsequent studies show that causality would run from oil prices to the exchange rate, but the results of this study did not find causality running from either the exchange rate to the price of oil, or the price of oil to the exchange rate. The results did show that causality ran from the price of oil to the price of gold, and also from the exchange rate to the price of gold.

To show how the exchange rate, oil, and gold would react to exogenous shocks, we used the impulse response function to examine this, the results are shown for different time periods in the appendix. The decomposition of prediction error covariances by variable determines how much of the forecast error variance of each variable can be explained by an exogenous shock to the other variables. The results are also displayed in the appendix for different time periods. We can also see from the impulse response function that the direction, the relationship from the exchange rate to oil is positive and from oil to the exchange rate is negative. The results are shown in the appendix for the rest of the variables.

In conclusion we can not say that a relationship between these variables does exist. May be it is a very complex relationship, that cannot be captured by our statistical methodologies. We may need further study in this regard.

VIII. Appendix

Figure 1:

Line chart showing the movement of ER, Oil and Gold from 1989-2009

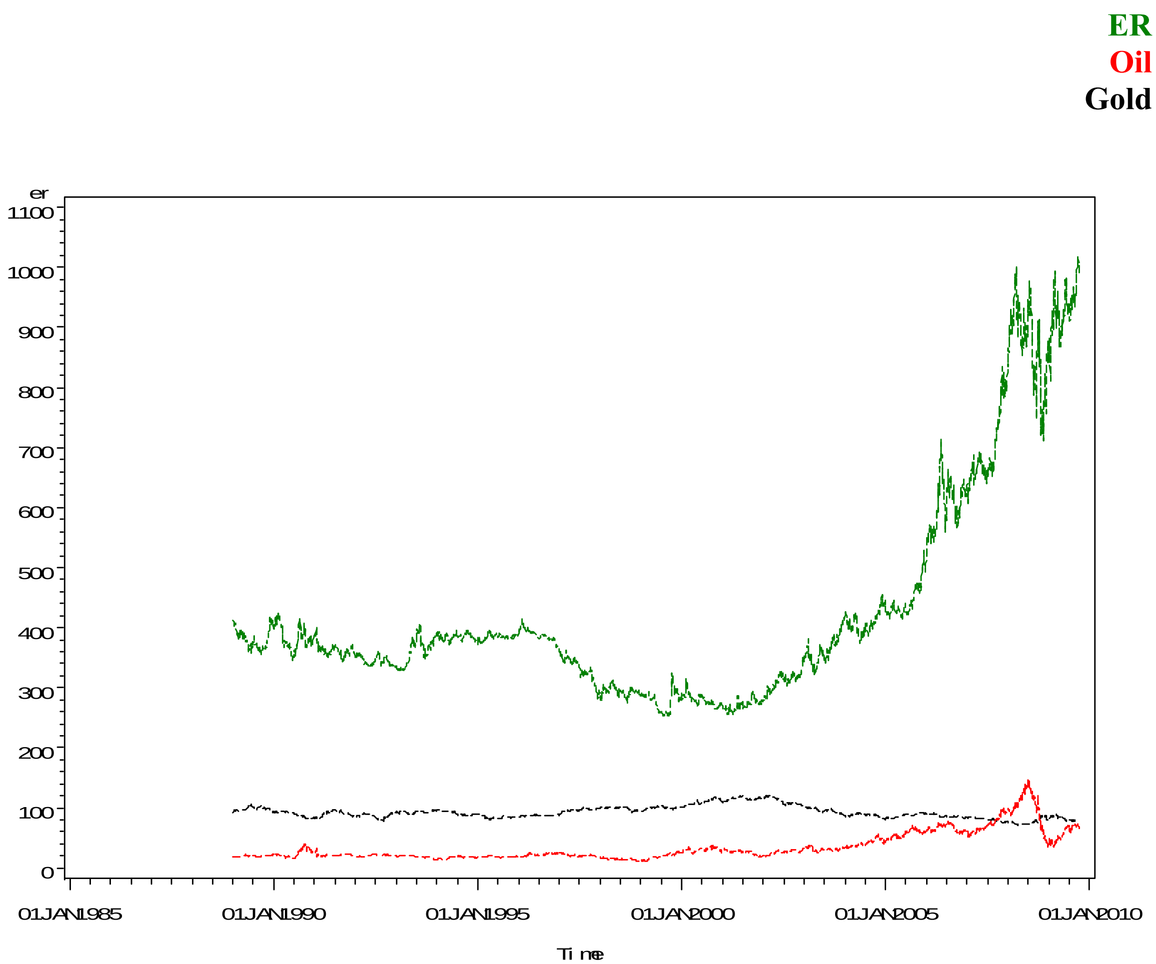


Table 1:

Simple Summary Statistics

Variable	Type	Number	Mean	Standard Dev.	Min	Max
ER	Dependent	5203	92.79	10.35	71.33	120.90
Oil	Dependent	5203	34.21	23.69	10.72	145.29
Gold	Dependent	5203	426.45	176.37	252.55	1017.30

Table 2:

AR Coefficient Estimates: VAR(3)

Lag	Variables	ER	Oil	Gold
1	ER	0.98221	-0.00739	-0.00246
	Oil	0.06775	0.93532	0.00618
	Gold	-0.32869	0.04849	1.00221
2	ER	0.00790	0.00911	0.00002
	Oil	-0.06613	-0.00218	-0.00163
	Gold	0.24337	-0.17550	-0.02236
3	ER	0.00989	-0.00152	0.00242
	Oil	-0.00173	0.06462	-0.00433
	Gold	0.08506	0.12944	0.02029

Information Criteria

	VAR(1)	VAR(2)	VAR(3)	VAR(4)
AICC	2.098332	2.093554	2.091522	2.086227
HQC	2.102298	2.101484	2.103411	2.102075
AIC	2.09833	2.093546	2.091504	2.086195
SBC	2.109674	2.116238	2.125546	2.131593
FPEC	8.152545	8.113638	8.09708	8.054214

Table 3: Normality ARCH

Variable	Durbin Watson	Chi –Square	Pr > Chi-Square	F Value	Pr > F
ER	2.00014	609.91	<.0001	17.47	<.0001
Oil	1.99637	9999.99	<.0001	984.63	<.0001
Gold	2.00084	9999.99	<.0001	112.50	<.0001

Table 4:

Dickey-Fuller Unit Root Tests

Variable	Type	Rho	Pr < Rho	Tau	Pr < Tau
ER	Zero Mean Single Mean Trend	-0.23 -4.90 -5.45	0.6304 0.4455 0.7874	-0.60 -1.41 -1.54	0.4575 0.5818 0.8141
Oil	Zero Mean Single Mean Trend	-0.37 -4.20 -11.07	0.5590 0.5183 0.3691	-0.21 -1.34 -2.39	0.6121 0.6139 0.3864
Gold	Zero Mean Single Mean Trend	1.50 2.30 -1.53	0.9677 0.9988 0.9805	1.65 0.97 -0.51	0.9765 0.9963 0.9832

- **Note: Type => Type of model ,Rho and Tau => test statistic,Pr => associated p-values**

Table 5:

Cointegration Rank Test Using Trace

Ho: Rank=r	H1: Rank>r	Eigenvalue	Trace	5% Critical Value	Drift in ECM	Drift in Process
0	0	0.0013	9.2893	24.08	NOINT	Constant
1	1	0.0005	2.6457	12.21		
2	2	0.000	0.0058	4.14		

Table 6:

Granger Causality Wald Test

Test	DF	Chi-Square	Pr > ChiSq
1	1	0.75	0.3869
2	1	3.31	0.0691
3	1	1.23	0.2670
4	1	4.48	0.0343
5	1	0.34	0.5612
6	1	0.11	0.7393

Test 1: Group 1 variables: oil
Group 2 variables: er

Test 2: Group 1 variables: oil
Group 2 variables: gold

Test 3: Group 1 variables: er
Group 2 variables: oil

Test 4: Group 1 variables: er
Group 2 variables: gold

Test 5: Group 1 variables: gold
Group 2 variables: er

Test 6: Group 1 variables: gold
Group 2 variables: oil

Table 7:

Univariate Model ANOVA Diagnostics

Variable	R-Square	Standard Dev.	F value	Pr > F
ER	0.9976	0.50345	439019	<.0001
Oil	0.9979	1.08170	497735	<.0001
Gold	0.9989	5.74342	980066	<.0001

Table 8:

Testing for Stock-Watson's Common Trends Using Differencing Filter

Ho: Rank=m	H1: Rank=s	Eigenvalue	Filter	5% Critical Value	Lag
1	0	1.000460	2.40	-14.10	2
2	0	1.000405	2.11	-8.80	
	1	0.997896	-10.95	-23.00	
3	0	1.000381	1.98	-6.80	
	1	0.998041	-10.19	-15.70	
	2	0.998041	-10.19	-31.50	

Table 9:

Simple Impulse Response by Variable

In the pair of $y_{1(er)} \rightarrow y_2$ (oil) at lag is -.00048. This represents that impact on y2 after one unit change in y1 after 3 periods.

Variable	Lag	ER	Oil	Gold
ER	1	1.00001	0.00018	-0.00003
	Std	0.00017	0.00052	0.00006

	2 Std	1.00003 0.00035	0.00037 0.00104	-0.00006 0.00013
	3 Std	1.00004 0.00052	0.00055 0.00156	-0.00008 0.00019
	4 Std	1.00005 0.00070	0.00074 0.00208	-0.00011 0.00026
	5 Std	1.00007 0.00087	0.00092 0.00260	-0.00014 0.00032
	6 Std	1.00008 0.00105	0.00110 0.00311	-0.00016 0.00038
	7 Std	1.00009 0.00122	0.00128 0.00362	-0.00019 0.00045
	8 Std	1.00011 0.00139	0.00146 0.00414	-0.00022 0.00051
	9 Std	1.00012 0.00157	0.00164 0.00465	-0.00025 0.00057
	10 Std	1.00013 0.00174	0.00182 0.00516	-0.00027 0.00064
	11 Std	1.00015 0.00192	0.00200 0.00566	-0.00030 0.00070
	12 Std	1.00016 0.00209	0.00218 0.00617	-0.00033 0.00076
	13 Std	1.00017 0.00226	0.00236 0.00668	-0.00035 0.00082
	14 Std	1.00019 0.00244	0.00254 0.00718	-0.00035 0.00082
	15 Std	1.00020 0.00261	0.00272 0.00768	-0.00041 0.00095
	16 Std	1.00021 0.00279	0.00289 0.00818	-0.00044 0.00101
	17 Std	1.00023 0.00296	0.00307 0.00868	-0.00046 0.00108
	18 Std	1.00024 0.00314	0.00325 0.00918	-0.00049 0.00114
	19 Std	1.00025 0.00331	0.00342 0.00968	-0.00052 0.00120
	20 Std	1.00027 0.00348	0.00360 0.01017	-0.00054 0.00126
Oil	1 Std	-0.00016 0.00037	0.99740 0.00112	0.00027 0.00014
	2 Std	-0.00032 0.00075	0.99482 0.00224	0.00053 0.00028
	3 Std	-0.00048 0.00112	0.99224 0.00335	0.00080 0.00041
	4 Std	-0.00064 0.00149	0.98966 0.00446	0.00106 0.00055
	5	-0.00080	0.98710	0.00132

	Std	0.00187	0.00556	0.00068
	6 Std	-0.00096 0.00224	0.98454 0.00665	0.00159 0.00082
	7 Std	-0.00112 0.00261	0.98199 0.00774	0.00182 0.00095
	8 Std	-0.00128 0.00298	0.97944 0.00883	0.00211 0.00109
	9 Std	-0.00144 0.00334	0.97691 0.00991	0.00237 0.00122
	10 Std	-0.00160 0.00371	0.97438 0.010198	0.00263 0.00135
	11 Std	-0.00176 0.00408	0.97185 0.01205	0.00289 0.00149
	12 Std	-0.00191 0.00444	0.96934 0.01311	0.00315 0.00162
	13 Std	-0.00207 0.00481	0.96683 0.01417	0.00341 0.00175
	14 Std	-0.00223 0.00517	0.96433 0.01523	0.00367 0.00188
	15 Std	-0.00238 0.00554	0.96183 0.01627	0.00392 0.00201
	16 Std	-0.00254 0.00590	0.95934 0.01732	0.00418 0.00214
	17 Std	-0.00270 0.00625	0.95686 0.01835	0.00444 0.00227
	18 Std	-0.00285 0.00662	0.95439 0.01938	0.00469 0.00240
	19 Std	-0.00301 0.00698	0.95192 0.02041	0.00495 0.00253
	20 std	-0.00316 0.00734	0.94946 0.02143	0.00520 0.00266
Gold	1 Std	-0.00028 0.00199	0.00225 0.00595	1.00015 0.00073
	2 Std	-0.00056 0.00397	0.00450 0.01189	1.00030 0.00146
	3 Std	-0.00085 0.00596	0.00675 0.01781	1.00045 0.00219
	4 Std	-0.00113 0.00795	0.00898 0.02372	1.00060 0.00292
	5 Std	-0.00141 0.00994	0.01122 0.02961	1.00075 0.00364
	6 Std	-0.00169 0.01193	0.01344 0.03549	1.00090 0.00437
	7 Std	-0.00198 0.01392	0.01566 0.04136	1.00106 0.00509
	8 Std	-0.00226 0.01591	0.01788 0.04721	1.00121 0.00582

	9 Std	-0.00255 0.01790	0.02009 0.05304	1.00137 0.00654
	10 Std	-0.00283 0.01989	0.02229 0.05886	1.00152 0.00726
	11 Std	-0.00312 0.02188	0.02449 0.06466	1.00168 0.00798
	12 Std	-0.00340 0.02387	0.02669 0.07046	1.00183 0.00870
	13 Std	-0.00369 0.02586	0.02887 0.07623	1.00199 0.00942
	14 Std	-0.00398 0.02785	0.03106 0.08199	1.00215 0.01014
	15 Std	-0.00426 0.02985	0.03324 0.08774	1.00230 0.01086
	16 Std	-0.00455 0.03184	0.03541 0.09347	1.00246 0.01157
	17 Std	-0.00484 0.03383	0.03757 0.09919	1.00262 0.01229
	18 Std	-0.00513 0.03583	0.03974 0.10490	1.00278 0.01300
	19 Std	-0.00542 0.03782	0.04189 0.11059	1.00294 0.01371
	20 std	-0.00571 0.03982	0.04404 0.11626	1.00310 0.01443

Table 10:

Decomposition of Prediction Error Covariance by Variable

Variable	Lead	ER	Oil	Gold
ER	1	0.25375	0.00000	0.00000
	2	0.50752	0.00000	0.00000
	3	0.76131	0.00000	0.00000
	4	1.01513	0.00000	0.00000
	5	1.26897	0.00000	0.00000
	6	1.52283	0.00000	0.00000
	7	1.77672	0.00000	0.00000
	8	2.03064	0.00000	0.00000
	9	2.28457	0.00000	0.00000
	10	2.53854	0.00001	0.00001
	11	2.79252	0.00001	0.00001
	12	3.04653	0.00001	0.00001
	13	3.30056	0.00001	0.00001
	14	3.55462	0.00002	0.00002
	15	3.80870	0.00002	0.00002
	16	4.06281	0.00003	0.00003

	17	4.31694	0.00003	0.00003
	18	4.57109	0.00004	0.00004
	19	4.82527	0.00005	0.00004
	20	5.07947	0.00005	0.00005
Oil	1	0.01774	1.15631	0.00000
	2	0.03552	2.30762	0.00000
	3	0.05334	3.45394	0.00001
	4	0.07119	4.59530	0.00003
	5	0.08908	5.73173	0.00006
	6	0.10700	6.86325	0.00011
	7	0.12497	7.98989	0.00018
	8	0.14296	9.11166	0.00027
	9	0.16100	10.22861	0.00040
	10	0.17907	11.34074	0.00055
	11	0.19718	12.44808	0.00074
	12	0.21533	13.55066	0.00098
	13	0.23351	14.64851	0.00125
	14	0.25173	15.74164	0.00157
	15	0.26998	16.83008	0.00195
	16	0.28828	17.91385	0.00237
	17	0.30660	18.99298	0.00286
	18	0.32497	20.06749	0.00340
	19	0.34337	21.13740	0.00402
	20	0.36181	22.20274	0.00469
Gold	1	2.28456	2.97244	27.73751
	2	4.57113	5.95414	55.48330
	3	6.85973	8.94508	83.23740
	4	9.15034	11.94527	110.99986
	5	11.44299	14.95471	138.77069
	6	13.73766	17.97338	166.54995
	7	16.03436	21.00130	194.33767
	8	18.33309	24.03845	222.13388
	9	20.63385	27.08484	249.93863
	10	22.93665	30.14046	277.75193
	11	25.24148	33.20530	305.57384
	12	27.54836	36.27938	333.40438
	13	29.85728	39.36267	361.24360
	14	32.16824	42.45519	389.09152
	15	34.48125	45.55692	416.94819
	16	36.79631	48.66786	444.81364
	17	39.11342	51.78802	472.68790
	18	41.43258	54.91738	500.57101
	19	43.75380	58.05595	528.46300
	20	46.07707	61.20372	556.36392

Table 11:

Proportion of Prediction Error Covariance by variable

Variable	Lead	ER	Oil	Gold
ER	1	1.00000	0.00000	0.00000
	2	1.00000	0.00000	0.00000
	3	1.00000	0.00000	0.00000
	4	1.00000	0.00000	0.00000
	5	1.00000	0.00000	0.00000
	6	1.00000	0.00000	0.00000
	7	1.00000	0.00000	0.00000
	8	1.00000	0.00000	0.00000
	9	1.00000	0.00000	0.00000
	10	1.00000	0.00000	0.00000
	11	0.99999	0.00000	0.00000
	12	0.99999	0.00000	0.00000
	13	0.99999	0.00000	0.00000
	14	0.99999	0.00001	0.00000
	15	0.99999	0.00001	0.00001
	16	0.99999	0.00001	0.00001
	17	0.99999	0.00001	0.00001
	18	0.99998	0.00001	0.00001
	19	0.99998	0.00001	0.00001
	20	0.99998	0.00001	0.00001
Oil	1	0.01511	0.98489	0.00000
	2	0.01516	0.98484	0.00000
	3	0.01521	0.98479	0.00000
	4	0.01526	0.98474	0.00001
	5	0.01530	0.98469	0.00001
	6	0.01535	0.98463	0.00002
	7	0.01540	0.98458	0.00002
	8	0.01545	0.98452	0.00003
	9	0.01550	0.98447	0.00004
	10	0.01554	0.98441	0.00005
	11	0.01559	0.98435	0.00006
	12	0.01564	0.98429	0.00007
	13	0.01569	0.98423	0.00008

	14	0.01574	0.98416	0.00010
	15	0.01579	0.98410	0.00011
	16	0.01584	0.98403	0.00013
	17	0.01588	0.98397	0.00015
	18	0.01593	0.98390	0.00017
	19	0.01598	0.98383	0.00019
	20	0.01603	0.98376	0.00021
Gold	1	0.06924	0.09009	0.84067
	2	0.06925	0.09020	0.84055
	3	0.06926	0.09032	0.84042
	4	0.06927	0.09043	0.84030
	5	0.06928	0.09054	0.84018
	6	0.06929	0.09066	0.84005
	7	0.06930	0.09077	0.83993
	8	0.06931	0.09088	0.83981
	9	0.06932	0.09099	0.83969
	10	0.06933	0.09111	0.83956
	11	0.06934	0.09122	0.83944
	12	0.06935	0.09133	0.83932
	13	0.06936	0.09144	0.83920
	14	0.06937	0.09155	0.83907
	15	0.06938	0.09167	0.83895
	16	0.06939	0.09178	0.83883
	17	0.06940	0.09189	0.83871
	18	0.06941	0.09200	0.83859
	19	0.06942	0.09211	0.83847
	20	0.06943	0.09222	0.83835

Table 12:

Crude Oil Price in Nominal and Real Terms
(US Dollars Per Barrel)
Base: 1973 = 100

Year	Nominal Oil Price	Nominal Price Adjusted for		
		Exchange Rates	Inflation	Combined
1973	3.05	3.05	3.05	3.05
1974	10.73	11.06	9.39	9.68
1975	10.73	10.86	8.37	8.47
1976	11.51	12.57	8.18	8.93
1977	12.39	13.41	8.01	8.67
1978	12.70	12.60	7.64	7.58
1979	17.25	16.48	9.45	9.04
1980	28.64	27.33	13.89	13.26
1981	32.51	35.66	14.18	15.55
1982	32.38	39.76	12.97	15.93
1983	29.04	38.79	10.90	14.57
1984	28.20	41.44	9.97	14.66
1985	27.01	41.16	9.06	13.80
1986	13.53	16.94	4.40	5.50
1987	17.73	19.88	5.57	6.25
1988	14.24	15.54	4.32	4.72
1989	17.31	19.87	5.00	5.74
1990	22.26	23.38	6.07	6.38
1991	18.62	19.84	4.85	5.16
1992	18.44	19.24	4.62	4.82
1993	16.33	18.88	3.96	4.58
1994	15.53	17.90	3.66	4.22
1995	16.86	18.63	3.85	4.26
1996	20.29	22.60	4.51	5.03
1997	18.68	22.33	4.06	4.86
1998	12.28	14.91	2.63	3.19
1999	17.47	21.67	3.68	4.57
2000	27.60	37.76	5.67	7.76
2001	23.12	32.65	4.64	6.56
2002	24.36	33.13	4.80	6.53

Figure 2:

Response to impulse in Exchange Rate

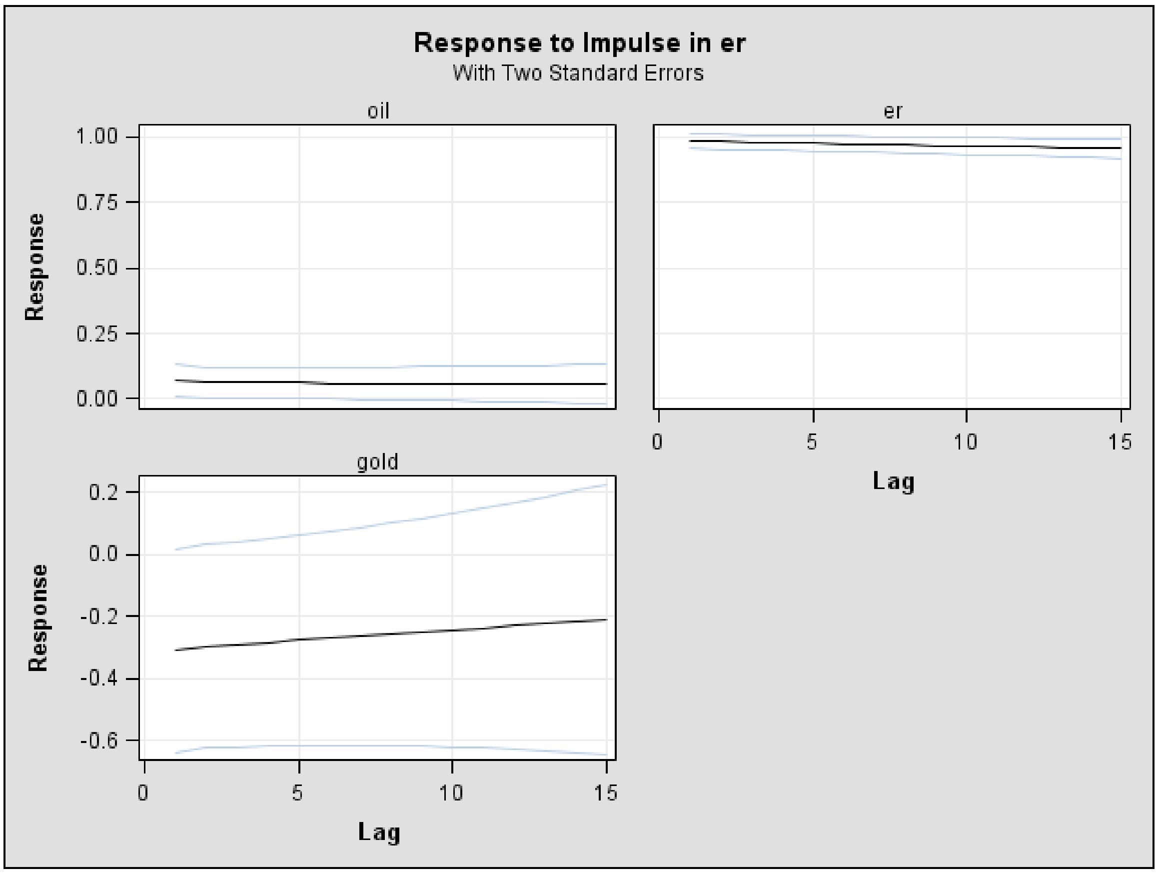


Figure 3:

Response to impulse in Oil

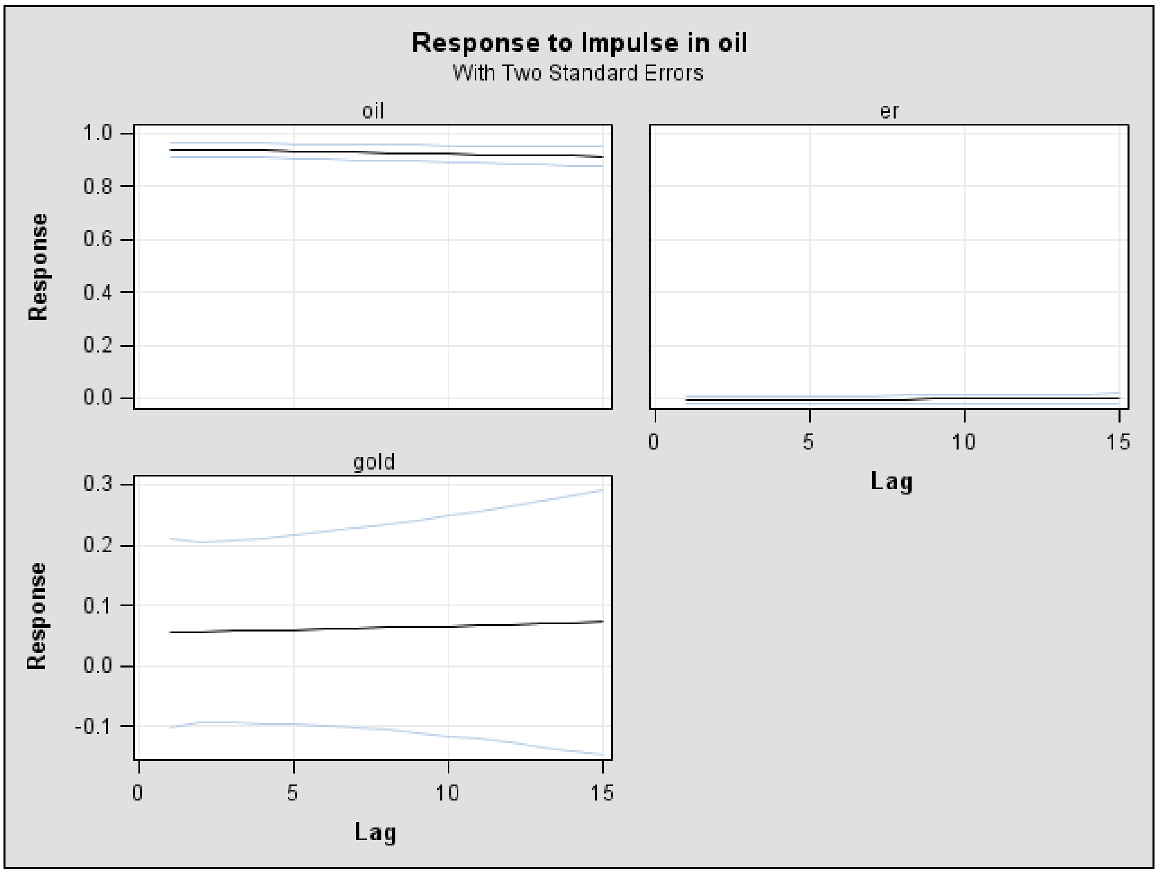
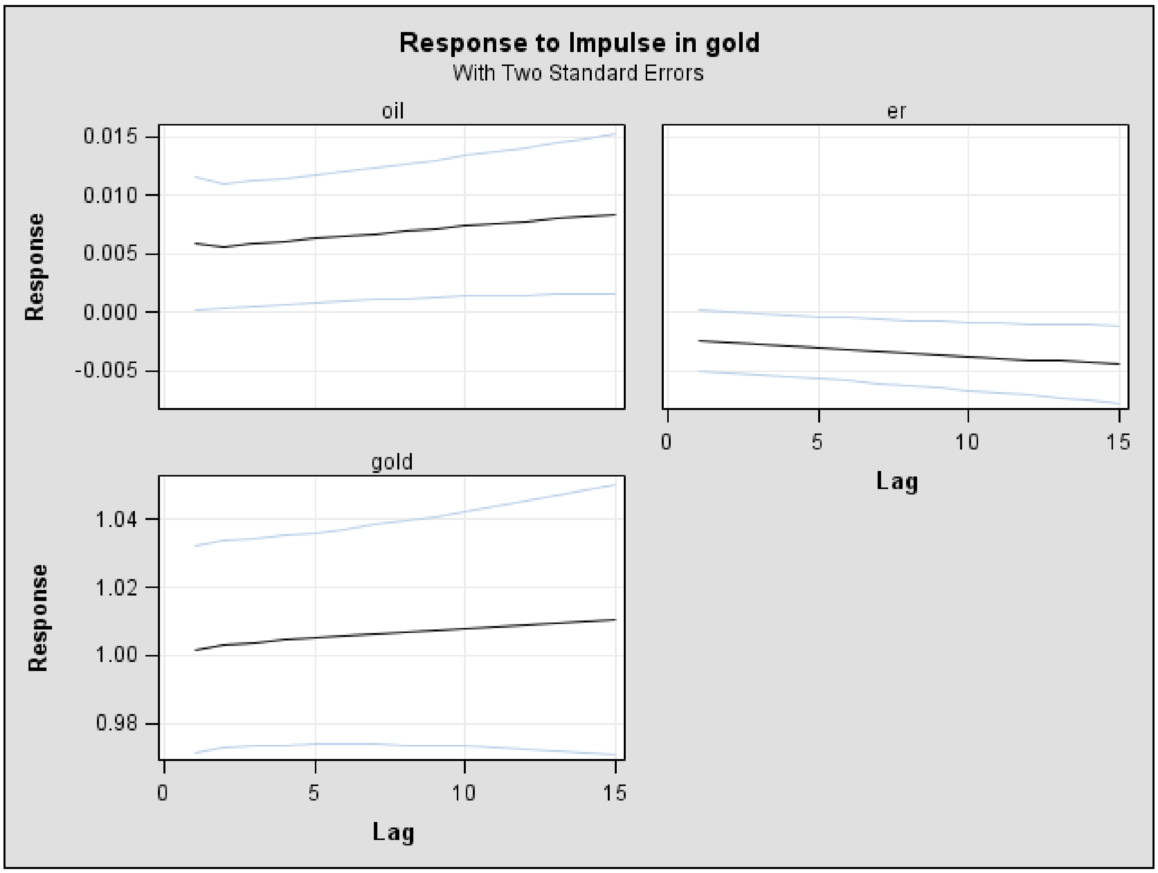


Figure 4:

Response to impulse in Gold



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