Haigazian University

Gold Price Determinants: An Empirical Study

By
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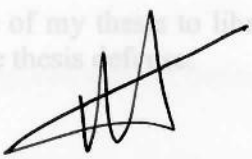

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AN ABSTRACT OF THE PROJECT OF

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This paper demonstrates an empirical link between gold price, consumer price index, Euro exchange rate, the Brent oil price and the Dow Johns industrial average. The research shows that there is a relationship between the gold price and each of the other variables, each one alone and all together. In the first part, simple regression models are used to find out the relationship between the gold and the other variables. In the last part of the paper, we do a multiple regression model by taking all the dependent variables together to find their relationship with the gold price, using concurrent economic data from 1997 to 2005.

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CHAPTER I

INTRODUCTION

Gold is a chemical element in the chemical periodic table that has the symbol Au (from Latin aurum, "gold"),and is a soft, dense, bright yellow metallic element. Gold is one of the transition elements of the periodic table. Its atomic number is 79.[1]

Gold is extremely inactive. It is unaffected by air, heat, moisture, and most solvents. It will, however, dissolve by using acids, like hydrochloric and nitric acids.[1]

Gold melts at about 1064° C (about 1947° F), boils at about 2808° C (about 5086° F). It is widely distributed although it is rare, being 75th in order of abundance of the elements in the crust of the earth. It is almost always associated with varying amounts of silver. Gold also is found in seawater to the extent of 5 to 250 parts by weight to 100 million parts of water. Although the quantity of gold present in seawater is more than 9 billion metric tons, the cost of recovering the gold would be far greater than the value of the gold that could be recovered.[2]

The metal has been known and highly valued from earliest times, not only because of its beauty and resistance to corrosion, but also because gold is easier to work than all other metals.

Gold became used as currency and as a basis for international monetary transactions before introducing the paper money. This is why it was decided to have one

[1] http://www.bambooweb.com/articles/g/o/Gold.html

[2] Encarta Encyclopedia Deluxe (2002)

unit. The unit used in weighing gold is the troy ounce; one troy ounce is equivalent to 31.1 grams of fine gold.

The major portion of the gold produced is used in coinage and jewelry. For these purposes it is alloyed with other metals to give it the necessary hardness. The term expressing the ratio of precious metal in an alloy is called carat. A carat, usually spelled karat, indicates 1/24 part by weight of a precious metal, such as gold, in an alloy. Thus, 18 karat gold is 18/24 or 75% gold and the remaining part is made up of silver and cupper, while the 24 karat gold is pure gold.

Gold production dates from the Etruscan, Minoan, Assyrian, and Egyptian civilizations, when gold was derived from alluvial sands and gravels by simple processes of washing or panning.[3]

The annual supply of gold to the market comes from two sources: new mine production, which is about 63 percent of the total supply of gold to the market, and the recycling of the scrap gold.

The world's leading supplier of gold is South Africa, producing 449 metric tons in 1999. Its most important gold mines are in the Witwatersrand region. Some 70 other countries produce gold in commercial quantities, but two thirds of the total worldwide production now comes from South Africa, the United States, Australia, China, Canada, and Russia.[4]

On December 31, 1974, the U.S. federal government lifted a 41-year ban on the private ownership of gold. Around that time gold was being traded on the London bullion market at record highs at that time, approaching $200 an ounce. After subsequent sharp decreases, prices rose to a high of $850 in January 1980.The price of

[3] " Jewelry 7000 Years"(1986)

[4] "Gold Survey 2004"(2004)

gold then dropped considerably and in the early 1990s settled at about $370 an ounce, while nowadays it is in the $500 levels.

The gold standard, in economics, is a monetary system where all forms of legal tender may be converted, on demand, into fixed quantities of fine gold, as defined by law. Until the 19th century, most countries of the world maintained a bimetallic monetary system. The widespread adoption of the gold standard during the second half of the 19th century was largely a result of the Industrial Revolution, which brought about a vast increase in the production of goods and widened the basis of world trade. The countries that adopted the gold standard had three principal aims: to facilitate the settlement of international commercial and financial transactions, to establish stability in foreign exchange rates, and to maintain domestic monetary stability. They believed these aims could best be accomplished by having a single standard of universal validity and relative stability. Hence the gold standard is sometimes called the single gold standard.[5]

In 1975 the role of gold was diminished when the U.S. government began to sell some of its holdings on the open market, making gold more of a commodity than a standard in the international monetary system. In 1978, in conjunction with reforms made by the International Monetary Fund, Congress formally removed the U.S. from the gold standard on an international basis. At the end of the decade no major currency was redeemable in gold. The central bank's reserves were down. Countries are selling their gold. This is why the central banks of the world renewed the Central Bank Gold Agreement. This was an agreement to provide the right conditions for orderly disposal of gold by those seeking to reduce the level of their holdings.

[5] http://www.bambooweb.com/articles/g/o/Gold.html

The largest gold holder in the world is the United States. The total gold reserve is equal to 8135 tones. Lebanon also has large reserves of gold. It is approximated by 270 tones. This is not bad for a small country like Lebanon.

The gold market in Lebanon was considered as an important market especially before the civil war. All the merchants from all around the world used to come to Lebanon to buy gold and jewelry but during the war all these customers stopped coming to Lebanon and found new markets. The biggest market in the world for gold and jewelry, is nowadays Dubai.

After the war Lebanon's gold market has revived. The fabrication of gold has increased tremendously to twelve tones yearly. Most of the fabrications are for export. The largest importers are The United Arab Emirates, Libya, The Kingdom of Saudi Arabia and Jordan. The local market is also an active market. The high season for this market is the summer. The summer sales are about 75 percent of the total sales of the year. This season is known for its traditional occasions. People get married, graduate, and baptize their babies. These are all traditions that make the people to buy gold. The total yearly local gold sales are considered about 7 tones per year excluding the jewelry sales.

The total aboveground value of gold in the world is currently around $2.08 trillion at $420/oz. ($420/oz. x 31.99 oz./ Kg x 155,000,000 Kg)compared with the approximately $15 trillion value of the U.S. stock market and $22.4 trillion for the U.S. non-financial debt market. Gold mining is a $31 billion per year industry. Given that the price volatility of gold is around 10% per year. Ibbotson, Siegel and Love (1985) estimated that gold bullion represented 5% of total invest able world wealth.

The rate of growth of gold mining has essentially matched the world population growth over past 30 years. IMF data show that total world population grew a compounded 1.89%. While the global stock of gold grew by 1.46%. Thus, the world stock of gold per capita has remained relatively stable over the past period.

As it is showed above gold market is an important sector of the economy of Lebanon. It is very important to determine the price of gold because a small change in the price of gold without anticipating can cause the firms and the factories, to lose a lot of money. This research will entail discovering significant determinants of gold price in the following parts.

CHAPTER II

LITERATURE REVIEW

According to Sherman (1983) gold markets are efficient. They are comparable to other financial variables such as interest rates and foreign exchange rates and new information is quickly incorporated into prices. Under uncertainty many investors turn to gold because it is perceived to be a "currency without borders", a safe haven, a highly liquid and secure asset that can be accessed at any time, by any investor. The investor can access the gold market either through banks or through investment banks. A change in investor sentiment during periods of economic distress may lead investors to consider investing in gold, as gold tends to hold its value over time.

Many asset classes such as stocks and bonds tend to move in the opposite direction. Gold is positively correlated to these assets. The economic forces which determine the price of gold are divergent to the forces that determine other financial assets.

According to Shishko (1977), Johnson and Soenen (1997), Davidson, Faff and Hillier (2003) gold is an efficient hedge against inflation, political unrest and currency risk, which all affect the equilibrium price of this metal. Kaufman and Winters (1989) reiterate gold's role as a hedging device and comment that since gold holds its value over time, the price of the yellow metal should rise with inflation. Chua (1990), states that gold's most important contribution is the ability to maintain value during financial crisis. In addition, if the dollar falls in value, gold prices traditionally rise. Van Eeden (2000), states that the price of gold is dependent on the U.S. dollar. When the dollar

declines the dollar denominated price of gold rises. This is true since in this paper the regression showed us that where there is an increase in the euro exchange rate, i.e. the fall of the dollar, there is an increase in the gold price.

Faugere and Van Erlach (2004), offer a gold asset pricing theory that treats gold as a store of wealth. They demonstrate a theoretical and empirical link between the gold price, inflation, and foreign exchange rates and the general valuation of the stock market. Their approach is based on a generalization of Required Yield Theory. Required Yield Theory explains the valuation of financial assets via investors' general requirement to earn a minimum expected after tax real return equal to long term GDP per capita growth.

They argue that since gold fulfills the unique function of a global store of value, its yield must vary inversely to the yield required by financial asset classes, thus providing a hedge in the case where many assets are losing their value.

The extant literature has well documented empirical relationships between gold prices and global macroeconomic variables such as inflation and currency exchange rates. For example, Sjaastad and Scacciavillani (1996) show that after excluding the sharp rise in gold prices in the early 1980's, about half of the variance in USD gold prices during the period 1982-1990 appears to be accounted by fluctuation in exchange rates. Ghosh (2002) found that gold is an inflation hedge in the long run. He further attempted to justify short-term gold prices volatility by appealing for example to changes in the real interest rate and the price of the dollar vs. the rest of the world exchange rates fluctuations.

On the other hand, Lawrence (2003) states that there is no statistically significant correlation between real returns, i.e. percentage change, on gold and changes

in macroeconomic variables such as GDP, inflation and interest rates, and return on gold is less correlated with returns on equity than are the returns of other commodities. On the other hand Coyne (1976) focuses primarily on gold as a hedging instrument and finds that for periods in which the gold market was free to fluctuate, gold tended to move in a direction opposite to the price of other financial assets.

Throughout the history of civilization, gold has been the single most global store of value. To this day, it fulfills this unique function. This is why analysts say that gold is a safe haven investment.

Faugere and Van Erlach (2004) postulated the following conditions. First, the global real price of gold essentially is a real price earning ratio for gold. This means that gold is considered as a stock. It should have a high P/E. Second, because of the law of one price, all around the world the gold price is the same. The market decides the price and organizes the trade. Third, the world wide stock per capita should be stable, as it was explained above.

Given the above conditions, Faugere and Van Erlach (2004) introduce their model. They theoretically show that at any point in time, all the investors expect a certain profit from their investments. This profit equals to the average GDP/capita of the country that the investors lives in plus the expected inflation. That is given by:

$$RY_{wt+1} = g_w + \pi_{wt+1}$$

Where RY_{wt+1} is the global required yield, g_w stands for the global GDP/capita long-term growth rate and π_{wt+1} is expected global inflation rate.

If P_{wt} represent gold's real price, then P_{wt} equals the following:

$$P_{wt} = C \times RY_{wt+1} / (1 + \pi_{wt+1})$$

This shows that the gold's real price equals a linear function of required yield up to a multiplicative constant C. They explained with this function that the real price of gold will decrease when global inflation accelerates, something that we will prove in our analysis. The real price of gold will be constant as long as inflation and productivity remains constant. So the nominal price of gold will rise with the price level.

To extend the above result to local currency denominated gold prices, they take into account the relative importance of each country in the global economy as well as the effect of exchange rates. This shows that in general, as the domestic currency depreciates, the real domestic gold price appreciates.

Faugere and Van Erlach (2004) also discuss the cost approach to determine the price of gold. They show that the required yield theory can explain the absolute price of gold bullion via the average production cost. They assume that the gold mining industry has achieved its long-run maximum efficient capacity, and since the industry has large barriers to entry, the real profit is the long-run global GDP/capita growth rate of 1.5%. The reason why long-run GDP/Capita growth rate determines the industry's profit margin is that the long run average industry margin must be equal to the long-term average corporate profit margin, otherwise the quantity supplied would change to bring this relationship into line.

The authors, Faugere and Van Erlach, say that during the gold standard era, outside periods of severe inflation, the fixed convertibility of dollars into gold made it unnecessary for investors to hold gold as a precautionary motive or as safe haven. While, they say that we should remember that the high inflation at the beginning of the seventies was responsible for the large depletion of the U.S. government gold reserves and eventual collapse of the gold standard.

Barsky and Summers (1984), conclude that the real price of gold does not change when the real interest rate remains constant. While this paper clearly shows that even a small movement in inflation rates will affect the gold price.

Faugere and Van Erlach (2004), have omitted some factors. The paper did not examine central bank activities, hedging activities, supply and demand changes, and global tax changes.

They conclude the paper by stating that as long as global assets are priced to yield a global constant real return and since gold is global store of value, its price will vary directly with the global required yield and global inflation rate.

CHAPTER III

RESEARCH METHODOLGY

This research will entail discovering significant determinants of the gold price, depending on clear hypotheses testing. The research will be of an exploratory descriptive nature. It will involve secondary data collection. Hypotheses will be set based on a combination of historical review and personal experience in the gold field. Analysis will be made based on the use of SPSS version 10. Interpretation of the result will be based on different regression analyses.

a) Data collection:

The secondary data used in this project was of two types, and collected from different sources.

The first type was the daily gold prices, Euro exchange rates, and the Brent price for two hundred forty four days, extending from May 4, 2004 till April 29, 2005, which covers 244 working days. This information were collected from the following web sites:

a. http://kitco.com (Kitco company which is the world's premier retailers of precious metals)
b. http://www.oanda.com/convert/fxhistory (Oanda.com specialized in currencies)
c. http://www.eia.doe.gov/emeu/international/petroleu.html. (Energy Information Administration, specialized in energy statistics)

The second type was the Consumer Price Index (CPI) and the Dow Jones Industrial Average (Dow). The data for these two were collected from January 1997 till March 2005 thus covering ninety nine months. We selected the monthly average for the Dow Jones Industrial Average because no daily reliable source on daily data was available. While the for the CPI data, there was no other choice since the CPI data was only on a monthly basis. These data were collected from the following sites:

a. http://inflationdata.com (inflationdata.com, specialized in all forms of information about the nature of inflation)
b. http://www.djindexes.com (Dow Jones Indexes, specialized in the historical Dow Jones industrial averages)

For the data to be compatible and for the regression analysis to be well run, we found out the monthly data by taking the averages of the daily data for each month, covering from January 1997 till March 2005, thus covering ninety nine months.

For the gold prices we took the London p.m. fix and when we needed the gold price on a monthly basis, we took the monthly average of the London p.m. fix.

b) Hypotheses:

Based on the literature review, this paper will try to test the following hypotheses:

H_1: Gold is an efficient hedge against inflation, which affects the equilibrium price of this metal. The nominal price of gold will rise with the CPI.

H_2: The price of gold is dependent on the U.S. dollar. If the dollar falls in value, gold prices traditionally rise.

H_3: Gold tends to move in a direction opposite to the Dow Jones Industrial Average.

H_4: Gold price increases as the price of the Brent increases.

c) Tests to be used:

Simple and multiple regression analysis were run in this paper, to test for the relationship between gold and Euro exchange rate, the Brent, inflation and the Dow Jones Industrial Average. Then multiple regression analysis was run to test for the relationship between the gold price and all the independent variables taken all together.

The data that were collected during this project were time series data. The lag of the dependent variable was used in some parts to provide more precise parameter estimates in time series data.

The logarithmic transformation method was also used in this project. The most common transformation that was used was to transform the dependent variable and the independent variable by taking their logarithm. Natural logarithms were used, which means that they use the base e, which is approximately 2.71828.

There are two reasons to use the transformation. First, the gold variable is never negative. The logarithmic transformation guarantees that regardless of the value of the constant or the coefficient, the predicted value of the dependent variable will always be a positive number.

Second, the linear model says that the effect of increasing a given independent variable by one unit is to produce a certain absolute change in the dependent variable.

The logarithmic model, by contrast, says that the effect of changing the independent variable by one percent is to produce a certain percentage change in the dependent variable. This makes more sense sometimes.

CHAPTER IV

RESULTS & ANALYSIS

Regression is a statistical method for studying the relationship between a single dependent variable and one or more independent variables. It is one of the most statistical used techniques in all researches.

There are two major uses for multiple regression: prediction and causal analysis. We are interested in this paper in the prediction about our dependent variable, which is the gold price.

The aim of the study is to determine whether our independent variables affect the price of gold and to estimate the magnitude of that effect.

We will cover in this paper the simple regression analysis and the multiple linear regression analysis.

It follows that:

$$Y_t = a + bX_t + \varepsilon_t$$

In this equation, Y is the dependent variable and X is the independent variable. The coefficient a is called the intercept and the coefficient b the slope.

A. Gold & Euro

Many analysts relate the change in gold price to the change in the exchange rate of the Euro. To find out if this relation is correct, we did a regression analysis taking gold as the dependent variable and the Euro exchange rate to the dollar as the independent variable.

The Euro is the exchange rate with the dollar, i.e. one Euro equals so many dollars.

i) Our regression analyzed data on a daily bases from 04/05/04 to 29/04/05 which made a sample of 244 working days. Table 1.1 shows the results of the regression.

$$Y_t = 51.925 + 289.249\, X_t + \varepsilon_t$$

We start the interpretation of the table by the adjusted R-square, which is 0.163. This indicates that 16.30 percent of the total variation is explained by the Euro exchange rate.

The Durbin-Watson of the regression is 2.017.This shows that the error terms are not serially correlated. This means that we fail to reject the null hypothesis of no serial correlation.

Then we are interested in testing if there is a linear association between the change in gold price and the change in the Euro exchange rate. This is done by testing the following hypothesis.

H_0: $b = 0$

H_a: $b \neq 0$

Since the t-statistic is 6.959 > 1.960, i.e. greater than the critical t-statistic, i.e. we conclude H_a, that $b \neq 0$ or that there is a linear association between Y and X. while

the t-statistic for the constant is less than the critical value this means that is not statistically significant.

The last figure still not discussed in this part is the elasticity. The elasticity of this regression is obtained by the following formula.

Elasticity = (change of Y / change of X)*(average X / average Y).

Here we get a figure of 0.8759, this means that an increase of 1 percent in the exchange rate will lead to an increase of 0.8759 percent in gold price.

Table 1.1

	sample size	244	**Averages**	
	Frequency	daily	**Gold**	418.47
	independent var.	Euro	**Euro**	1.2672
	dependent var.	Gold		
	Constant	**slope**		
Coefficient	51.925	289.249		
t-stat	0.985	6.959		
Prob.	0.326	0		
Std. Error	52.715	41.567		
Elasticity	0.8759			
adj. R square	0.163			
Durbin-Watson	2.017			

ii) In this part we are using the transformations, i.e. logarithmic transformation. The regression of $Y_t = a + b X_t + \varepsilon_t$ is transformed into $\log Y_t = a + b \log X_t + \varepsilon_t$.

For both descriptive and prediction purposes, we can find parameter estimates and all other information regarding this equation, in table 1.2.

Table 1.2

	sample size	244	**Averages**	
	Frequency	daily	**LN Gold**	6.0341
	independent var.	LN Euro	**LN Euro**	0.2361
	dependent var.	LN Gold		
	Constant	**slope**		
Coefficient	5.81	0.949		
t-stat	265.622	10.383		
Prob.	0	0		
Std. Error	0.022	0.091		
adj. R square	0.305			
Durbin-Watson	1.96			

The regression line turns out to be the following:

$$\log Y_t = 5.81 + 0.949 \log X_t + \varepsilon_t$$

Let the two tailed significant level, here also, be equal to 0.05. The sample of data for 244 days was again collected from 04/05/04 to 29/04/05.

The adjusted R-square value for this regression is 0.305. This indicates that the model, as whole, explains 30.5 percent of the variation in the dependent variable.

Now we wish to use the Durbin-Watson statistic to test the significance of a positive, first order autocorrelation for errors when Y is used in a linear regression with X, using the significance level 0.05.

The hypothesis test is as follows.

H_0: The regression has no serial correlation

H_a: The regression has a serial correlation

Since Durbin-Watson test equals 1.96, which is very close to 2. This means that the error terms are not serially correlated.

Then we test if the parameters are significant. This is done by looking for the t-statistics. The t-statistics for the constant and the slope are 265.622 and 10.383 respectively. Since they are both higher than the cutoff rate of 2, it implies that they are both statistically significant.

To test whether the slope is statistically different from one, we have to calculate the t-statistic by taking the coefficient minus one and divide it by the standard error. The standard error of the slope is calculated by the SPSS.

t-statistic = (0.949 – 1) / 0.091 = -0.56

Since the criteria to reject the null hypothesis that the slope equal to one is for t-statistic to be < |-2|, then we accept the null hypothesis that the beta is not significantly different from one.

On average log Y will equal to the constant when log X equals to zero, this means that when the exchange rate of the Euro to the dollar is one, this implies that the gold price (Y) will equal to $e^{5.81} = 333.62$ dollars per ounce.

At the end of this part we can say that any change in the Euro exchange rate affects the price of gold and we can predict the price of gold by knowing the new exchange rate of the Euro.

B. Gold & CPI

Gold is said to be a safe haven for investors. Investors always turn their investments to gold when they notice that the value of their investments is depreciating. They think that gold will be a good shelter since it is known that gold never loses its value.

The regression was carried out on the SPSS, and the output can be seen in the tables 2.1 through 2.5.

i) The first regression is done by taking gold as the dependent variable (Y), and taking CPI as the independent variable (X). Table 2.1 and table 2.2 shows the results of the regression.

We get the following linear equation:

$$Y_t = -229.313 + 3.15\ X_t + \varepsilon_t$$

Statistically, the relationship is significant. The coefficients of determination, i.e. the Adjusted R-square is reasonable (adj. R-square = 0.377), implying a rather good fit.

The t-statistics of the slope and the constant are significant, since both are higher than 1.96. This implies that the relationship has a low chance of being disproved.

The null hypothesis is rejected, that is H_a: $b \neq 0$. So there is a linear association between the change in gold price and the change in the CPI.

The Standard Error of the Estimate is 0.406, which is low. The ANOVA test is significant while the elasticity is high. Under the usual circumstances, the overall regression can be considered as successful. The Durbin-Watson is 0.07. To get the critical value for the Durbin-Watson statistic at a 5 percent and an n=99 we look to the

Durbin-Watson table. The upper and the lower critical values are found to be $d_l = 1.63$ and $d_u = 1.72$ respectively. Since Durbin-Watson is less than d_l (i.e. $0.07 < 1.65$), we reject the null hypothesis and conclude that the regression has a positive serial correlation among the error terms. This means that, in any one period, the current error term contains not only the effects of current shocks but also the carryover from previous shocks.

Table 2.1

	sample size	99	**Averages**	
	Frequency	monthly	**CPI**	174.5152
	independent var.	CPI	**Gold**	320.47
	dependent var.	Gold		
	constant	**slope**		
coefficient	-229.313	3.15		
t-stat	-3.235	7.768		
Prob.	0.002	0		
Std. Error	70.892	0.406		
Elasticity	1.715			
adj. R square	0.377			
Durbin-Watson	0.07			

Table 2.2

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	96811.119	1	96811.119	60.339	.000[a]
	Residual	155633.1	97	1604.465		
	Total	252444.3	98			

a. Predictors: (Constant), CPI

b. Dependent Variable: GOLD

To explain the regression equation we can say that a one unit base increase in the consumer price index level will lead to an increase of 3.15 dollars per ounce. Another explanation is that a one percent increase in the consumer price index will lead to an increase in the gold price by 1.715 percent. This shows that investors should use gold as a safe haven to secure their wealth from depreciating.

ii) A second independent variable is entered to the regression so that is becomes a multiple regression. The regression analyzed data from January 1997 to March 2005.

The results of the regression are found in table 2.3.

$$Y_t = -52.803 + 0.388\ X_t + 0.956\ Y_{t-1} + \varepsilon_\tau$$

Where Y_{t-1} stands for lag of Y, and the variables are auto correlated because the time series is correlated with itself at lag one month period.

An economic model that gives rise to a geometric lag is the partial adjustment model. Suppose that Y_t^* is the optimal price of gold at time t. X_t is one of independent variables and if Y_t is the actual price of gold, then a possible adjustment is

$$Y_t - Y_{t-1} = \delta\ (\ Y_t^* - Y_{t-1}\ )$$

Where $0 < \delta < 1$ is an adjustment coefficient. The equation above indicates that the change in the gold price from period t-1 to period t is a fraction of the difference between the actual price of gold Y_{t-1} and the optimal gold price Y_t^*.

Suppose the optimal price of gold is a function of the X_t,

$$Y_t^* = \alpha + \beta X_t + e_t$$

We substitute this equation in the first equation and we get the following

$$Y_t - Y_{t-1} = \delta (\alpha + \beta X_t + e_t - Y_{t-1})$$

$$Y_t - Y_{t-1} = \delta\alpha + \delta\beta X_t - \delta Y_{t-1} + \delta e_t$$

Solving the equation for Y, we have

$$Y_t = \delta\alpha + (1 - \delta) Y_{t-1} + \delta\beta X_t + \delta e_t$$

$$Y_t = \beta_1 + \beta_2 Y_{t-1} + \beta_3 X_t + \nu_t$$

The significant thing here is that the error term ν_t does not involve e_{t-1} and it is not correlated with the lagged dependent variable Y_{t-1} on the right hand side of the equation. Thus , the least square procedure can be used to consistently estimate the parameters of

$$Y_t = \beta_1 + \beta_2 Y_{t-1} + \beta_3 X_t + \nu_t$$

This justifies the inclusion of the lagged dependent variable in the regression.

The R-square is significantly very high. This shows that the total variance is explained by 96 percent when the CPI and the lag gold are introduced, implying a good fit. We can notice that by introducing the lag variable the adjusted R-square increased, which helps to increase the percentage of total variation explained by the CPI.

We calculate the Durbin's h for this regression because we have the lag:

Durbin's h = $(1 - d/2) * (n / (1 - ns^2))^{1/2} = 0.706 < 2$.

The Durbin's h test equals 0.706 for this regression. Upon looking to the critical Durbin's h, we notice that the critical Durbin's h is equal to two and Durbin's h is less than the critical value. Therefore we can say that there is no serial correlation, i.e. we do not reject the null hypothesis that says the regression has no serial correlation.

Table 2.3

	sample size	99		**Averages**	
	Frequency	Monthly		**CPI**	175
	independent var.	CPI	Lag Gold	**Gold**	320
	dependent var.	Gold			
	constant	**slope**	**Lag gold**		
coefficient	-52.803	0.388	0.956		
t-stat	-2.775	2.966	36.672		
Prob.	0.007	0.004	0		
Std. Error	19.028	0.131	0.026		
elasticity	0.2113				
adj. R square	0.96				
Durbin-Watson	1.863				
long run elasticity	4.802				
Durbin's h	0.706				

The t-statistics of the coefficients are -2.775 and 2.966 and they are higher than the critical t-statistics of an alpha 0.05. So we reject the H_0 and conclude that the coefficients are different than zero, i.e. the coefficients have a significant effect.

The elasticity of this regression is equal to 0.2113. This means that an increase of one percent of CPI will lead to an increase of 0.2113 percent in the gold price. While the long run elasticity equals to 4.802.

Long run slope = $((0.388)/(1 - 0.956)) = 8.818$.

iii) In this section we transform the regression equation of the first part, to alter the relationship between the dependent variable and the independent variable. The transformed relationship is sometimes more appealing than the original, linear relationship.

Table 2.4

	sample size	99	**Averages**	
	Frequency	Monthly	**LN CPI**	5.1604
	independent var.	LN CPI	**LN Gold**	5.7581
	dependent var.	LN Gold		
	Constant	**slope**		
coefficient	-2.146	1.532		
t-stat	-1.902	7.005		
Prob.	0.06	0		
Std. Error	1.128	0.219		
adj. R square	0.329			
Durbin-Watson	0.071			

The most common transformation of the dependent variable is to take its logarithm. This gives us the equation.

$$\log Y_t = -2.146 + 1.53 \log X_t + \varepsilon_t$$

The results for this regression are found in table 2.4.

These results are similar to those we got for the strictly linear model. The new adjusted R-square is 0.329, while the adjusted R-square for the linear model was 0.377.

The coefficient of the slope has a high t-statistic which makes it highly significant. This means that a 1 percent increase in CPI will lead to an increase of 1.532 percent in the gold price. Only the Durbin-Watson statistics is low, it is equal to 0.071,

and thus the low value for the Durbin-Watson statistic implies that the model errors are positively correlated.

The Durbin-Watson hypothesis test is:

H_0: The errors from one period to the next period do not exhibit positive correlation.

H_a: The errors from one period to the next period imply a positive autocorrelation.

Durbin-Watson is < Durbin-Watson's lower critical value, 1.65. For this reason we conclude H_a and reject the null hypothesis.

iv) In the last section of this part we transform the regression line $Y_t = -52.803 + 0.388\ X_t + 0.956\ Y_{t-1} + \varepsilon_t$, to a logarithmic function of $\log Y_t = -0.753 + 0.198 \log X_t + 0.953 \log Y_{t-1} + \varepsilon_t$.

The results of this regression is found in table 2.5

Let the significant level be equal to 0.05, two tailed. A sample of 99 working months was been collected from January 1997 till March 2005, to estimate this regression equation.

The adjusted R-square value for this regression is 0.956. The new adjusted R-square is significantly higher than the adjusted R-square of the regression that does not include the lag variable. This indicates that the model explains 95.6 percent of the variation in the dependent variable.

Table 2.5

	sample size	99		**Averages**	
	Frequency	Monthly		**LN CPI**	5.16
	independent var.	LN CPI	Lag LN Gold	**LN Gold**	5.76
	dependent var.	LN Gold			
	constant	**slope**	**Lag LN Gold**		
coefficient	-0.753	0.198	0.953		
t-stat	-2.518	2.868	36.053		
prob.	0.013	0.005	0		
Std. Error	0.299	0.069	0.026		
adj. R square	0.956				
Durbin-Watson	1.879				
long run elasticity	3.775				
Durbin's h	0.623				

When time series data are used in the regression analysis, the effect of the error or residual in one period often carries over subsequent period. The Durbin's h hypothesis test was executed, since we have the lag variable, to find out if there is an autocorrelation for the errors.

The hypothesis test is as follows:

H_0: The errors from one period to the next period do not exhibit positive correlation.

H_a: The errors from one period to the next period imply a positive autocorrelation.

The Durbin's h was calculated as following:

Durbin's h = $(1- 1.879/2)*(99/(1-99(0.026)^2))^{1/2} = 0.623$

The value of Durbin's h is computed from the data and it is less than two, then we do not reject H_0.

Then we test for the significance of the slope, if it is different from one. The t-statistics of the coefficient is calculated by the following method.

t-statistics = $(0.198 - 1) / 0.069 = -11.623$

The absolute t-statistics is higher than two, i.e. we reject the null hypothesis and accept the alternative hypothesis that the coefficient of the slope is significantly different than one.

The 0.198 means that a one percent increase in CPI will lead to an increase if 0.198 percent in the gold price. While the long run elasticity is equal to 3.775. one percent increase in CPI will lead to an increase of 3.775 percent in the long run.

C. Gold vs. Brent

With respect to Adam Hamilton (April 1, 2005), oil and gold are the most important commodities on the planet today and the ratio of their nominal prices is far from a trivial issue. The gold/oil ratio expresses the interrelationship between the commodity that forms the foundation of our entire global economy and the commodity that has been the ultimate form of money for a long time of human history.

Oil forms the foundation of extensive global trade today and hence the world economy. Virtually everything that we consume in the world is transported via oil-powered ships, trains, airplanes, or trucks. Without oil, the global logistic network system will halt. The world will turn back to the medieval ages.

On the other side, gold has been and always will be the ultimate monetary standard. Gold is the standard by which many of the world currencies are judged. The gold supply in nature is scarce so its supply can't be inflated, and it's very valuable with respect to its size. Economists sometimes call the gold the perfect money.

i) To determine the relationship between gold and oil, if there is, we take a sample of 243 working days from 04/05/04 to 29/04/05. The analyzed data were the London p.m. fix and the closing rate of the Brent price per barrel.

Table 3.1 shows the outcome of the regression analyzed.

The equation of this regression is as follows:

$$Y_t = 352.379 + 1.505\ X_t + \varepsilon_t$$

Table 3.1

	sample size	243	**Averages**	
	Frequency	daily	**Gold**	418.47
	independent var.	Brent	**Brent**	43.09
	dependent var.	Gold		
	Constant	**slope**		
coefficient	352.379	1.505		
t-stat	19.926	3.766		
Prob.	0	0		
Std. Error	17.684	0.4		
elasticity	0.1550			
adj. R square	0.051			
Durbin-Watson	1.769			

The adjusted R-square of this regression is 0.051. This is not a large figure. This indicates that 5.10 percent of the total variation is explained by the Brent price.

The Durbin-Watson hypothesis test is:

H_0: The errors from one period to the next period do not exhibit positive correlation.

H_a: The errors from one period to the next period imply a positive autocorrelation.

Durbin-Watson is very close to Durbin-Watson's critical value, 1.769. For this reason we conclude H_0 and reject the alternative hypothesis.

We can notice in table 3.1 that the t-statistics of the constant and the slope are 19.926 and 3.766 respectively. This makes the two highly significant.

Then the following hypothesis is tested:

H_0: $b = 0$

H_a: $b \neq 0$

The t-statistic for the coefficient of the slop is 3.766 which is higher than 1.960. This means that we conclude the alternative hypothesis, which admits that there is a linear association between the gold price and the Brent price.

The elasticity figure tells us that a one percent increase in the price of the Brent will lead to an increase of 0.155 percent in gold price.

ii) The logarithmic transformation is used in this regression. We transform the regression of gold with respect to Brent, and it becomes as the following:

$$\log Y_t = 5.366 + 0.177 \log X_t + \varepsilon_t$$

The outcome of this regression analysis is found in table 3.2.

The transformation of the regression was very helpful to our study, since it increased the adjusted R-square from 0.051 to 0.106. Now the model explains 10.5 percent of the variation in the dependent variable.

We can also notice that the slope of this regression equation is 0.177 and it is very close to the slope of the regression equation that we had before the transformation.

The Durbin-Watson hypothesis test is:

H_0: The errors from one period to the next period do not exhibit positive correlation.

H_a: The errors from one period to the next period imply a positive autocorrelation.

Durbin-Watson is < Durbin-Watson's lower critical value, 1.511. For this reason we conclude H_a and reject the null hypothesis

The two parameters of the regression line are highly significant since their t-statistics are both higher than the cutoff rate of two.

Table 3.2

	sample size	243	**Averages**	
	Frequency	daily	**LN Gold**	6.0341
	independent var.	LN Brent	**LN Brent**	3.7744
	dependent var.	LN Gold		
	Constant	**slope**		
coefficient	5.366	0.177		
t-stat	43.847	5.461		
Prob.	0	0		
Std. Error	0.122	0.032		
adj. R square	0.106			
Durbin-Watson	1.511			

To test as whether the slope of the line is statistically different than one, we conduct a hypothesis test.

t-statistic = (0.177 – 1) / 0.032 = -25.72

Since the criteria to reject the alternative hypothesis that the slope is different from one is for t-statistic to be $> | 2 |$, then we accept the alternative hypothesis the slope is significantly different from one.

The elasticity of the regression line is equal to 0.177. A one percent increase in the price of one barrel of Brent will lead to an increase of 0.177 percent in the price of gold.

iii) We add a lag variable to the last regression line, $\log Y_t = 5.366 + 0.177 \log X_t + \varepsilon_t$, it turns to:

Table 3.3

	sample size	243		**Averages**	
	Frequency	daily		**LN Gold**	6.03
	independent var.	LN Brent	Lag LN Gold	**LN Brent**	3.77
	dependent var.	LN Gold			
	constant	**slope**	**Lag LN Gold**		
coefficient	4.034	0.134	0.247		
t-stat	11.348	4.037	3.973		
Prob.	0	0	0		
Std. Error	0.206	0.071	0.002		
adj. R square	0.158				
Durbin-Watson	2.103				
long run elasticity	0.1113				
Durbin's h	-0.8032				

$$\log Y_t = 4.034 + 0.134 \log X_t + 0.247 \log Y_{t-1} + \varepsilon_t$$

The adjusted new R-square is even higher than before at 0.158. The given variable can explain now 15.8 percent of the variation in the gold price.

All the coefficients of the regression line are statistically higher than aero, since their t-statistics are all significantly higher than the critical value of 2.

The slope is tested to be different than one. So we need the t-statistic for the slope.

t-statistic = (0.134 – 1) / 0.071 = -12.20

The absolute t-statistic is higher than the critical t-statistic; we reject the null hypothesis that the coefficient of the slop is not significantly different than one.

The long run slope is equal to ((0.134) / (1 – 0.247)) = 0.178.

Durbin's h = (1- d/2) * (n / (1 – ns^2))$^{1/2}$ = -0.8032 < |2|, there is no serial correlation, we do not reject the null hypothesis.

D. Gold & Dow

There are analysts, like Mr. Richard Russell, who wrote a paper on the relationship between the Dow and gold on April 12, 2005 in the edition of Richard's Remarks. Mr. Russell tells us that the ratio of Dow to gold had dropped to one to one, i.e. one share of the Dow buys one ounce of gold. The Dow/gold ratio climbed a record high of just over 40.

A lot of analysts think that there is a relation between these two. Here we will do a regression analysis to find whether there is a relation or not between the two.

i) Our regression analyzed data form January 1997 to March 2005, taking the average Dow of each month, as independent variable, with the gold average London p.m. fix of each month as the dependent variable.

Table 4.1 gives us the results of this regression analysis.

$$Y_t = 351.53 - 0.0033\ X_t + \varepsilon_t$$

We can directly see from the table 4.1, that the adjusted R-square is approximately equal to zero. This implies that there is no liner association between the average Dow and the price of gold in the sample of data, and the Dow variable is of no help in reducing the variation in the observation of the gold with linear regression.

Table 4.1

	sample size	99	**Averages**	
	Frequency	monthly	**Gold**	320.47
	independent var.	Dow	**Dow**	9526.59
	dependent var.	Gold		
	Constant	**slope**		
coefficient	351.53	-0.0033		
t-stat	8.3	-0.747		
Prob.	0	0.457		
Std. Error	40.828	0.004		
elasticity	-0.0981			
adj. R square	-0.005			
Durbin-Watson	0.042			

ii) To increase the adjusted R-square we enter the lag variable to the above equation so that it becomes as follows:

$$Y_t = -6.724 + 0.001\ X_t + 1.004\ Y_{t-1} + \varepsilon_t$$

The output of this regression analysis is found in table 4.2

The first thing that we notice is the high adjusted R-square. The adjusted R-square has moved to 0.957, after adding the lag variable, which is very high. Now the we can say that 95.7 percent of the total variation is explained by the regression.

The coefficients of the regression line are not all statistically significant since they are 0.573 and 0.715 are not greater than the cutoff rate of two. Only the t-statistic of the lag variable is greater than the cutoff rate and it is equal to 46.175.

Table 4.2

	sample size	99		**Averages**	
	Frequency	Monthly		**Gold**	320.5
	independent var.	Dow	Lag gold	**Dow**	9527
	dependent var.	Gold			
	constant	**slope**	**Lag gold**		
Coefficient	-6.724	0.001	1.004		
t-stat	-0.573	0.715	46.175		
Prob.	0.568	0.476	0		
Std. Error	11.727	0.001	0.022		
Elasticity	0.0178				
adj. R square	0.957				
Durbin-Watson	1.801				
long run slope	-1.003				
Durbin's h	1.015				

We test the hypothesis for the coefficient of the slope if it is different from zero.

H_0: $\beta = 0$

H_a: $\beta \neq 0$

t-statistic is 0.715 < 1.960, so we conclude the null hypothesis, that there is no linear association between The Dow and the gold price.

The Durbin's h is equal to 1.015, which is lower than the critical Durbin's h. This means that we fail to reject the null hypothesis and that there is no serial correlation among the error terms.

Elasticity of the regression is equal to 0.0178. This means that a one percent increase in the Dow average will lead to an increase of 0.0178 percent in the gold price.

While the long run slope elasticity implies that an increase of one percent in the Dow index will lead to a decrease the gold price by 1.003 percent.

iii) In this part, we transformed the regression equation into a logarithmic equation.

$$\log Y_t = 7.052 - 0.142 \log X_t + \varepsilon_t$$

Again, we notice that the adjusted R-square is not significant. It is very close to zero. This implies that there is no liner association between the log of the average Dow and the log of the price of gold in the sample of data, and the Dow variable is of no help in reducing the variation in the observation of the gold with linear regression.

The results of the regression are found in table 4.3

Table 4.3

	sample size	99	**Averages**	
	Frequency	Monthly	**LN Gold**	5.758
	independent var.	LN Dow	**LN Dow**	9.154
	dependent var.	LN Gold		
	constant	**slope**		
coefficient	7.052	-0.142		
t-stat	6.507	-1.195		
Prob.	0	0.235		
Std. Error	1.084	0.118		
adj. R square	0.004			
Durbin-Watson	0.047			

E. Gold with all the independent variables

In the previous parts, we examined the relationship between the gold price and other independent variables. However, we are interested in the relationship between the gold price and all the independent variables Brent, Dow, Euro exchange rate and the CPI.

One way to study the relationship between a dependent variable and two or more independent variables is multiple regression. Our predictions of our determinant variable can be made more accurate by using all the dependent variables.

i)We take gold as the dependent variable, while all the others as dependent variables

In this part we use the SPSS to compute the multiple regression and the results are presented in tables 5.1 and 5.2

Table 5.1

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	231564.6	4	57891.157	272.790	.000[a]
	Residual	19736.371	93	212.219		
	Total	251301.0	97			

a. Predictors: (Constant), BRENT, EURO, DOWAV, CPI

b. Dependent Variable: GOLD

Table 5.2

	sample size	99				**Averages**
	Frequency	monthly				**Gold**
dependent var.	Gold					320.47
independent var.	CPI, Dow, Brent & Euro					
	constant	**slope CPI**	**slope Dow**	**slope Euro**	**slope Brent**	
coefficient	-175.46	1.617	-0.009	237.2	1.973	
t-stat	-3.779	5.654	-6.086	18.52	5.918	
prob.	0	0	0	0	0	
Std. Error	46.43	0.286	0.002	12.81	0.333	
elasticity		0.881	-0.268	0.788	0.154	
adj. R square	0.918					
Durbin-Watson	0.495					
Averages		174.5	9527	1.065	24.96	

The multiple regression equation that we get is the following:

$$Y_t = -175.459 + 1.617\,X_{1t} - 0.00927\,X_{2t} + 237.169\,X_{3t} + 1.973\,X_{4t} + \varepsilon_t$$

Y_t = The price of one ounce of gold at time t.

X_{1t} = The CPI index at time t.

X_{2t} = The Dow index at time t.

X_{3t} = The Euro exchange rate to the dollar at time t.

X_{4t} = The Brent price at time t.

ε_t = The error term at time t.

The coefficients of the regression are all statistically significant and can be interpreted as follows:

a) With each one point increase in CPI, gold price goes up, on average by 1.617 dollars, assuming all the other variables are held constant.

b) With each one point increase in Dow, gold price will decrease, on average by 0.00927 dollars, assuming all the other variables are held constant.

c) With each one point increase in the Euro exchange rate, gold will increase, on average by 237.20 dollars, assuming all the other variables are held constant.

d) With each one dollar increase in the Brent price, gold will increase, on average by 1.973 dollars, assuming all the other variables are held constant.

The elasticity of the slopes can be interpreted as follows:

a) The elasticity of the slope of CPI is 0.818, this means that an increase of 1 percent in the CPI will lead to an increase of 0.881 percent in the gold price.

b) The elasticity of the slope of the Dow industrial average is -0.268, this means that an increase of 1 percent in the Dow industrial average will lead to a decrease of 0.268 percent in the gold price

c) The elasticity of the slope of the Euro exchange rate is 0.788, this means that an increase of 1 percent in the Euro exchange rate will lead to an increase of 0.788 percent in the gold price.

d) The elasticity of the slope of the Brent is 0.154, this means that an increase of 1 percent in the price of Brent will lead to an increase of 0.154 percent in the price of gold.

To test whether gold is related to CPI, Dow, Euro exchange rate and the Brent:

H_o: All the coefficients of the slops are equal to zero.

H_a: One or more of the coefficients of the slops are not equal to zero.

The significant level is 0.05. We can find the F in table 5.1, equal to 272.79. The Critical F is found from the F distribution table, which is about 2.5. Since the value computed for the sample F equals 272.79 is greater than $F_{0.05,4,94} = 2.5$, we reject the null hypothesis. We conclude that all the independent variables are related to the gold price.

Only the Durbin-Watson is small, it is equal to 0.495. Which is less than the lower Durbin-Watson critical, $d_l = 1.59$. So we reject the null hypothesis.

The adjusted R-square is very high equal to 0.918. Thus, when the four variables are considered, the variation in the gold price is reduced by 91.8 percent.

ii) The Durbin-Watson of the regression was too small. To get over this problem we introduce to the regression the lag gold and we get the following:

$$Y_t = - 85.91 + 0.693\ X_{1t} - 0.002\ X_{2t} + 67.13\ X_{3t} + 0.515\ X_{4t} + Y_{t-1} + \varepsilon_t$$

Y_t = The price of one ounce of gold at time t.

X_{1t} = The CPI index at time t.

X_{2t} = The Dow index at time t.

X_{3t} = The Euro exchange rate to the dollar at time t.

X_4 = The Brent price at time t.

Y_{t-1}= The price of gold at time t-1.

ε_t = The error term at time t.

Tables 5.3 and 5.4 give us the results of this regression.

Table 5.4

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	243068.8	5	48613.759	543.289	.000[a]
	Residual	8232.202	92	89.480		
	Total	251301.0	97			

a. Predictors: (Constant), BRENT, EURO, DOWAV, CPI, LAGGOLD

b. Dependent Variable: GOLD

Table 5.3

	sample size	99				**Averages**
	Frequency	monthly				**Gold**
dependent var.	Gold					320.47
independent var.	CPI, Dow, Brent, Euro and lag gold					
	constant	**slope CPI**	**slope Dow**	**slope Euro**	**slope Brent**	**Lag Gold**
coefficient	-85.906	0.693	-0.002	67.13	0.515	0.714
t-stat	-2.756	3.418	-2.506	3.915	2.047	11.339
prob.	0.007	0.001	0.014	0	0.44	0
Std. Error	31.168	0.203	0.001	17.15	0.252	0.063
elasticity		0.377	-0.059	0.223	0.04	
adj. R square	0.967					
Durbin-Watson	1.657					
Averages		174.5	9527	1.065	24.96	
long run elasticity		1.32	-0.208	0.780	0.140	
Durbin's h	2.19					

The fist thing that we notice is that the Durbin-Watson has increased to 1.657. Thus the critical values for the Durbin-Watson are, $d_l = 1.57$ and $d_u = 1.78$. we can say

that the test is inconclusive, since the Durbin-Watson falls between the lower and upper critical values.

Durbin's h = $(1- d/2) * (n / (1 - ns^2))^{1/2} = 2.19 > 2$, there is serial correlation.

The F test for this regression is highly significant. Since the critical value of F0.05,5,93 is equal approximately to 2.29, while the F that we got is equal to 549.289. Thus, we reject the null hypothesis that one or more of the coefficient of the slopes are equal to zero. We notice also that the constant and the coefficients are all significant because the t-statistics of them are all high.

The coefficients of the regression can be interpreted as follows:

a) With each one point increase in CPI, gold price goes up, on average by 0.693 dollars, assuming all the other variables are held constant.

b) With each one point increase in Dow, gold price will decrease, on average by 0.002 dollars, assuming all the other variables are held constant.

c) With each one point increase in the Euro exchange rate, gold will increase, on average by 67.13 dollars, assuming all the other variables are held constant.

d) With each one dollar increase in the Brent price, gold will increase, on average by 0.515 dollars, assuming all the other variables are held constant.

The long run elasticity of the slopes can be interpreted as follows:

a) The long run elasticity of the slope of CPI is 1.32, this means that an increase of 1 percent in the CPI will lead to an increase of 1.32 percent in the gold price.

b) The long run elasticity of the slope of the Dow industrial average is -0.208, this means that an increase of 1 percent in the Dow industrial average will lead to a decrease of 0.208 percent in the gold price

c) The long run elasticity of the slope of the Euro exchange rate is 0.780, this means that an increase of 1 percent in the Euro exchange rate will lead to an increase of 0.780 percent in the gold price.

d) The long run elasticity of the slope of the Brent is 0.14, this means that an increase of 1 percent in the price of Brent will lead to an increase of 0.14 percent in the price of gold.

Comparing the results of the long run elasticity of the table 5.3 with the results of the elasticity of table 5.2, we notice that they are relatively equal.

iii) In this part, we transformed the regression equation into a logarithmic equation:

$$\log Y_t = -0.36 + 0.381 \log X_{1t} - 0.087 \log X_{2t} + 0.221 \log X_{3t} + 0.034 \log X_{4t} + 0.741 \log Y_{t-1} + \varepsilon_t$$

Y_t = The price of one ounce of gold at time t.

X_{1t} = The CPI index at time t.

X_{2t} = The Dow index at time t.

X_{3t} = The Euro exchange rate to the dollar at time t.

X_4 = The Brent price at time t.

Y_{t-1} = The price of gold at time t-1.

ε_t = The error term at time t.

Tables 5.5 and 5.6 give us the results of this regression.

Table 5.5

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.143	5	.429	481.638	.000[a]
	Residual	8.187E-02	92	8.899E-04		
	Total	2.225	97			

a. Predictors: (Constant), LNEURO, LNBRENT, LNDOW, LNCPI, LAGLNG

b. Dependent Variable: LNG

Table 5.6

	sample size	99				**Averages**
	Frequency	monthly				**Gold**
dependent var.	Gold					5.76
independent var.	LNCPI, LNDow, LNBrent, LNEuro and lag LNgold					
	constant	**slope CPI**	**slope Dow**	**slope Euro**	**slope Brent**	**Lag Gold**
coefficient	0.36	0.381	-0.087	0.221	0.034	0.741
t-stat	0.657	3.437	-2.639	3.809	1.97	11.172
prob.	0.513	0.001	0.01	0	0.052	0
Std. Error	0.548	0.111	0.033	0.058	0.017	0.064
adj. R square	0.963					
Durbin-Watson	1.673					
Averages		5.16	9.15	0.236	3.77	
long run elasticity		1.318	-0.536	0.035	0.087	
Durbin's h	2.11					

The fist thing that we notice is that the Durbin-Watson did not change. Thus the critical values for the Durbin-Watson are, $d_l = 1.57$ and $d_u = 1.78$. we can say that the

test is inconclusive, since the Durbin-Watson falls between the lower and upper critical values.

Durbin's $h = (1- d/2) * (n / (1 - ns^2))^{1/2} = 2.11 > 2$, there is serial correlation.

The F test for this regression is highly significant. Since the critical value of F0.05,5,93 is equal approximately to 2.29, while the F that we got is equal to 481.63. Thus, we reject the null hypothesis that one or more of the coefficient of the slopes are equal to zero. We notice also that the coefficients are all significant because the t-statistics of them are all high.

The coefficients of the regression can be interpreted as follows:

a) With each one point increase in CPI, gold price goes up, on average by 0.381 dollars, assuming all the other variables are held constant.

b) With each one point increase in Dow, gold price will decrease, on average by 0.087 dollars, assuming all the other variables are held constant.

c) With each one point increase in the Euro exchange rate, gold will increase, on average by 0.221 dollars, assuming all the other variables are held constant.

d) With each one dollar increase in the Brent price, gold will increase, on average by 0.034 dollars, assuming all the other variables are held constant.

The long run elasticity of the slopes can be interpreted as follows:

a) The long run elasticity of the slope of CPI is 1.318, this means that an increase of 1 percent in the CPI will lead to an increase of 1.318 percent in the gold price.

b) The long run elasticity of the slope of the Dow industrial average is -0.536, this means that an increase of 1 percent in the Dow industrial average will lead to a decrease of 0.536 percent in the gold price

c) The long run elasticity of the slope of the Euro exchange rate is 0.035, this means that an increase of 1 percent in the Euro exchange rate will lead to an increase of 0.035 percent in the gold price.

d) The long run elasticity of the slope of the Brent is 0.087, this means that an increase of 1 percent in the price of Brent will lead to an increase of 0.087 percent in the price of gold.

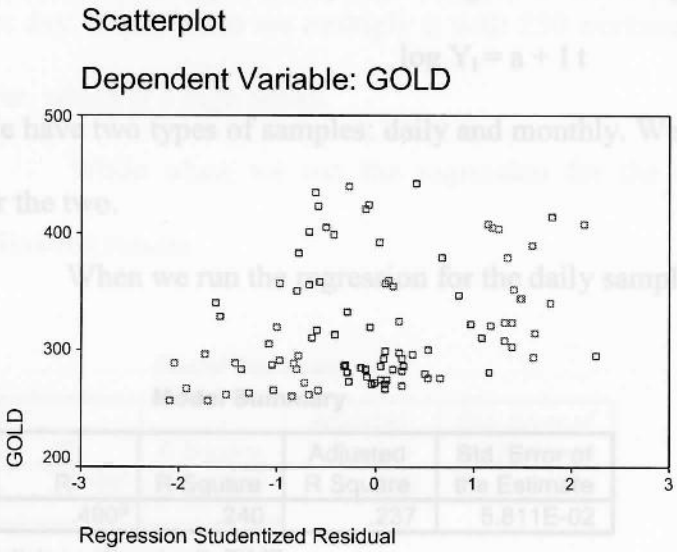
F. Heteroskedasticity

When the economic data generation process is such that the error variance for a regression model is not constant for all observations, we say that the error terms are heteroskedastic. This assumption is reasonable for cross sectional and time series data.

To check for Heteroskedasticity we run the regression but this time we change the method, we choose the stepwise method.

We ask the SPSS to plot the scatter plot (plot 1). We can see from the plot that there is no pattern. This means that there is no Heteroskedasticity.

Plot 1



G. Trend Analysis

When the original data or the smoothed data in a time series show evidence of trend, we should be interested in finding a suitable way to measure and represent this trend. To find the trend we do the following.

$$Y_t = Y_0 (1 + I)^t$$

Y_t : is the price of gold at time t

Y_0 : is the price of gold at time zero

I : is the growth rate

We transform the equation to the following:

$$\log Y_t = \log Y_0 + t \log (1 + I)$$

but $\log (1 + I)$ equals approximately to I since I is small, and since $\log Y_0$ is constant we can replace it by a, so we get the following:

$$\log Y_t = a + I t$$

We have two types of samples: daily and monthly. We should run the regression for the two.

When we run the regression for the daily sample we get the following:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.490[a]	.240	.237	5.811E-02

a. Predictors: (Constant), TIME

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.258	1	.258	76.428	.000[a]
	Residual	.817	242	3.377E-03		
	Total	1.075	243			

a. Predictors: (Constant), TIME

b. Dependent Variable: LNGOLD

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.977	.008		796.018	.000
	TIME	4.617E-04	.000	.490	8.742	.000

a. Dependent Variable: LNGOLD

This shows that gold is appreciating at the rate of I, which is 0.04617% per day. While when we multiply it with 250 working days, we get 11.55% per year, which is a high return.

While when we run the regression for the monthly data we get the following results:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.588[a]	.345	.339	.1229

a. Predictors: (Constant), TIME

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.773	1	.773	51.181	.000[a]
	Residual	1.465	97	1.510E-02		
	Total	2.238	98			

a. Predictors: (Constant), TIME

b. Dependent Variable: LNG

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.604	.025		225.144	.000
	TIME	3.092E-03	.000	.588	7.154	.000

a. Dependent Variable: LNG

Here we can see that gold is appreciating at the rate of I again but this time at the rate of 0.3092% per month. When we multiply it with 12 months, we get that it is equal to 3.71% per year.

I. Omitted Factors

We have omitted in our analysis several factors that could impact the gold price. We did not include GDP changes, supply and demand of gold, political disturbance, tax rate changes, aggregate income and capital gains. All these may affect the gold price.

CHAPTER V

CONCLUSION

This study has demonstrated a number of findings. The paper underlined the importance of the relationship between the gold price, whether with the Euro exchange rate, the CPI, the Dow Jones industrial average, the Brent price, or with all of the above together. It has been shown that the gold price has moved at a pace higher than the CPI, the Euro and the Brent, making gold a good shelter against inflation, while an increase in the Dow industrial average will affect negatively on the gold price. All the other variables move in the same direction except the Dow Jones industrial average. We can explain this by the following: an increase in the Dow Jones industrial average will imply that the stock market is doing well and this will make the investors to shift from the gold market to the stock market. On the other hand that increase in the CPI, Brent and the Euro exchange rate means that there is the risk of inflation. The investor will rush to the gold market and turn their investment into gold, since it is a safe haven. This will lead to an increase in the demand of gold and therefore the price of gold will automatically increase.

We also found out from the trend analysis that the return on gold should be between 3.71% and 11.55%.

Gold is a substitute to stocks and to the dollar. Gold is a hedge against inflation. So, gold is likely to appreciate if there is a recession, hence gold maybe countercyclical.

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