# HAIGAZIAN UNIVERSITY

## THE DETERMINANTS OF GOLD PRICE IN US DOLLARS AND LEBANESE POUNDS

By
LEVON KARIBIAN

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LEVON KARIBIAN

Approved by:

Dr. Samih Azar, Associate Professor — First Reader
Faculty of Business Administration & Economics

Dr. Hassane Saadeh, Assistant Professor — Second Reader
Faculty of Business Administration & Economics

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# AN ABSTRACT OF THE PROJECT OF

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Gold is a scarce commodity and has become a rare metal; currently, 165,000 metric tons of gold exists above ground. Between 1870 and 1900 all major industrial countries, other than China, switched to the gold standard, linking their currencies to gold; hence, the gold standard was adopted. The present research project aims to study and analyze the relationship between gold prices on one hand, and the Brent oil prices, the Dow Jones Industrial Average (DJIA), Consumer Price Index (CPI), and Euro/USD exchange rate, on the other hand. The study manifests numerous findings as well as the interesting and important relationship of the aforementioned assets. Taking into consideration Toros Sajian's (2006) empirical study about the price determinants of gold, a comparison was made and unit root tests were carried out on his sample (January 1997-March 2005), as well as on our sample. Elasticities of the log-levels and levels, with and without lagged dependent variables, were calculated and our estimates were found to be close to his estimates. However, the results of Toros were not reliable because of non-stationarity. This was proved by the Durbin-Watson statistics and the Durbin's h statistics, as well the Augmented Dickey-Fuller tests. Thus, we rejected the null hypothesis that there is no serial correlation in residuals. Furthermore, we conducted the ADF test on the sample of Toros. All the values and their respective probabilities indicated that we do not reject

the null hypothesis that there is a unit root.

Therefore, we estimated regressions in first differences of the logs and thus, we conducted a multiple regression of the first differences of the logs of the four independent variables on the sample of Toros. We found that the USD/EUR exchange rate was the only significant predictor of gold prices. We provided the descriptive statistics for his sample and analyzed the regression. We also tested for normality, linearity, and heteroscedasticity. Later, we conducted an ANOVA F-test to examine whether omitting the insignificant variables was a good choice and thus it was proved to be a good choice. Coming to our sample which ranged from September 1985 till November 2010, we used the same steps. We tested for the hypothesis whether there is at least one independent variable that explains gold price in US Dollars .We found the USD/EUR exchange rate and the Brent oil prices to be the significant predictor of gold prices. The DJIA and CPI were proved to be insignificant predictors of gold price. By taking into consideration the F-test and the ANOVA F-test on the R-Squares on removing the insignificant variables, we failed to reject the null hypothesis that the omitted variables have zero coefficients. However, using the same F-test and ANOVA F-test, we found that there is at least one variable that explains significantly the gold prices. In the last section, again a multiple regression was carried out but by using Lebanese Pounds as the base currency instead of the US Dollars. The variables used were the same variables as before but converted into Lebanese Pounds. As for the exchange rate, the LBP/EUR exchange rate was used instead of the USD/EUR exchange rate. All the variables were significant predictors for gold prices except for the Dow Jones Industrial Average (in LBP). By taking into consideration the F-test and the ANOVA F-test on the R-Squares on removing the insignificant variables, we failed to reject the null hypothesis that the omitted variables have zero coefficients. However, using the same F-test and ANOVA F-test, we found that there is at least one variable that explains significantly the gold prices.

Besides the four independent variables that we used in our study, there are several other indicators that could be taken into consideration in future research, such as world political situation (disturbances, wars, threats, invasions, etc), supply and demand factors, market interest rates, tax rates, jewelry demand. All these are factors that could, most probably, affect gold prices.

# OUTLINE

## I. Introduction

The lure of gold is not without richness or complexities; however, the purity and simplicity of the lustrous metal has led to the downfall of many especially in waged wars and declarations of love. The first documented appearance of gold can be traced back to the 4$^{th}$ millennium BC in the Balkans in the form of artifacts, such as those found in the Varna Necropolis, Bulgaria; essentially, gold's lineage and history, if any, is remnant of the earliest civilizations of man. Despite being an inert material, its relative intrinsic value and unrivalled properties were not matured until the discovery, mining, and refinement by man; in 3600 BC, early Egyptian goldsmiths carried out the first melting of ores in order to separate the precious metal inside creating instant value to the metal. Currently, it is considered a reserve asset, continuously and securely being held in private, governmental, and public vaults all around the world; concurrently, there is a scientific dimension and use of gold, as mentioned shortly below, that results in the increase of value of gold's properties. Bearing the symbol Au from the Latin word "Aurum," gold is a chemical element found in the periodic table with an atomic number of 79; this number signifies the number of protons in the nucleus of every atom of gold. It melts at 1064 degrees centigrade and boils at 2808. Gold is not affected by any kind of atmospheric condition such as heat, cold or moisture; however, it can only be dissolved by acids.

Between 1870 and 1900 all major industrial countries, other than China, switched to the gold standard, linking their currencies to gold; hence, the gold standard was adopted. In order to demonstrate the relative importance of gold over time in various facets (not pertaining to the monetary but practical aspects of the metal), there are a few major advancements to consider. In 1961, gold bonding wire was used in microchips engineered at Bell Labs in the

United States; concurrently, within the same year the first manned space flight used gold to protect sensitive instruments from radiation. Today, approximately a few billion chips are bonded in a similar matter every single year, controlling all manner of indispensible electrical devices. In 1985, SmithKline & French, a pharmaceutical giant, developed Auranofin, a gold based drug for the treatment of rheumatoid arthritis; the drug received regulatory approval and is conveniently put up for sale for the first time. In 1999, the First Central Bank Gold Agreement (CBGA) was implemented allowing 15 European central banks to declare gold as an important element and facet of their reserves; furthermore, they collectively capped gold sales at 400 tons per year over the next five years. In 2001, the Boston Scientific marketed the first gold-plated stent (Niroyal) used in heart surgery. Inserted inside large arteries and veins, such stent acts like scaffolding, prop open the blood vessels to allow adequate flow. In the second quarter of 2009, central banks collectively become net purchasers of gold for the first time in two decades. This reflects a combination of slowing sales from European banks and growing purchases by emerging market countries. In 2010, world currencies were undermined by inflation fears and successive financial crises. The London pm fix achieved 35 separate successive highs in the year to date. Finally in 2011, gold started to be used in catalytic convertors by a leading European diesel car manufacturer; the first use of gold in automotive emissions control.

Gold is a scarce commodity and has become a rare metal; currently, 165,000 metric tons of gold exists above ground. However, approximately, 60% of gold today is converted into jewelry. Various countries in Eastern Asia and the Middle East, including India, where gold has a strong cultural significance, collectively constitute 70% of the world's jewelry consumption.

Furthermore, other sources that contribute to the increasing demand for gold are central banks, investment and commercial banks, and the technology sector.

The majority of the world's gold is supplied by mines, operated on every continent of the globe (It is important to note that around a hundred million people worldwide depend on gold mining for their livelihood- [www.gold.org]). In addition, central banks contribute to the supply by selling part of their reserves. It is worth noting that central banks nowadays, and collectively, are net buyers of gold after 18 years of being net sellers. The gold price has risen every year since 2001 from its low of around $250. From then until November 2010, the gold price has risen to over $1400, a cumulative rise of 460%. Five of the years between 2002 and 2010 were marked by annual gains of 20% or more. Gold prices have reached record highs 22 times during 2010.

The daily gold price is determined by the physical and derivatives gold market. The daily benchmark price is the traditional London fix price which is set twice daily; once at 10am and then at 3pm. Gold's price is usually measured in US dollars per troy ounce. As of January 2011, in official figures as per the World Gold Council, the United States holds the most amount of gold reserves in the world amounting to 8,133.5 tons, compared to where Lebanon holds the 18$^{th}$ rank with 286.8 tons. Lebanon also has the second largest gold reserves among the countries in the Middle East. Riyad Salameh, the Central Bank Governor, considers this as "a pillar of monetary stability in the absence of key natural resources and a safe haven in times of crises."(www.dailystar.com.lb) Throughout Lebanon's history, gold has been a backup for the whole economic and monetary system protecting the central bank's obligations. Most of the fabrication of gold in Lebanon, which is in jewelry form, is for export. The demand and sale of jewelry in Lebanon is mainly driven by the touristic season which is during summer. Before the Civil War, Lebanon was considered the most important market for gold buyers. However, since then, Dubai has become the primary market in the region, engaging buyers and sellers from all over the world with vast number of jewelry exhibitions taking place through the year.

We started the paper by replicating Toros results with Toros sample. Elasticities of the log-levels and levels, with and without lagged dependent variables, were calculated and our estimates were found to be close to his estimates. In log-levels with dependent variables, the coefficients of oil and CPI were found to be close to each other, whereas the USD/EUR and the DJIA coefficients were found to be considerably different. In levels with lagged dependent variables, our results were also found to be close to each other.

Coming to the methodology of Toros, the Durbin-Watson that he used is inappropriate since lagged variables exist. For autoregressive moving average models, the Durbin-Watson statistic is biased, so that autocorrelation is underestimated. When one or more lagged dependent variables are present, the Durbin-Watson statistic will be biased towards 2- this means that even if serial correlation is present it may be close to 2. Durbin suggests a test that is strictly valid for large sample but often used for small samples. This test for serial correlation when there is a lagged dependent variable in the equation is based on the h statistics. For log with lags we found the Durbin's h to be 2.0116 and in the case of level with lags the Durbin's h was 2.0052. Both values were greater than 1.96 at 95% confidence interval level which means that in both cases we rejected the null hypothesis that there is no serial correlation between the residuals.

Subsequently, we constructed a table which represents the Augmented Dickey-Fuller test for the sample of Toros. All the values together with their respective probabilities indicate that we do not reject the null hypothesis that there is a unit root. In other words, we do not reject the fact that the variables are non-stationary.

Therefore, we estimated the regressions of the first difference of the logs for Toros sample which consisted of 98 records. Only the USD/EUR exchange rate was found to be the significant predictor of gold prices. It needs to be mentioned that the case of October 1999 was considered an outlier, but it was not removed because its removal did not affect considerably our results. The only considerable value that changed was the mean of the variable dlllgoldus (which is the first difference of the log of the price of gold, in ounce, in US Dollars), which changed from 2.52 to 0.60 after removing the outlier.

The histogram had a bell-shaped curve and the normal probability plot showed up deviations from normality and the points lied on the straight line. As for the scatter plot, there were random array of dots evenly dispersed around zero. Thus, the assumptions of normality, linearity, and homoscedasticity were not all met. Moreover, it was proved that the residuals were independently distributed since Durbin Watson is 1.890, close to 2. It was proved that there is no positive serial correlation of residuals since the calculated Durbin-Watson fell between the upper limit and 2. The value of $R^2$ indicated that the variable USD/EUR exchange rate accounts for 16.3% of the variation in gold price. The value of the un-standardized USD/EUR exchange rate to be 0.547 (significant) which means that every 1 percent depreciation of the US Dollar against the Euro will cause gold prices to increase 0.547 percent.

An ANOVA F-test was conducted on the R-squares for the removal of insignificant variables to examine whether the omission of the variables was a good choice. The results showed that the omission of the three variables (oil, DJIA, and CPI) was indeed a good choice (F-test < F-critical; 0.6818 < 6.90; p > 0.01).

In the next section we conducted regression for the first differences of the logs for the whole sample which consisted of 302 records (September 1985- November 2010). The Euro/USD exchange rate best correlated with the outcome of gold price ($r=.33$, $p<0.05$).The histogram had a bell-shaped curve and the normal probability plot also didn't show deviations from normality and the points lied on the straight line. As for the scatter plot, there were random array of dots evenly dispersed around zero. Thus, the assumptions of normality, linearity, and homoscedasticity were all met. Moreover, it was proved that the residuals were independently distributed since Durbin Watson is 1.827, close to 2. It was proved that there is no positive serial correlation of residuals since the calculated Durbin-Watson fell between the upper limit and 2. The value of $R^2$ indicated that the two variables USD/EUR exchange rate and price of oil account for 13.6% of the variation in gold price. The un-standardized coefficient of oil is 0.064, which means that for every 1 percent increase in the oil price, there's a 0.064 percent increase in the price of gold. As for the USD/EUR exchange rate, every 1 percent depreciation of the US Dollar against the Euro will cause gold prices to increase 0.342 percent. An ANOVA F-test on the R-squares on removing the variables with insignificant coefficients was conducted and was calculated to be 1.92 which is smaller than the critical value of 4.68 at 99% confidence level. This means that the omission of the two variables (DJIA and CPI) was a good choice.

We concluded that there is instability in the regressions between the sample of Toros and the whole sample. The mean percentage changes are quite different between the two samples whereas the standard deviations are somehow close to each other. In our sample both oil and USD/EUR exchange rate were significant variables, whereas only the USD/EUR exchange rate was the significant variable in the sample of Toros. Our results showed that every 1 percent depreciation of the US Dollar against the Euro will cause gold prices to increase by 0.339 percent, whereas in the case of Toros every 1 percent depreciation of the US Dollar against the Euro caused gold prices to increase by 0.559 percent.

Unit root tests were carried out with a trend on the logs of all the variables (all in Lebanese Pounds) and their first differences. All the values together with their respective probabilities indicated that we do not reject the null hypothesis that there is a unit root. In other words, we do not reject the fact that the variables are non-stationary. Consequently, and since all asset prices were random walks, we could not run a normal linear regression. Thus, regression was run on the first difference on the logs.

The variable DJIA (in LBP) was considered to be an insignificant variable in predicting gold prices in the whole sample using Lebanese Pounds as the base currency. CPI (in LBP) correlated best to the gold price in LBP ($r=.89$, $p < 0.05$). The histogram had a bell-shaped curve and the normal probability plot also showed up deviations from normality and the points lied on the straight line. As for the scatter plot, there were random array of dots evenly dispersed around zero. Thus, the assumptions of normality, linearity, and homoscedasticity were all met. Moreover, it was proved that the residuals were independently distributed since Durbin Watson is 1.80, close to 2. It was proved that there is no positive serial correlation of residuals since the calculated Durbin-Watson fell between the upper limit and 2. The value of $R^2$ indicated that the variables LBP/EUR exchange rate, CPI, and the price of oil (all in LBP) account for 81.8% of the variation in gold prices.

The un-standardized coefficient of oil is 0.056, which means that for every 1 percent increase in the price of oil (in LBP), gold prices will increase 0.056 percent. As for the Euro/LBP exchange rate, a one percent depreciation of the Lebanese Pounds against Euro, gold prices will increase 0.344 percent. As for the variable CPI (in LBP) a one percent increase in the CPI (LBP) will cause gold prices to increase 0.583 percent.

An ANOVA F-test on the R-squares for the removal of the variable with insignificant coefficient was conducted to examine whether the omission of the variables was a good choice. The results showed that the omission of one variable was indeed a good choice. (F-test < F-critical; $3.28 < 3.78$; $p > 0.01$). We conclude that the determinants of gold price in Lebanon are the following: PPP-CPI and Brent oil price, and LBP/EUR exchange rate.

In both, US Dollar and Lebanese Pound regressions, we tested for the hypothesis whether there is at least one independent variable that explains gold price in US Dollars and Lebanese Pounds. Looking at the F-tests [$F = 23.559$; $p < 0.001$ in case of US Dollars and $F = 446.322$; $p < 0.001$ in case of LBP] and the ANOVA F-tests, the regressions significantly explain the dependent variable. Thus, there is at least one variable that explains significantly gold prices. On removing the insignificant variables for each of the regressions in the first differences of the logs ($1.92 < 4.68$; $p > 0.01$ in case of US Dollars and $1.92 < 4.68$; $p > 0.01$ in case of LBP), we fail to reject the null hypothesis that the omitted variables have zero coefficients.

## II. Literature Review

Assessing the fair value of gold largely remains a mystery in finance. While authors sometimes find empirical relationships between gold prices and macroeconomic variables such as inflation and exchange rates, little evidence has been offered for connections between gold and other asset classes. Faugère and Van Erlach (2005) offer a gold asset pricing theory that treats gold as a store of wealth. They demonstrate a theoretical and empirical link between gold price and inflation, 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 the general requirement to earn a minimum expected after-tax real return equal to long-term GDP per capita growth. They hold that because gold fulfills the unique function of a global store of value, its yield must vary inversely with the yield required by any financial asset class, thus providing a hedge when a particular asset class is losing value. The literature has well documented empirical relationships between gold price 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 1980s, about half of the variance in USD gold prices during the period 1982-1990 appears to be accounted for by fluctuation in real exchange rates. *The real exchange rate can be defined as the nominal exchange rate taking into account the inflation differentials among countries.* Faugère and Van Erlach's (2005) theory explains about 88% of actual U.S. dollar (USD) gold prices and 92% of actual gold returns on a quarterly basis, including the peak prices of gold, over the 1979-2002 period. They attempt to justify short-term gold price volatility by appealing (for example) to changes in the real interest rate and the USD versus the rest of the world's exchange rate fluctuations. In applying their theory for gold valuation, they hypothesize that the global real price of gold essentially is a real P/E ratio for gold, which means that gold can be considered as a stock. They also hypothesize that the global real price of gold must vary inversely with all other main financial asset class real P/E to preserve the real value of any investor's capital against adverse movements in the values of financial asset classes.

Another hypothesis is the law of one price of gold where the exchange rate fluctuations must impact local currency-denominated gold prices to eliminate potential international gold arbitrages. Last but not least, mining supply must be stable in relation to supply movements and the worldwide stock of gold per capita should not increase in the long run.

They theoretically show that at any point in time, all investors expect a certain profit from their investments. This profit equals to the average GDP per capita of the country that the investors live in, plus the expected inflation. The equation 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 per capita long-term growth rate and $\pi_{wt+1}$ is the expected global inflation rate.

If $P_{wt}$ represents 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 explain with this function that the real price of gold will decrease when global inflation accelerates. The real price of gold will be constant as long as inflation and productivity is constant. So the nominal price of gold will rise with the price level. Furthermore, Faugère and Van Erlach (2005) 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 state 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 a safe haven.

Therefore, the authors examined the relationship between gold price and inflation, foreign exchange rates, and general valuation of stock markets. Hence, in our study, we also took into consideration all of these variables.

McCown and Zimmerman (2006) examine the investment performance of the metals using the traditional asset pricing models used to evaluate securities. They find that an investment in gold bullion adds no systematic risk to an investor's portfolio. An estimate of the capital asset pricing model yields a beta that is statistically indifferent from zero. They run the following ordinary least squares regression equation:

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_i (R_{m,t} - R_{f,t}) + \varepsilon_t$$

where $R_{i,t}$ is the return on metal i, $R_{f,t}$ is the risk free rate (Yield on a U.S. Treasury Bill with maturity equal to the investment horizon), and $R_{m,t}$ is the return on the market portfolio. This is consistent with the returns on gold for the period from 1970 to 2003, which have been just slightly higher than the Treasury bill rates. Since the CAPM model lumps all sources of risk into one set, they jump to the next step and use the arbitrage pricing model of Ross (1976). The arbitrage pricing model is estimated by running the following regression:

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_{i,m} (R_{m,t} - R_{f,t}) + \beta_{i,def} DEF_{t-1} + \beta_{i,ter} TER_{t-1} + \beta_{i,ind} IND_{t+1} + \beta_{i,din} DIN_t + \varepsilon_t$$

where $DEF_{t-1}$ is the default spread (difference between the yield to maturity of Baa corporate bonds and U.S. Treasury notes), $TER_{t-1}$ is the term spread (Difference between the Yield to

Maturity of ten year U.S.Treasury notes and 90 day U.S. Treasury bills), $IND_{t+1}$ is the change in industrial production (change in U.S. industrial production, leading one period) and $DIN_t$ is the change in the inflation rate (change in the log CPI rate). This version of the model makes the risk premium on the metal equal to a constant, plus its market beta times the market risk premium, plus its betas on each of the other risk factors, times the risk factors. Any of the betas can be positive or negative. Next, they run the regression with and without the market risk. They have constructed annual, quarterly, and monthly data. Looking at the annual data the adjusted R-squares of gold is 0.402 (with market risk) and 0.418 (without market risk). The value of the adjusted R-square means how well the model can be generalized. Gold has positive, statistically significant regression coefficients on the industrial production (2.208 and 2.043 at 95% confidence interval) and change in inflation risk factors (8.461 and 8.753 at 99% confidence interval). This shows that gold is indeed a good hedge against inflation at the annual horizon. For the quarterly and monthly data, the adjusted R-squares of gold are close to zero, indicating that gold is a favorable hedge in the long run but not in the short run.

Estimates of the arbitrage pricing model reveal that gold has a strong ability to hedge against inflation risk, and can thus be a very useful addition to an investor's portfolio. In their research, in order to test for a relation between the metals prices and inflation they test for co-integration. Two or more random variables are co-integrated if they have a common stochastic trend. This means that their unpredictable movements are related. Thus, if gold prices (or silver prices) and aggregate consumer prices are co-integrated, we have additional evidence that the metal is a good hedge against inflation risk in the long run. For the most important contribution of this research, they find that the time series of both gold and silver prices are co-integrated with the Consumer Price Index in the U.S. This shows that the stochastic movements of the metals and the aggregate price level have a common trend, which reinforces the finding that they are useful inflation hedges. Their conclusion is that gold can be a useful addition to many investment portfolios, virtually uncorrelated with stock returns and also a good hedge against inflation risk. The precious metals data consist of the month-end spot prices for gold and silver. These were obtained from Datastream and begin with 1970. Gold shows a fairly high positive correlation of 0.445 with the consumer price index on an annual basis. The correlation decreases as the time horizon decreases, but remains positive.

So, in their study, McCown and Zimmerman (2006) took into consideration the yields of US Treasury notes, Baa corporate bonds, US T-Bills, change in the US industrial production, and the CPI. In our study the CPI was the only variable that we used from their study.

Kearny and Lombra (2008) study the non-neutral short run effects of derivates on gold prices. The research findings suggest that the use of derivatives by gold producers, whether it was to hedge against the risk of declining gold prices, or for other purposes, probably pushed gold prices below what they would have been based upon historical relationships. Conversely, when gold producers reduced their net derivative positions over the April 1999 to January 2006 period, this de-hedging appears to have helped boost gold prices back toward levels consistent with longer run fundamentals. Since forward contracts occupy the greatest proportion in the global hedge book: 81% from 1996 to 1999 and 77% from 2000 to January 2006, Kearny and Lombra (2008) focus on the impact of the use of forward contracts by producers in the market for gold. They employ the following formula:

$$\log \left(\frac{\text{Gold Price}}{\text{CPI}}\right)_t = \alpha_0 + \alpha_1 \text{Post80}_t + \alpha_2 \text{RealR}_t + \varepsilon_t$$

In each case, the data for the third month of each quarter are used to construct quarterly series; daily data are averaged over the month in converting to monthly.

Gold prices, obtained from the Commodity Research Bureau, consist of the daily closing price from the 24-hour global market, including Tokyo, London and New York. The 10-year Treasury bond rate is from the Federal Reserve Board, release H.15; the 10-year rate was selected to represent 'the' long-term interest rate and the CPI, all urban consumers (all items), seasonally adjusted, was used to convert nominal gold prices and interest rates to real. The Post80 dummy variable is set equal to one from January 1980 to April 1987 to pick up the volatility in real gold prices and interest rates during the Volcker disinflation and the stock market crash in 1987. Real $R_t$, the real long-term interest rate, is the difference between the 10-Year Treasury bond rate in time t-1 and inflation in time t. They find the coefficient on the real interest rate to be negative and significant (p-value is 0.0006), implying the real interest rate is inversely related to the real price of gold over the 1973 to January 2006 period. In addition, the significance of Post80 implies an upward shift in the relation over the 1980 to 1987 period. They start the analysis by testing for stationarity using a sequence of Augmented Dickey–Fuller and/or F-tests. An augmented Dickey–Fuller test (ADF) is a test for a unit root in a time series sample. It is an augmented version of the Dickey–Fuller test for a larger and more complicated set of time series models. The augmented Dickey–Fuller (ADF) statistic, used in the test, is a negative number. Their findings are consistent with the hypothesis that producer use of derivatives during the second half of the 1990s probably pushed gold prices below what they would have otherwise been, based upon historical relationships, while their de-hedging over April 1999 to January 2006 helped boost gold prices back toward levels consistent with longer run fundamentals. This is important, since the adverse effect on gold prices and returns in the 1990s altered the relationship between gold and other asset prices and what otherwise might have been considered a successful portfolio investment strategy (Markellos and Mills, 2001 and Markellos, 2004). According to the predictions of Kearny and Lombra's (2008) model, as real interest rates rise (fall), the willingness to hold alternative assets, in this case gold, decreases (increases) and the price of gold falls (rises). In conclusion, their results suggest that the surge in gold prices by 95% from $284 per ounce in the fourth quarter of 1999 to $554 in the first quarter of 2006 is the result, in part, of the massive reduction in the net shorts ('de-hedging') of producers. The latest data available (first quarter 2006) show that over this period producers reduced their net short positions by over 44 million ounces. Hence, we can conclude gold prices have tended to move closer to what one would expect based upon historical relationships that predated the massive increase in the use of derivatives.

In our study we did not use any of the variables which were used by Kearny and Lombra (2008). (They used the 10-year T-bond rate and real interest rate)

Hammoudeh, Sari, and Ewing (2008) examine the co-movements among the prices of four strategic commodities that have long, adequate daily series: oil, gold, silver, and copper. They employ the ARDL approach developed in Pesaran and Pesaran (1997) and Pesaran, Shin, and Smith (2001) for three groupings of commodity and financial variables. For the exchange rate they use foreign exchange value of the dollar against the major currencies. The interest rate is proxied by the 3-month U.S. Treasury bill rate instead of the federal funds rate (FFR) because FFR is characterized by jumps as a result of large swings in its short-term cycles or transitory component relative to its long-term trend or permanent component (Hammoudeh and Bhar, 2007). In the method they apply, they use the ARDL approach. The autoregressive distributed lag (ARDL) approach is a co-integration technique for determining long-run relationships among variables under study which is a more statistically significant approach for determining co-integrating relationships in small samples. An advantage of the ARDL approach is that, while other co-integration techniques require all of the regressors to be integrated of the same order, ARDL can be applied irrespective of their order of integration. It thus avoids the pretesting problems associated with standard co-integration tests. ARDL is used whenever the variables in the long-run relation of interest rates are trend stationary. Thus, the general rule has been to de-trend the series and to model the de-trended series as stationary distributed lag or ARDL models. Group 1 includes the four commodity prices; group 2 encompasses the four prices and U.S. T-bill rate; and group 3 augments group 2 with the exchange rate. In group 1 they focus to examine the co-movements of these four important commodity prices. In particular, they test for causal relationships and, if one or more exist, they try to determine which one of the commodities has the directional lead. They find that prices of gold and silver are to a varying degree affected by factors related to the jewelry industry, and the price of gold is also subject to interventions by central banks as part of their foreign reserves policies to influence exchange rates. The unrestricted regression, in the case of gold, is given by the equation:

$$\Delta LGOLD_t = a_{oiG} + \sum_{i=1}^{n} b_{iG}\Delta LWTIS_{t-i} + \sum_{i=1}^{n} c_{iG}\Delta LCOPS_{t-i} + \sum_{i=1}^{n} d_{iG}\Delta LGOLD_{t-i}$$

$$+ \sum_{i=1}^{n} e_{iG}\Delta LSLVR_{t-i} + \lambda_{1G} LWTIS_{t-1} + \lambda_{2G} LCOPS_{t-1} + \lambda_{3G} LGOLD_{t-1} +$$

$+ \lambda_{4G}LSLVR_{t-1} + \varepsilon_{3t}$

GOLD: gold spot price per troy ounce

WTIS: oil spot price per barrel

COPS: copper spot price per ton

SLVR: Silver spot price per troy ounce

In these equations, *b, c, d,* and *e* denote the short-run coefficients. L is the lag operator and $a_0$ is a constant. The long-run multipliers of the underlying ARDL model are found from λs. The general F statistics are used to test the hypotheses by computing the variables in levels. In the next step, they estimate the long- and short-run parameters within a VER (Vector Error Representation) model, which require employing a two-step procedure. First, the order of the lags in the ARDL model is selected and then the model is estimated.

In group 2, the major objective is to find out whether changes in commodity prices can be considered as a precursor for future adjustments in interest rates. The finding has implications for monetary authority on how to conduct monetary policy that can use the derived information to adjust future interest rates to stabilize commodity prices. The results of group 2 imply that there is no feedback effect on the gold price from the other commodity prices and interest rate (T-bill rate). Coming to group 3, the primary focus is to determine whether the exchange rate is the primary mover of the gold price or vice versa. The results of co-integrating equations show that an increase in the price of gold implies a depreciation of the

U.S. dollar versus the major currencies in the long run (from January 2, 1990 till May 1, 2006). These findings consolidate the corresponding result in group 1. Investors move to gold as a flight to safety in anticipation of a decline in the value of the dollar whether as a result of a perception of an economic downturn or a looming crisis. They found that the increase in the price of gold will have a negative impact on the LER (log exchange rate). The coefficient is -0.3381 and the t-statistic is -2.38.

The short-run (3-month) dynamics for the exchange rates reveal that increases in the prices of gold and silver have a depreciating effect on the U.S. dollar versus the major currencies, while the U.S. T-bill rate has an appreciating effect. LTB (log T-Bill) is the 3-month T-bill rate obtained from the Board of Governors of the US Federal Reserve System and the LER (log exchange rate), is the trade weighted average of the foreign exchange value of the US dollar against the major currencies.

The variables that Hammoudeh, Sari, and Ewing (2008) used were the 3-month T-bill rate (which is equivalent to the interest rate) and the exchange rate. We only used the exchange rate in our study.

Ratner and Klein (2008) evaluate the performance of gold from 1975-2005. The stand-alone performance of gold is assessed, as is the potential benefit of adding 5% gold to a diversified global portfolio. The U.S. total stock market index is used for comparison purposes, and the analysis is performed from the perspective of U.S. investors. As a stand-alone investment, it is shown that gold is a relatively poor investment compared with the U.S. stock market over the long-term. Of course, investors who time their holdings of gold correctly could have earned returns in excess of the U.S. stock market during pockets of time (one to five years) since 1975. Lacking the ability to correctly "time the market," the impact of a buy-and-hold 5% gold investment on an optimized global portfolio is examined. It is shown historically that gold has generally low or negative correlations with U.S. equities. As such, it is hypothesized that the addition of gold to an optimal international portfolio has the potential to enhance performance. Two sets of portfolios are formed. The first set creates six rolling five-year investment sub-periods from 1976-2005. The second set of portfolios examines the performance-to-date of investing in gold during the last 5 years, 10 years, 20 years, and 31 years. Jensen's alpha is a popular investment performance measure used here to indicate the amount of excess return that can be earned by adding 5% gold to the benchmark global portfolio. Jensen's alpha can be explained as follows:

Jensen's alpha = Portfolio Return − [Risk Free Rate + Portfolio Beta * (Market Return − Risk Free Rate)]

Jensen's alpha is a risk-adjusted performance measure that is used to calculate the returns of a portfolio predicted by the CAPM. A positive alpha indicates that the addition of gold improves portfolio performance, while a negative alpha shows that the inclusion of gold negatively affects performance. Between 2001 and 2005, Jensen's alpha is reported as 0.75%. This indicates a positive impact on portfolio performance from gold investment. During the 1996-2000 sub-period, Jensen's alpha (-0.81%) indicates that gold negatively impacts performance. From 1986-1990, the alpha (0.08%) shows a small improvement to performance. In the 1981-1985 sub-period, the alpha (-1.34%) is again negative. The 5-year Jensen's alpha (0.75%) again indicates a positive impact from gold during the 2001-2005 periods. However, the

10-year and 20-year portfolios have negative Jensen's alpha results of -0.08% and -0.09%, respectively. The portfolio results, along with calculated values of Jensen's alpha, indicate that the benefit, if any, of investing in gold is time-period dependent. In some periods, there is a small improvement in portfolio performance, while in other periods there is a small decline in performance. Over the long term (31 years), there is no material benefit to investing in gold as the Jensen's alpha is 0.02%, which is a small positive performance impact. In sum, Jensen's alpha suggests that the benefit of a 5% gold investment in a diversified global portfolio becomes negligible over longer time periods. As a final point, a five-year bootstrap simulation is applied to the optimal efficient portfolio, which again demonstrates the small potential improvement in portfolio performance.

Ratner and Klein (2008) use the total stock market index in their study. In this context, we used the DJIA index in our study.

Baur and Lucey (2009) analyze the role of a safe haven asset in financial markets and provide evidence that investor benefit from the existence of a safe haven asset. They state that gold is a safe haven asset rather than a hedge or a diversifier in a portfolio at extreme market conditions. Specifically, gold is a safe haven for stocks and not for bonds. Daily returns are used in order to analyze whether investors react to extreme negative shocks relatively fast and use gold as a safe haven asset. Gold only functions as a safe haven for a limited period of time (around 15 trading days) in case of an event of extreme negative shock in the market. In the long run, gold is not a safe haven, that is; investors who hold gold more than 15 trading days after an extreme negative shock lose money with their gold investment. The econometric model used by Baur and Lucey (2009) is derived directly from the hypothesis that gold is a safe haven asset conditional on stock and bond market returns. Hence, they condition the return of gold on movements of stocks and bonds, which almost naturally determines the model structure with gold specified as the dependent variable and stock and bond returns specified as the independent variables. Their principal regression model takes the form:

$$r_{gold,t} = a + \Sigma\, b_{0(i)}\, r_{gold,t-i} + \Sigma\, b_{1(i)}\, r_{stock,t-i} + \Sigma\, b_{2(i)}\, r_{stock,t-i(q)} + \Sigma\, c_{1(i)}\, r_{bond,t-i} + \Sigma\, c_{2(i)}\, r_{bond,t-i(q)} + \epsilon_t$$

where $r_{gold}$, $r_{stock}$, and $r_{bond}$ are the returns of gold, stock, and bond prices, respectively. The terms $r_{stock,t(q)}$ and $r_{bond,t(q)}$ account for asymmetries of positive and negative (extreme) shocks and are included in order to focus on falling stock and bond markets. In particular, they analyze the role of gold in times of stress or extreme stock or bond market situations and include regressors that contain stock or bond returns that are in the q% lower quantile such as the 5%, 2.5% and 1% quantile. If the return is larger than the q% quantile, the value of $r_{stock,t(q)}$ or $r_{bond,t(q)}$ is zero. The structure of the model assumes that stock or bond prices can affect the price of gold. This is consistent with the safe haven hypothesis. If stocks or bonds exhibit extreme negative returns, investors buy gold and bid up the price of gold. If the price of gold is not affected, investors neither purchase nor sell gold in such adverse market conditions. It is important to analyze the relationship among the assets dynamically since lagged stock or bond returns can have a different impact on gold returns than contemporaneous stock or bond returns. In other words, it is possible that negative stock returns at *t* increase the price of gold at *t* but decrease the price of gold at *t+1*. This would have strong implications for investors and the existence of a safe haven. It would imply that gold is only a contemporaneous safe haven but not a safe haven in the longer run. For example, it would not be a safe haven for investors that purchase gold after an extreme negative return shock had occurred. Capie, Mills et al. (2005) also estimate a dynamic regression model and assume the error term to exhibit conditional autoregressive heteroscedasticity, modelled via a GARCH process. They follow their framework and specify an asymmetric GARCH process for the errors in the equation.

Now, the focus is on the contemporaneous version (no lags) of the equation to explain the relationship of the model and the hypotheses. If $b_1$ ($c_1$) is zero or negative, it implies that gold is a hedge for stocks (bonds) since the assets are uncorrelated with each other on average. Whether gold is a safe haven asset for stocks or bonds is tested via the parameters $b_2$ and $c_2$, respectively. If the total effect in (extremely) falling stock or bond markets is non-positive (sum of $b_1$ and $b_2$ for stocks and sum of $c_1$ and $c_2$ for bonds), gold serves as a safe haven asset for stocks or bonds since they are uncorrelated (sum of coefficients is zero) or negatively correlated (sum of coefficients is negative) with each other. A negative correlation of gold and stocks or gold and bonds in extreme market conditions implies that the price of gold increases in such conditions thereby compensating investors for losses incurred with stock or bond investments.

The coefficient estimates for the effect of stocks on gold is given by $b_{1=}$ -0.0475 (t-statistic=-3.23). The coefficient estimates for bonds are $c_1$ =0.0069 (t-statistic=0.24). These estimates imply that gold is a hedge for stocks in the US. The opposite effect holds for gold as a hedge for bonds. The fact that the sum of the coefficient estimates is non-positive for the 2.5% and 1% quantile but positive for the 5% quantile implies that gold only serves as a safe haven for shocks exceeding the 2.5% and 1% threshold (quantile). The following is the equation they provided:

$$r_{gold,t} = a + b_1 r_{stock,t} + b_2 r_{stock,t(q)} + c_1 r_{bond,t} + c_2 r_{bond,t(q)} + e_t$$

They also provided the following equation for the conditional volatility:

$h_t = \alpha e^2_{t-1} + \gamma e^2_{t-1} D(e_{t-1<0}) + \beta h_{t-1}$

*where α (the ARCH term), γ (the asymmetric component), and β (the GARCH term)* are the parameters governing the conditional volatility. The coefficient estimates here, are $\alpha$=0.0313 (t-statistic=4.05), $\gamma$=0.0849 (t-statistic=8.75), $\beta$=0.9096 (t-statistic=141.38).

Finally, a portfolio analysis evaluates the evolution of all assets simultaneously in periods in which gold potentially serves as a haven asset. Such an analysis illustrates how profitable it is for investors to buy and sell gold in periods of market turmoil. This finding suggests that investors buy gold on days of extreme negative returns and sell it when market participants regain confidence and volatility decreases. The results also show that there is a large difference as to whether investors hold gold at all times or purchase gold only after an extreme negative shock occurs. The latter strategy decreases the value of an investor's portfolio.

In our study we used the stock market variable, but did not use the bond market variable.

Baur (2009) studies the volatility of gold. The volatility of equity returns generally exhibits an asymmetric reaction to positive and negative shocks. Economic explanations for this phenomenon are leverage and volatility feedback effects. He studies the volatility of gold and demonstrates that there is an inverted asymmetric reaction of gold to positive and negative shocks, i.e. positive shocks increase the volatility by more than negative shocks. In an econometric point of view, he specifies the following equation to estimate the conditional mean of the return of gold:

$$r_{Gold,t} = \mu + \beta X_t + e_t$$

The parameters to estimate are $\mu$ and $\beta$.

$X_t$ is a regressor matrix which contains additional variables that can influence or explain any asymmetric volatility effect. Such variables are lagged returns of gold, a commodity index, or a stock market index with or without an asymmetric impact on the gold return.

In order to estimate the volatility of gold he uses the following equation:

$$h_t = \pi + \gamma_1 (e_{t-1})^2 + \gamma_2 (e_{t-1})^2 I(e_{t-1}<0) + \delta h_{t-1}$$

Here, the parameters to estimate are $\pi$, $\gamma_1$, $\gamma_2$ and $\delta$. The constant volatility is estimated by $\pi$, the effect of lagged return shocks of gold on its volatility (ARCH) is estimated by $\gamma 1$ and a differential effect if the return shock is negative is captured by $\gamma_2$. If there is a symmetric effect of lagged shocks on the volatility of gold $\gamma_2$ is zero. The coefficient estimates for daily returns are highly significant 0.0643 and t-statistics of around 29 and around 700 for gold returns denominated in US Dollar, respectively. He finds the t-statistic for the daily returns of gold to be -15.8452 which explains the significance of the test (the greater the t-stat. value, the greater the contribution is significant in the prediction).

Concerning the volatility, he finds that the volatility of the daily gold return in US Dollar is 0.015 for shocks equal to -8% and exceeding 0.4 for shocks equal to +8%. Hence, the increase in volatility with positive shocks is almost three times (2.81) larger than the increase in volatility with negative shocks. The results demonstrate that the volatility of gold exhibits an inverted asymmetry of positive and negative shocks relative to the asymmetry found for the volatility in equity markets. Since financial leverage and volatility feedback cannot explain this effect, he argues that the effect is related to the safe haven property of gold.

Since the results can be influenced by the distributional assumptions regarding the error distribution he estimates the asymmetric GARCH model of a GARCH (1, 1)-type by Maximum-Likelihood with a Gaussian error distribution and a student-t error distribution. He states that that this effect is a result of the safe haven property of gold. Macroeconomic and financial uncertainty is transmitted from the equity market to the gold market causing the special asymmetric reaction. The empirical results hold for gold bullion and gold coins denominated in different currencies, different time periods and for different distributional assumptions. Finally, he shows that the inverted volatility effect of gold can lower the aggregate risk of a portfolio for specific correlation levels. In his study Baur (2009) first describes the data; he uses daily, weekly, monthly and quarterly data of different gold spot prices (per ounce) in different currency denominations, weights (troy ounce or kg) and types (gold bullion or coins) for a sample period of 30 years from November 19, 1979 to November 18, 2009. The descriptive statistics show increasing average returns (mean) and risk (standard deviation) from daily to quarterly frequencies. This pattern is weaker for the minimum of returns but strong for the maximum return observation. An analysis of the return properties within certain return frequencies (e.g. daily returns) further shows that the currency denomination exhibits a strong impact on the returns of gold. In the econometric framework Baur (2009) assesses the importance of positive and negative returns of gold on its volatility. He focuses on the asymmetric reaction of gold returns on its volatility for two major reasons. First, if the volatility of gold exhibits different reactions to shocks the low correlation of gold with other assets might be compromised in certain conditions and second, the economic explanations for asymmetric volatility for equities are not applicable for gold and commodities in general. Financial leverage or volatility feedback cannot be the direct cause of any asymmetry in the volatility of gold. If gold is used as a diversifier or a hedge against financial or macroeconomic uncertainty it can decrease the risk in terms of expected return due to the negative correlation (e.g. see Baur and Lucey, 2009) but increase the volatility of a portfolio in times of financial market turmoil. This effect can compromise the low or negative correlation effect gold demonstrates with other assets in such periods. For instance they found a negative correlation of 0.2 between stocks and gold for a set of portfolios (80% stock, 20% gold). The increased volatility of gold leads to a negative reaction in the portfolio variance due to the covariance term which dominates the individual variance contribution of gold. Talking in numbers, the standard deviation in portfolio X is 0.40 for stocks and 0.10 for gold; in portfolio Y, it's 0.40 for stocks but 0.20 for gold. The portfolio variance in X (0.0868) is higher than the one in Y (0.0720).

We used the variable that Baur (2009) used in his study which is the stock market.

Baur and McDermott (2009) examine and analyze the role of gold in the global financial system. Their study is an extension of the study by Baur and Lucey (2009) where they extend the analysis in a number of important ways. Baur and McDermott (2009) look at investor reactions to varying degrees of 'stormy weather'. Their dataset differentiates between 'storms' of various sizes, in terms of both the severity and the duration of shocks to the financial system. They also pursue a multi-country analysis, using major emerging and developed countries from a sample of 53 international stock markets, thus to test the safe haven effect across a broad cross-section of world stock markets. Their data cover a 30-year period from March 1979 to March 2009. They also broaden the research approach by examining two further questions related to the safe haven property and the role of gold in the global financial system: (i) To what extent does gold protect wealth during extreme market conditions, i.e. is it a weak or strong safe haven? And (ii) what role do currency movements play in either driving or disguising the safe haven property of gold.

A strong (weak) hedge is defined as an asset that is negatively correlated (uncorrelated) with another asset or portfolio on average. A strong (weak) safe haven is defined as an asset that is negatively correlated (uncorrelated) with another asset or portfolio in certain periods only, e.g. in times of falling stock markets. The distinguishing feature of the two types of asset described above is the length of the effect. The important property of the hedge is that it holds on average while the key property of the safe haven is that it is only required to hold in certain periods, e.g. a financial crisis. Assets that work as a hedge against stocks might co-move with stocks in crisis periods since investors sell different types or all assets simultaneously. In contrast, it is possible that there are assets that are only negatively correlated in crisis periods and co-move with the other asset on average. In this case, investors purchase the asset in these times only. The asset does not lose value in such times and thus works as a safe haven. Looking at specific crisis periods, Baur and McDermott (2009) find that gold was a strong safe haven for most developed markets during the peak of the recent financial crisis.

Baur and McDermott (2009) test the hypothesis that gold represents a safe haven against stocks of major emerging and developing countries, offering protection to investors against losses in financial markets. A descriptive and econometric analysis for a sample spanning a 30 year period from 1979 to 2009 shows that gold is both a hedge and a safe haven for major European stock markets and the US, but not for Australia, Canada, Japan and large emerging markets such as the BRIC (Brazil, Russia, India, China) countries. They present econometric models to analyze the safe haven property of gold. The gold price is assumed to be dependent on changes in the stock market. Moreover, they assume that the relationship is not constant but is influenced by specific, extreme, market conditions. They present 3 equations that are needed in analyzing the safe haven property of gold. The model is a multiple regression model. The first equation is

$$r_{Gold,t} = a + b_t r_{stock,t} + e_t$$

This equation models the relation of gold and stock returns. The parameters to estimate are $a$ and $b_t$. The error term is given by $e_t$. The parameter $b_t$ is modelled as a dynamic process given by the equation

$$b_t = c_0 + c_1 D(r_{stock}\, q_{10}) + c_2 D(r_{stock}\, q_5) + c_3 D(r_{stock}\, q_1)$$

The parameters to estimate in this equation are $c_0$, $c_1$, $c_2$ and $c_3$. The dummy variables denoted as *D(…)* capture extreme stock market movements and are equal to one if the stock market exceeds a certain threshold given by the 10%, 5% and 1% quantile of the return distribution. If one of the parameters $c_1$, $c_2$ or $c_3$ is significantly different from zero, there is evidence of a non-linear relationship between gold and the stock market. If the parameters are non-positive (including $c_0$), gold acts as a weak safe haven for the market under study. If the parameters are negative and statistically different from zero, gold functions as a strong safe haven. Gold is a hedge for the market under study if the parameter $c_0$ is zero (weak hedge) or negative (strong hedge) and the sum of the parameters $c_1$ to $c_3$ are not jointly positive exceeding the value of $c_0$.

The third equation presents the GARCH (1, 1) model which is used to account for heteroscedasticity in the data. The equation is the following:

$$h_t = \pi + \alpha e^2_{t-1} + \beta\, h_{t-1}.$$

For the monthly returns, they find the hedge coefficients to be -0.064 for North America which means gold is a hedge against stocks. The coefficients in extreme market conditions are found to be -.002 and -0.070 for the 0.05 and 0.01 quantile respectively. Here, these negative values indicate that gold is a strong safe haven. Similar values were found for the European countries (and for the weekly and daily data), but not for the emerging countries, Australia, Canada, and Japan.

We use the variable as Baur and McDermott (2009) used in their study which is the stock market variable. We didn't test for the safe haven characteristic of gold since our data was monthly data and the data that they used was daily. So if we were to convert our data into 1% quantiles, our sample which consisted of 302 records would only result in 3 samples which is not enough to carry out any kind of regression.

Ciner, Gurdgiev, and Lucey (2010) investigate five major financial asset classes, examining how and under what circumstances each may act as a hedge or a safe haven to each other. Using the approach of Baur and Lucey (2010) and Baur and McDermott (2010) they find that, in line with conventional investment strategies, gold acts as a safe haven for most assets (different kinds of equities), except oil. They examine the relationship between these assets over a 25 year period from Jan 1985 through Oct 2009 at a daily frequency. They apply the hedge-safe haven model of Baur and Lucey (2010) to test for the existence of safe havens and hedges.

Empirically, they estimate the following equation for each asset:

$$R_{i,t} = a + \Sigma\, b_{0(i)}\, r_{i,t-i} + \Sigma\, b_{1(i)}\, r_{j,t-i} + \Sigma\, b_{2(i)}\, r_{j,t-i(q)} + e_t$$

where $r_i$, $r_j$ are the return of the asset under analysis (e.g. gold) and the other assets (in this example stocks, bonds, oil and the dollar) respectively. The terms $r_j$, $t_{(q)}$ account for asymmetries of positive and negative (extreme) shocks and are included in order to focus on falling markets.

They find a negative and persistent gold-dollar relationship moving from -0.25 in the early years of the sample to -0.50 or greater in later years. Gold shows the expected general negative relationship with equities, and no clear pattern regarding bonds, generally near zero with the exception of the 2000-2004 periods when it turned significantly positive. For the US data, the coefficient of gold with respect to the equity returns is -0.06 with a t-statistic of -4.73. The coefficient of gold with respect to bond returns is -0.03 with a t-statistic of -12.76. Finally the coefficient of gold with respect to the dollar returns is 0.01 with a t-statistic of -18.92. Their initial finding is that gold seems to be remarkable as a hedge against all of the assets in their study, save for oil, in the full sample analysis. There is a negative and statistically significant relation between the gold market returns and equity, bond and dollar returns. This, on average, indicates that gold prices react differently to shocks and events than the other markets and can be regarded as an illustration of gold as an effective diversifier in investment portfolios. In fact, gold is the only market that can be regarded as a hedge against equities at least when the full sample period is considered. Moreover, a noteworthy relation exists between bond, dollar and gold markets, in which they act as long term hedges against each other. More specifically, bond returns have a significant negative contemporaneous relation with gold and dollar markets and dollar returns are also, on average, negatively correlated with both gold and bond returns. One could argue that such a linkage between these markets is not unexpected as a common variable, the inflation rate, is likely one of the most important factors determining price movements for these assets. As for oil, it has a positive relationship with gold (0.44) and a significant t-statistic value of 16.48. This means that both move together and in the same direction.

In our study we used the variables exchange rate and oil prices, but we did not use the bond returns, but we used the equity returns.

Shafiee and Topal (2010) state that there is a positive correlation between oil prices and gold prices and they later show that this correlation is high. They state that there have been two jumps in oil prices in history. The first one was between 1979 and 1980. The main reason for this can be attributed to the Iranian revolution and the war between Iran and Iraq. The second jump started in the middle of 2007 and has continued until recently. The main reasons for this jump were that wars in Iraq and Afghanistan made these two countries unstable, and that sanctions were imposed on Iran for continuing uranium enrichment, as well as the recent financial crisis. These two oil shocks were followed by gold price jumps. The nominal oil price increased by 23 times from January 1968 until the end of December 2008 and nominal gold price by 16 times during the same period. There are a number of different price modeling methods that have been discussed in financial literature. The geometric Brownian motion and mean reversion are two classical approaches which form the basis for some newer methods, such as stochastic price forecasting and mean reverting jump diffusion models. These models focus on historical price movements and a random term to estimate future prices. They do not consider price jumps or dips. The mean reverting jump diffusion model seeks to introduce a number of jumps per period in the model. This model does not separate mean reverting rate with jump time to forecast the price. This type of model contains slightly modified assumptions from the classical models. For example, the mean reversion model modifies random walk theory in geometric Brownian motion and assumes price changes are not completely independent of one another. The major problem with all of these models is that they were introduced specifically for the stock market, and thus initially applied primarily to forecast share prices or interest rates. The proposed new version of mean reverting jump diffusion solves the previously mentioned models' pitfalls. The model Shafiee and Topal (2010) employ, uses a stationary econometrics model to forecast gold prices. The stationary stochastic process denotes that the mean and variance of a variable are constant over time. Moreover, covariance in the two different periods (jump and dip periods) depends on gap or lag between the periods, not actual time at which the covariance is computed. For example, if the gold price time series is stationary, the mean, variance and auto-covariance in various lags remain the same irrespective at what point they are measured. This model proposes an econometrics model that finds a long-term relationship with historical data for estimating non-stationary series. Additionally, in the new model, the size of the random shock is measured, while applied random walk theory is ignored. One of the main problems of random walk theory is that the impact of a particular shock does not die away in the long-term. For example, the average gold prices in March 2007 and 2008 were around $654 and $968 per ounce, respectively. If we are using these two numbers to predict gold prices for March 2009 the results will be different. The size of the jump in March 2008 influences the prediction of gold prices in March 2009.The following paragraphs details the comprehensive model for testing random walk theory and the long-term trend of the reverting jump and dip diffusion model. The random walk theory is an example of what is known in economics literature as a unit root process. The following equation demonstrates the comprehensive model of time series of $X_t$ for testing random walk $X_t = \alpha_1 + \alpha_2 t + \alpha_3 X_{t-1} + u_t$ where $X_t$ is the spot price at time t, t the time measured chronologically and $u_t$ the white noise error. One of the possibilities of the equation is deterministic trend; it means $\alpha_1 \neq 0$, $\alpha_2 \neq 0$ and $\alpha_3 < 1$. This equation in econometrics is called a trend stationary process (TSP).The mean of $X_t$ is $\alpha_1 + \alpha_2 t$, which is not constant, while its variance is constant. The results indicated that, assuming the current price jump initiated in 2007 behaves in the same manner as that experienced in 1978, the gold price would stay abnormally high up to the end of 2014. After that, the price would revert to the long-term trend until 2018.

On the other hand, the study showed that there was no significant relationship between gold price and inflation since it showed that the relationship between gold price and inflation was around -9% (and a t-statistic of -1.96) over the last four decades. In other words, if the nominal gold price was increased by the inflation rate over the last 40 years, the current gold price should be five times more than the current nominal price in 2008.

Shafiee and Topal (2010) use the variables oil and inflation in their study. We employed both of these variables in our study.

Marzo and Zagaglia (2010) investigate how the relation between gold prices and the U.S. Dollar has been affected by the recent turmoil in financial markets. They use spot prices of gold and spot bilateral exchange rates against the Euro and the British Pound to study the pattern of volatility spillovers. They estimate the bivariate structural GARCH models proposed by Spargoli e Zagaglia (2008) to gauge the causal relations between volatility changes in the two assets. They also apply the tests for change of co-dependence of Cappiello, Gerard and Manganelli (2005). They document the ability of gold to generate stable co-movements with the Dollar exchange rate that have survived the recent phases of market disruption. The findings also show that exogenous increases in market uncertainty have tended to produce reactions of gold prices that are more stable than those of the U.S. Dollar. In their paper they use daily data for spot contracts of exchange rates between the U.S. Dollar and the Euro and the U.S. Dollar and the British Pound. The dataset also includes settlement prices for spot contracts of gold negotiated in the Chicago Board of Trade, expressed in U.S. dollars for 100 ounces. Both the exchange rate and gold price data were extracted from Datastream. During the turmoil, the U.S. Dollar depreciates, on average, with respect to the Euro, and appreciates with respect to the British Pound. The average price of the gold also increases. The gold price becomes more stable during the turmoil, as it displays a lower standard deviation during the turmoil period. This is however not the case for the exchange rates, that are characterized by more extreme movements. The USD/EUR exhibits a positive correlation with price of gold both before and during the turmoil. This can be interpreted as evidence suggesting that investors have used gold as a hedge for the USD/EUR exchange rate. For the USD/GBP exchange rate instead, the turmoil appears to be characterized by a break in the correlation with the price of gold. The turmoil apparently has induced investors to hold gold for hedging purposes also against a fall of the USD/GBP exchange rate.

We used the variable that Marzo and Zagaglia (2010) implied in their study which is the exchange rate.

Toros Sajian (2006) examines the relationship between gold and all the other independent variables. First, he takes gold as the dependent variable, while all the others and the dependent. After running SPSS, the following is the equation that he gets:

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

$Y_t$ = the price of one ounce of gold at time t

$X_{1t}$ = the CPI at time t

$X_{2t}$ = the DJIA index at time t

$X_{3t}$ = the Euro/US Dollar exchange rate at time t

$X_{4t}$ = the Brent price at time t

$\varepsilon_t$ = the error term at time t

Assuming all the other variables are constant, he finds the regression coefficients as follows:

- With one unit increase in the CPI, the gold price increases by $1.617, on average.
- With one unit increase in the DJIA, the gold price decreases by $0.00927, on average.
- With one unit increase in the Euro/US Dollar exchange rate, the gold price will increase by $273.20, on average.
- With one dollar increase in the Brent price, the gold price will increase by $1.973, on average.

He found the elasticity of the variables as follows:

- A 1% increase in the CPI will lead gold prices to increase by 0.881%.
- A 1% increase in the DJIA will lead gold prices to decrease by 0.268%
- A 1% increase in the Euro/US Dollar exchange rate will lead gold prices to increase by 0.788%.
- A 1% increase in the price of Brent will lead gold prices to increase by 0.154%.

The Durbin-Watson is 0.495 which is less than the lower Durbin-Watson critical (1.59), hence, the null hypothesis of no serial correlation is rejected. The adjusted R-square is high at 0.918, thus, when the four variables are considered, the variation in the gold price is reduced by 91.8%.

Coming to the second part of this final section, since the Durbin-Watson of the regression was very small, Toros introduces the lag gold to the regression to overcome this problem. The equation is the following:

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

Where $Y_{t-1}$ is the price of gold at time t-1. Here, the Durbin-Watson has increased to 1.657. Since this value falls between the lower (1.57) and upper (1.78) critical values, the test is inconclusive. Durbin's h is 2.19 which is greater than 2, thus, a serial correlation exists. The F value computed is 549.289, higher than the F critical of 2.29 at 0.05 significance level, which means that the rejection of the null hypothesis that one or more of the coefficient(s) of the slopes are equal to zero. It is also noticeable that the coefficients are all significant because the t-statistics are all high. The coefficients of the regression are as follows (assuming all the other variables are constant):

- One point increase in CPI will push gold prices up by $0.693, on average.
- One point increase in the DJIA will push gold prices down by $0.002, on average.
- One point increase in the Euro/US Dollar exchange rate will push gold prices up by $67.13, on average.
- One dollar increase in the Brent price will push gold prices up by $0.515, on average.

The long run elasticity of the slopes is as follows:

- A 1% increase in the CPI will lead gold prices to increase by 1.32%.
- A 1% increase in the DJIA will lead gold prices to decrease by 0.208%
- A 1% increase in the Euro/US Dollar exchange rate will lead gold prices to increase by 0.780%.
- A 1% increase in the price of Brent will lead gold prices to increase by 0.14%.

Comparing these values of elasticity with the previous ones, they are relatively equal. In the last part of this section Toros transforms the regression equation into a logarithmic one.

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

Here, the Durbin-Watson did not change; the test is still inconclusive. The F test is highly significant at 481.63 compared to the critical F of 2.29 at 0.05 significance level. The coefficients are also significant because the t-statistics are all high. The interpretation of the regression coefficients is as follows (holding all the other variables constant):

- One point increase in CPI will push gold prices up by $0.381, on average.
- One point increase in the DJIA will push gold prices down by $0.087, on average.
- One point increase in the Euro/US Dollar exchange rate will push gold prices up by $0.221, on average.
- One dollar increase in the Brent price will push gold prices up by $0.034, on average.

The long run elasticity of the slopes is as follows:

- A 1% increase in the CPI will lead gold prices to increase by 1.318%.
- A 1% increase in the DJIA will lead gold prices to decrease by 0.536%
- A 1% increase in the Euro/US Dollar exchange rate will lead gold prices to increase by 0.035%.
- A 1% increase in the price of Brent will lead gold prices to increase by 0.087%.

In the end of this section, to put things in a nutshell, the majority of the authors used the four variables which are included in our study which are: the DJIA, the CPI, the Euro/USD exchange rate, and Brent oil prices. Other variables used were bond returns, real interest rates, 10 year US T-notes, corporate bonds and the US industrial production, which were not included in our study.

We are going to try to replicate Toros result with his own sample and with a larger sample in the next section.

The following table summarizes the relationships in the variables of the different authors, as well as the methods used.

| Source | Variables used | Relationships | Coefficients | Methods used |
|---|---|---|---|---|
| Faugère and Van Erlach (2005) | 1.) General valuation of stock markets<br>2.) Foreign exchange rates<br>3.) Inflation | 1.) Inverse relationship between gold and stock markets<br>2.) Law of one price: exchange rates and gold prices<br>3.) Price of gold will directly vary with global inflation rate | No coefficients are reported | Required Yield Theory |
| McCown and Zimmerman (2006) | 1.) US T-Notes & US T-Bills<br>2.) Corporate bonds<br>3.) Change in the US Industrial production<br>4.) CPI | 1.) Returns of gold are higher than T-Notes and T-Bills rates<br>2.) Uncorrelated with corporate bonds<br>3.) Higher industrial production, higher gold prices<br>4.) Good hedge against inflation | 1.) 0.001 (t=0.36)<br>2.) -0.001 (t=-0.19)<br>3.) 0.12 (t=0.90)<br>4.) 1.68 (t=1.72) | Capital Asset Pricing Model (CAPM), Ordinary Least Squares Regression (OLS), arbitrage pricing model of Ross, ADF tests, KPSS test, GLS tests, Johansen test for co- integration |
| Kearny and Lombra (2008) | 1.) 10-year T-Bond rate<br>2.) Real interest rate | 1.) Inverse relationship between 10 year T-Bond rates and gold prices<br>2.) Inverse relationship between real interest rates and gold prices | 1.) -0.01 (t=0.46)<br>2.) -0.01 (t=1.99) | Structural break tests, ADF tests, Granger causality test, Barsky and Summers estimation |
| Hammoudeh, Sari, and Ewing (2008) | 1.) 3-month T-Bill rate (interest rate)<br>2.) Foreign exchange rate | 1.) Inverse relationship between the 3-month T-Bill rate and gold prices<br>2.) Depreciation of the US Dollar leads to increase in gold prices | 1.) No significant relationship<br>2.) -0.3381 (t=-2.38) | ADF, Akaike Information Criterion (AIC), Autoregressive Distributed Lag (ARDL), KPSS, OLS, Phillips-Peron (PP), Schwarz Bayesian Criteria (SBC), Vector Autoregression (VAR), Vector Error Representation (VER) |

| | | | | |
|---|---|---|---|---|
| Ratner and Klein (2008) | 1.) Total stock market index | 1.) Gold has negative correlation with equities | No coefficients are reported | Jensen's alpha, CAPM, Markowitz mean-variance optimization, Monte-Carlo simulation |
| Baur and Lucey (2009) | 1.) Bond market<br>2.) Stock market | In both cases gold has inverse relationship with bond and stock markets | 1.) -0.0046 (t=-0.10)<br>2.) -0.0581 (t=-0.57) | GARCH process |
| Baur (2009) | 1.) Stock market | Inverse relationship between gold prices and stock markets | 1.) -0.0274 (first sub-sample) to -0.0562 (second sub-sample)<br>t=highly significant for all variables | ARCH and GARCH process |
| Baur and McDermott (2009) | 1.) Stock market | Inverse relationship between gold prices and stock markets | 1.) -0.071 (t=-1.21) | Multiple regression, GARCH |
| Ciner, Gurdgiev, and Lucey (2010) | 1.) Foreign exchange rates<br>2.) Oil prices<br>3.) Bonds<br>4.) Equities | 1.) Negative relationship between dollar, bond returns, and equities on one hand and gold prices on the other hand<br>2.) Positive relationship between oil prices and gold prices | 1.) 0.01 (t=-18.92)<br>2.) 0.44 (t=16.48)<br>3.) -0.04 (t=-8.07)<br>4.) -0.05 (t=-9.13) | Multiple regression, GARCH |
| Shafiee and Topal (2010) | 1.) Oil<br>2.) Inflation | 1.) Positive correlation between gold prices and oil prices<br>2.) No relationship between inflation and gold prices | No coefficients available; | Brownian motion, mean reversion |
| Marzo and Zagaglia (2010) | 1.) Foreign exchange rate | 1.) When US Dollar depreciates, average gold prices increase | No coefficients are reported | Bivariate structural GARCH model |

In our regression in US dollars (in section IV) we found the USD/EUR exchange rate and oil prices to be significant predictors of gold prices. We found the coefficient of USD/EUR exchange rate to be 0.342, while Hammoudeh, Sari, and Ewing (2008) found it 0.3381, Ciner, Gurdgiev, and Lucey (2010) found it be 0.01. Faugère and Van Erlach (2005) and Marzo and Zagaglia (2010), on the other hand, reported positive correlations between these two variables without reporting coefficient estimates.

Coming to the second variable which is oil, we found the coefficient to be 0.064, while Ciner, Gurdgiev, and Lucey (2010) found it to be 0.04. Shafiee and Topal (2010) reported positive correlation between gold and oil, and did not report coefficient estimates.

As for our regression in Lebanese Pounds (in section V) we found the variables LBP/EUR exchange rate, oil prices (in LBP) and CPI (in LBP), to be significant predictors of gold prices. We found the coefficient of the LBP/EUR exchange rate to be 0.343, while Hammoudeh, Sari, and Ewing (2008) estimated it 0.3381 and Ciner, Gurdgiev, and Lucey (2010) estimated it 0.01. Faugère and Van Erlach (2005) and Marzo and Zagaglia (2010) only reported positive correlations between gold and USD/EUR exchange rate, and did not report coefficient estimates.

Coming to the second variable oil (in LBP), we found the coefficient to be 0.054, while Ciner, Gurdgiev, and Lucey (2010) estimated it to be 0.04. Shafiee and Topal (2010) did not report coefficient estimates, however they reported positive correlation between gold and oil.

As for the third variable CPI (in LBP), we estimated the coefficient to be 0.675, while McCown and Zimmerman (2006) estimated it 1.68. Faugère and Van Erlach (2005) and Shafiee and Topal (2010) did not report coefficient estimates, however they reported positive correlation between gold and CPI.

After completing the survey of the literature, we are going to use the following independent variables in relation to gold:

- Foreign exchange rates (USD/EUR & LBP/EUR exchange rates)
- Stock markets (DJIA)
- Inflation (CPI)
- Oil prices (Brent)

By using these variables in our study, we are going to test for the following hypothesis:

$H_0$: All coefficient slopes are zero

$H_1$: At least one coefficient is not zero

This means that we will test for the hypothesis whether there is at least one independent variable that explains gold price in US Dollars and Lebanese Pounds. We will test for this by using the F-statistic and the ANOVA test for each of the regressions in the first differences of the logs.

## III. Replicating Toros results with Toros sample

Table 1 (appendix b) consists of the elasticity of all the independent variables (Oil, DJIA, CPI, and Euro) with respect to the dependent variable which is gold as estimated by us. In the "log" section of the table, we have the elasticity of all the independent variables with respect to gold price.

### 1. Regression in log-levels without the lagged dependent variable

Looking at table 1 in the 'log' section and under the first column, 'Elasticity 1 Long run', we interpret the following:

- One percent increase in the Brent oil price will cause gold price to increase by 0.12743 % per ounce.
- One percent increase in the Dow Jones Industrial Average will cause gold price to decrease by 0.27342 % per ounce.
- One percent increase in the CPI will cause gold price to increase by 0.91602 % per ounce.
- One percent increase in the USD/EUR exchange rate will cause gold price to increase by 0.79608 % per ounce.

No calculations were needed in this case because the values are already the elasticities.

**2. Regression in log-levels with the lagged dependent variable**

Coming to the second column in the 'log' section under the column 'Elasticity 2 long run', which was calculated by transforming the short run logged coefficients into long run ($\frac{Coefficient}{1-\lambda}$), the following interpretations can be stated:

- One percent increase in the Brent oil price will cause gold price to increase by 0.10053 % per ounce.
- One percent increase in the Dow Jones Industrial Average will cause gold price to decrease by 0.28125 % per ounce.
- One percent increase in the CPI will cause gold price to increase by 1.4375 % per ounce.
- One percent increase in the USD/EUR exchange rate will cause gold price to increase by 0.77055 % per ounce.

**3. Regression in levels without the lagged dependent variable**

As for the elasticities in the 'Levels' section of the table under the column 'elasticity 1 long run', which was calculated by [coefficient × ($\frac{\bar{x}}{\bar{y}}$)] can be interpreted as the following:

- One percent increase in the Brent oil price will cause gold price to increase by 0.13666% per ounce.

- One percent increase in the Dow Jones Industrial Average will cause gold price to decrease by 0.26412 % per ounce.
- One percent increase in the CPI will cause gold price to increase by 0.93277 % per ounce.
- One percent increase in the USD/EUR exchange rate will cause gold price to increase by 0.79411 % per ounce.

**4. Regression in levels with the lagged dependent variable**

As for the last column in the section 'levels', the elasticities were calculated by taking the lagged variables and converting them to long run. This was done by the following equation: $\left(\frac{Coefficient}{1-\lambda}\right) \times \left(\frac{\bar{x}}{\bar{y}}\right)$; hence, we state the following:

- One percent increase in the Brent oil price will cause gold price to increase by 0.10321% per ounce.
- One percent increase in the Dow Jones Industrial Average will cause gold price to decrease by 0.26319 % per ounce.
- One percent increase in the CPI will cause gold price to increase by 1.51033 % per ounce.
- One percent increase in the USD/EUR exchange rate will cause gold price to increase by 0.78709 % per ounce.

## 5. Comparison of the results with Toros results

Next, we compare our results with the results of Toros (table 6.1 below). By taking the log of the gold and using lag, he found the elasticity of oil to be 0.08592. Our finding is 0.10053 which is somehow close. Coming to the variable DJIA, Toros found the elasticity to be -0.33590. We found it to be -0.28125. As for the CPI, he found the elasticity 1.31781 which is close to ours (1.43750). As for the last variable (USD/EUR), he found the elasticity 0.85328 which differs not so greatly than our value of 0.77055. So we can say that the elasticities that we calculated and those of Toros, are quite similar.

Table 5.1 Elasticity of Log with lags

| | Our results | Toros results |
|---|---|---|
| Oil (Brent) | 0.10053 | 0.08592 |
| DJIA | -0.28125 | -0.33590* |
| CPI | 1.43750 | 1.31781 |
| USD/EUR | 0.77055 | 0.85328** |
| Durbin's h | 2.0116 | 2.1099 |

* Toros mistakenly reported -0.63360

** Toros mistakenly reported 0.03496

Toros also calculated elasticity in levels without lags and as well as in levels with lags.

Table 5.2 (below) shows the elasticities of levels without lags. In Levels without lags Toros found the elasticity of the oil to be 0.15367 and we found it to be 0.13666 where the values are significantly close. As for the DJIA he found the elasticity of to be -0.26755 where we found it to be -0.26412. Coming to the elasticity of CPI Toros found it to be 0.88048 and we calculated it 0.93277. As for the last variable which is the USD/EUR, the elasticity of Toros is 0.78827, whereby our elasticity is 0.79411.

Table 5.2 Elasticity of level without lags

| | Our results | Toros results |
|---|---|---|
| Oil (Brent) | 0.13666 | 0.15367 |
| DJIA | -0.26412 | -0.26755 |
| CPI | 0.93277 | 0.88048 |
| USD/EUR | 0.79411 | 0.78827 |
| Durbin-Watson | 0.54745 | 0.49500 |

In levels with lags, Toros' elasticity and our elasticity did not contain remarkable differences. He found the elasticity of the oil, DJIA, CPI, and USD/EUR to be 0.14025, -0.20789, 1.31940, and 0.78003 respectively, while we found 0.10321, -0.26319, 1.51033, and 0.78709 for the oil, DJIA, CPI, and USD/EUR, respectively.

The following table compares our level with lag results with the results of Toros.

Table 5.3 Elasticity of level with lags

| | Our results | Toros results |
|---|---|---|
| Oil (Brent) | 0.10321 | 0.14025 |
| DJIA | -0.26319 | -0.20789 |
| CPI | 1.51033 | 1.31940 |
| USD/EUR | 0.78709 | 0.78003 |
| Durbin's h | 2.0052 | 2.1901 |

When comparing our results with the results of Toros, we can see from the tables that the coefficients are consistent and close to each other.

### 6. Problems with Toros methodology

Problems existed with the methodology of Toros of which was the Durbin-Watson statistic. Durbin's h-statistic should have been used instead of the Durbin-Watson statistic. Another problem was that the variables of Toros were non-stationary. Hence, we conducted Augmented Dickey-Fuller tests. In the next section we provide the definitions of the statistics and tests we used.

#### a. Definition of statistics and tests used

##### (i) Durbin-Watson Statistic

The Durbin-Watson statistic informs us whether the assumption of independent error is tenable. It tests for serial correlation between errors. By far it's the most popular test for autocorrelation.

The value should be as close to 2 as possible (the assumption of independent error is met)

Values close to 1 (<1) or greater than 3 are alarming.

The null hypothesis Ho: $\rho = 0$

The alternative hypothesis Ha: $\rho \neq 0$

To test the hypothesis DW calculates an estimate of $\rho$ from the regression residuals:

$$DW = \frac{\sum_{t=2}^{N} (\hat{\varepsilon}_t - \hat{\varepsilon}_{t-1})^2}{\sum_{t=1}^{N} \hat{\varepsilon}_t^2}$$

where t is the number of observations

So when DW=2, this indicates no correlation. The value of DW must always lie between 0 and 4. If the Durbin–Watson statistic is substantially less than 2, there is evidence of positive serial correlation. Values of less than one are alarming. Small values indicate that that the successive error terms are positively correlated.

To test for positive autocorrelation at significance $\alpha$, the test statistic $DW$ is compared to lower and upper critical values ($DW_{L,\alpha}$ and $DW_{U,\alpha}$):

- If $DW < DW_{L,\alpha}$, there is statistical evidence that the error terms are positively autocorrelated.
- If $DW > DW_{U,\alpha}$, there is statistical evidence that the error terms are not positively autocorrelated.
- If $DW_{L,\alpha} < DW < DW_{U,\alpha}$, the test is inconclusive.

Positive serial correlation is serial correlation in which a positive error for one observation increases the chances of a positive error for another observation. Positive serial correlation may affect our ability to conduct valid statistical tests. First, the F-statistic to test for overall significance of the regression may be inflated because the mean squared error (MSE) will tend to underestimate the population error variance. Second, positive serial correlation typically causes the ordinary least squares (OLS) standard errors for the regression coefficients to underestimate the true standard errors. As a consequence, if positive serial correlation is present in the regression, standard linear regression analysis will typically lead us to compute artificially small standard errors for the regression coefficient. These small standard errors will cause the estimated t-statistic to be inflated, suggesting significance where perhaps there is none. The inflated t-statistic, may in turn, lead us to incorrectly reject null hypotheses, about population values of the parameters. This Type I error could lead to improper investment recommendations.

**(ii)Durbin's h-statistic**

For autoregressive moving average models, the Durbin-Watson statistic is biased, so that autocorrelation is underestimated. When one or more lagged dependent variables are present, the Durbin-Watson statistic will be biased towards 2 – this means that even if serial correlation is present it may be close to 2. Durbin suggests a test that is strictly valid for large sample but often used for small samples. This test for serial correlation when there is a lagged dependent variable in the equation is based on the **h** statistics.

It's a fairly straightforward procedure.

Assume we estimated this model with OLS:

$$Y_t = \alpha + \gamma X_t + \beta Y_{t-1} + \varepsilon_t$$

The Durbin h statistics is defined as:

$$h = \hat{\rho}\sqrt{\frac{T}{1-T[Var(\hat{\beta})]}}$$

T = the number of observations,

$\hat{\rho}$ = the estimated correlation coefficient of the residuals, that is the autocorrelation coefficient of the residuals.

The $Var(\hat{\beta})$ is the variance of *the coefficient on the lagged dependent variable.*

Solving for $\hat{\rho}$ and substituting, we can write the **h** statistics as:

$$h = \left(1-\frac{DW}{2}\right)\sqrt{\frac{T}{1-T[Var(\hat{\beta})]}}$$

Durbin has shown that the h statistics is approximately normally distributed with a unit variance; hence, the test for first order serial correlation can be done using the standard normal distribution. It should be noted, however, that if $T[Var(\hat{\beta})]$ is greater than one, then the ratio with the square root becomes negative and this test cannot be applied.

So, the test is a normal distribution Z test and the null hypothesis is that $\rho = 0$.

If the value is greater than the critical value of the normal distribution at the 5% level (the critical value is 1.645 or 1.96 for a one tail test with 5% in the tail), we reject the null hypothesis of no serial correlation.

**(iii) Random Walk Theory**

The theory that stock price changes have the same distribution and are independent of each other, so the past movement or trend of a stock price or market cannot be used to predict its future movement.

Investopedia explains Random Walk Theory as the following*:*

In short, this is the idea that stocks take a random and unpredictable path. A follower of the random walk theory believes it's impossible to outperform the market without assuming additional risk. Critics of the theory, however, contend that stocks do maintain price trends over time - in other words, that it is possible to outperform the market by carefully selecting entry and exit points for equity investments.

This theory raised a lot of eyebrows in 1973 when author Burton Malkiel wrote "A Random Walk Down Wall Street", which remains on the top-seller list for finance books.

**(iv) Stationarity/Non-Stationarity**

From the definition of a random process, we know that all random processes are composed of random variables, each at its own unique point in time. Because of this, random processes have all the properties of random variables, such as mean, correlation, variances, etc. When dealing with groups of signals or sequences it will be important for us to be able to show whether or not these statistical properties hold true for the entire random process. To do this, the concept of stationary processes has been developed. The general definition of a stationary process is: a random process where all of its statistical properties do not vary with time.

Processes whose statistical properties do change are referred to as nonstationary.

Statistical stationarity: A stationary time series is one whose statistical properties such as mean, variance, autocorrelation, etc. are all constant over time. Most statistical forecasting methods are based on the assumption that the time series can be rendered approximately stationary (i.e., "stationarized") through the use of mathematical transformations. A stationarized series is relatively easy to predict: we simply predict that its statistical properties will be the same in the future as they have been in the past. The predictions for the stationarized series can then be "untransformed," by reversing whatever mathematical transformations were previously used, to obtain predictions for the original series. Thus, finding the sequence of transformations needed to stationarize a time series often provides important clues in the search for an appropriate forecasting model.

Another reason for trying to stationarize a time series is to be able to obtain meaningful sample statistics such as means, variances, and correlations with other variables. Such statistics are useful as descriptors of future behavior *only* if the series is stationary. For example, if the series is consistently increasing over time, the sample mean and variance will grow with the size of the sample, and they will always underestimate the mean and variance in future periods.

And if the mean and variance of a series are not well-defined, then neither are its correlations with other variables. For this reason we should be cautious about trying to extrapolate *regression* models fitted to nonstationary data.

Most business and economic time series are far from stationary when expressed in their original units of measurement, and even after deflation or seasonal adjustment they will typically still exhibit trends, cycles, random-walking, and other non-stationary behavior. If the series has a stable long-run trend and tends to revert to the trend line following a disturbance, it may be possible to stationarize it by de-trending (e.g., by fitting a trend line and subtracting it out prior to fitting a model, or else by including the time index as an independent variable in a regression), perhaps in conjunction with logging or deflating. Such a series is said to be trend-stationary. However, sometimes even de-trending is not sufficient to make the series stationary, in which case it may be necessary to transform it into a series of period-to-period and/or season-to-season differences. If the mean, variance, and autocorrelations of the original series are not constant in time, even after detrending, perhaps the statistics of the changes in the series between periods or between seasons will be constant. Such a series is said to be difference-stationary. (Sometimes it can be hard to tell the difference between a series that is trend-stationary and one that is difference-stationary, and a so-called unit root test may be used to get a more definitive answer.)

**(v) Augmented Dickey-Fuller test (ADF)**

In statistics and econometrics, an augmented Dickey–Fuller test (ADF) is a test for a unit root in a time series sample. It is an augmented version of the Dickey–Fuller test for a larger and more complicated set of time series models. The augmented Dickey–Fuller (ADF) statistic, used in the test, is a negative number. The more negative it is, the stronger the rejection of the hypothesis that there is a unit root at some level of confidence.

The testing procedure for the ADF test is the same as for the Dickey–Fuller test but it is applied to the model

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} - \cdots + \delta_{p-1} \Delta y_{t-p+1} + \varepsilon_t,$$

where α is a constant, β the coefficient on a time trend and *p* the lag order of the autoregressive process. Imposing the constraints α = 0 and β = 0 corresponds to modeling a random walk and using the constraint β = 0 corresponds to modeling a random walk with a drift.

By including lags of the order ρ the ADF formulation allows for higher-order autoregressive processes. This means that the lag length ρ has to be determined when applying the test. One possible approach is to test down from high orders and examine the t-values on coefficients. An alternative approach is to examine information criteria such as the Akaike information criterion, Bayesian information criterion or the Hannan-Quinn information criterion, and Schwarz information criterion.

The unit root test is then carried out under the null hypothesis $\gamma = 0$ against the alternative hypothesis of $\gamma < 0$. Once a value for the test statistic

$$DF_\tau = \frac{\hat{\gamma}}{SE(\hat{\gamma})}$$

is computed it can be compared to the relevant critical value for the Dickey–Fuller Test. If the test statistic is less (this test is non symmetrical so we do not consider an absolute value) than (a larger negative) the critical value, then the null hypothesis of $\gamma = 0$ is rejected and no unit root is present.

The intuition behind the test is that if the series is integrated then the lagged level of the series ($y_{t-1}$) will provide no relevant information in predicting the change in $y_t$ besides the one obtained in the lagged changes ($\Delta y_{t-k}$). In that case the $\gamma = 0$ null hypothesis is not rejected.

For instance, a model that includes a constant and a time trend is estimated using sample of 50 observations and yields the $DF_\tau$ statistic of −4.57. This is more negative than the tabulated critical value of −3.50, so at the 95 per cent level the null hypothesis of a unit root will be rejected.

Table 6.1 below represents the elasticity of the independent variables with their respective logs (with and without lags) and levels (with and without lags). Since our model is a multiple regression model, the coefficient estimates depend on the covariances between the independent variables. As we can see, the resulting coefficients are close to each other. This can be explained by the fact that the covariances with the additional lagged variable are small.

The fact that the coefficient on the CPI is so unstable is that the CPI, or its log, is highly correlated with the lagged dependent variable.

**b. Durbin-Watson and Durbin's h statistics for the two regressions with and without lags**

The table below illustrates the elasticity of the independent variables as we estimated using Toros sample together with their respective Durbin-Watson and Durbin's h statistics.

Durbin-Watson statistic is inappropriate to use whenever lagged variables exist; hence, it is meaningful only in case of no lags. Whenever there are lagged variables, Durbin's h is the most suitable to use.

Table 6.1 Elasticity of independent variables as per our estimate of Toros sample

| | Log without lag | Log with lag | Level without lag | Level with lag |
|---|---|---|---|---|
| Oil (Brent) | 0.12743 | 0.10053 | 0.13666 | 0.10321 |
| DJIA | -0.27342 | -0.28125 | -0.26412 | -0.26319 |
| CPI | 0.91602 | 1.43750 | 0.93277 | 1.51033 |
| USD/EUR | 0.79608 | 0.77055 | 0.79411 | 0.78709 |
| Durbin-Watson | 0.56823 | - | 0.54745 | - |
| Durbin's h | - | 2.0116 | - | 2.0052 |

The Durbin's h statistic is 2.0116 for the log with lag which is greater than 1.96 at 95% confidence interval level. This means that we reject the null hypothesis that there is no serial correlation in residuals.

As for the level with lag, the Durbin's h value is 2.0052 which is also greater than 1.96 at 95% confidence interval level. This, again, means that we reject the null hypothesis that there is no serial correlation between gold and the other independent variables.

Since there is a serial correlation of residuals, the standard errors of the coefficients are understated, which means that the t-statistics are overstated.

The Durbin-Watson in our sample (level without lags) is 0.54745 and 0.49500 (table 5.2) with Toros, indicating that the successive error terms are positively correlated which hinders us in reaching a substantial and confident conclusion.

The Durbin h statistic in our sample (level with lags) is 2.0052 and 2.1901 (table 5.3) with Toros, which is greater than 1.96 at 95% confidence interval level. In case of log-levels with lags our estimate of Durbin's h is 2.0116 where Toros' estimate is 2.1099. This means that we both rejected the null hypothesis that there is no serial correlation. This doesn't count as evidence in our favor, because the t-statistic will be inflated and we will reach wrong conclusions in our study.

**c. Variables are non-stationary: Dickey-Fuller tests**

Table 6.5 January, 1997 – March, 2005 (Toros sample)

ADF + constant + trend lags by minimizing Schwarz information criterion

| | Level | First Difference |
|---|---|---|
| Log (goldus) | -1.9764<br>(0.6066) | -9.3845<br>(<0.0001) |
| Log (oil) | -2.4075<br>(0.3735) | -9.7424<br>(<0.0001) |
| Log (djia) | -2.4168<br>(0.3688) | -8.3459<br>(<0.0001) |
| Log (cpi) | -2.4452<br>(0.3545) | -8.0019<br>(<0.0001) |
| Log (euro) | -0.9150<br>(0.9495) | -7.2398<br>(<0.0001) |

*Note: (p-values in parenthesis)*

The preceding table represents the Augmented Dickey-Fuller test for the sample of Toros. All the values together with their respective probabilities indicate that we do not reject the null hypothesis that there is a unit root. In other words, we do not reject the fact that the values are non-stationary.

Consequently, and since all asset prices are random walks, we cannot run a normal linear regression. For this reason, we calculate the first difference for each of the variables and their respective probabilities. As we can see from the table, all the probabilities are less than 0.0001, which means that we do not reject the null hypothesis that there is a unit root. Consequently, our values are stationary. Hence, this allows us to run a linear regression.

The differences that exist between our and Toros' results may have occurred due to one of the several reasons such as:

- spurious relation
- multicollinearity
- data revision
- human error
- different statistical softwares
- different data (Toros took monthly average of daily data)

In conclusion, the coefficients of Toros and our results are close to each other. Furthermore, since the values are non stationary, we cannot use standard errors. That's why we did not repeat standard errors and t-statistics. Hence, that's why we did not test for unit elasticity.

## IV. Estimation of the regressions in first-differences of the logs

### 1. Data Collection

First, the CPI data was obtained from the website http://www.inflationdata.com which specializes and provides different forms of information and data regarding inflation. The data used was on a monthly basis since the CPI is calculated on a monthly basis.

The data of the second variable, which is the DJIA, was obtained from http://finance.yahoo.com and the data was based on the monthly averages of the open and close values of the index.

Coming to third variable, which is the Euro exchange rate it is composed of two categories. The first is the USD/EUR exchange rate which was obtained from http://www.oanda.com which is specialized in currencies. As for the second category, it is the LBP/EUR rate which was obtained from Banque du Liban's website http://www.bdl.gov.lb.

As for the fourth variable, it is the Brent oil price. The data was obtained from http://www.indexmundi.com which is a data portal that gathers facts and statistics from multiple sources and turns them into easy to use visuals.

Coming to the gold price, it is divided into two categories. The gold price per ounce in US dollars was obtained from http://www.kitco.com which is the world's most dependable website for metal prices. The second category is the gold price per ounce in Lebanese Pounds, which was obtained from Banque du Liban's website http://www.bdl.gov.lb.

Since the Euro currency emerged in January 1999, and since our data begins from September 1985, we calculated the USD/Euro rate by dividing the gold price in Lebanese pounds by the gold price in US dollars. By this, we get the LBP/USD rate. Dividing the Euro in Lebanese pounds by the rate of US Dollars in Lebanese pounds we get the USD/EUR rate.

Regarding the Toros sample, the case of October 1999 was considered an outlier, but it was not removed because its removal did not affect considerably our results. The only considerable value that changed was the mean of the variable dlllgoldus, which changed from 2.52 to 0.60 after removing the outlier.

A sequential multiple regression, using SPSS regression was conducted. In this section we ran the regression taking into consideration all four independent variables.

**2. Descriptive Statistics for Toros Sample with all variables**

The sample consisted of 98 records (January 1997 till March 2005). Definition of the variables is presented in Appendix A. Descriptive statistics for the four predictor variables are presented in the table below. The mean of the variable dlllgoldus means that the monthly average percentage change of the variable is 0.21% which is equivalent to 2.52% per year (0.21% x 12). The mean of dllleuro, dlllcpi, dllldjia, and dllloil is 0.09%, 0.20%, 0.49%, and 0.83% change per month on average, respectively, and 1.08%, 2.40%, 5.88%, and 9.96% change per year on average, respectively. As for the standard deviation, it is calculated by taking the value in the table and multiplying it by the square root of 12 (12 months a year). The standard deviation of the variable dlllgoldus is 0.03293 which multiplied by the square root of 12 gives us 0.1141, which means that the yearly standard deviation is 11.41%. As for the independent variables dllleuro, dlllcpi, dllldjia, and dllloil the yearly standard deviation is 8.40%, 0.95%, 14.03%, and 33.54% respectively.

**Descriptive Statistics**

| | Mean (monthly) | Std. Deviation(monthly) | Mean (yearly) | Std. Deviation(yearly) |
|---|---|---|---|---|
| dlllgoldus | .0021 | .03293 | 0.0252 | 0.1141 |
| dllleuro | .0009 | .02426 | 0.0108 | 0.0840 |
| dlllcpi | .0020 | .00274 | 0.0240 | 0.0095 |
| dllldjia | .0049 | .04049 | 0.0588 | 0.1403 |
| dllloil | .0083 | .09681 | 0.0996 | 0.3354 |

### 3. Toros sample regression with all variables

The data revealed the absence of missing values. Looking at the correlation matrix (table 3), we can see a strong correlation between euro and gold ($r=.40$, $p < 0.05$). We can say the USD/EUR exchange rate is the strongest predictor for the gold price.

The value of $R^2$ (table 4) indicates that the four variables account for 18.1% of the variation in gold price. [$F$ (4, 93) =5.144; $p < 0.001$]

Looking at the coefficients table (Table 5), we find the value of the un-standardized USD/EUR exchange rate to be 0.559 (significant), which means that for every 1 percent depreciation of the US Dollar against the Euro gold prices will increase by 0.559 percent. As for the variables oil, DJIA, and CPI they were not significant predictors of gold price.

Moreover, it was proved that the residuals were independently distributed since Durbin Watson is 1.932, close to 2. Looking at the Durbin-Watson statistics table of critical values (1% significance level) with n=98 and D-L and D-U equaling 1.45592 and 1.62254, respectively, it is proved that there is no positive serial correlation of residuals, since the calculated Durbin-Watson falls between the upper limit and 2.

### 4. Testing for normality, linearity, and heteroscedasticity (with all variables)

To test for the normality of residuals, we looked at the histogram and the normal probability plot (Figure 1 and 2). The histogram should have a bell-shaped curve. Any deviation from this curve is a sign of non-normality. The normal probability plot also shows up deviations from normality. The straight line represents a normal distribution, and the points represent the observed residuals. Therefore, in a perfectly normally distributed data set, all points will lie on the line. In our case, both the histogram and normal probability plot showed a normally distributed data. As for heteroscedasticty, we look at the scatter plot (Figure 3), the graph should look like a random array of dots evenly dispersed around zero. The x-axis (horizontal) represents the z predicted value, which is the standardized predicted value of the dependent variable based on the model. The y-axis (vertical) represents the standardized residuals of the error. These values are the standardized differences between the observed data and the values that the model predicts. Since our graph funnels out, it means that there is heteroscedasticity. However, since there isn't any sort of curve in this graph then the data has not broken the assumption of linearity.

Thus, the assumptions of normality, linearity, and homoscedasticity were not all met.

**5. Toros sample regression by omitting insignificant variables**

The data revealed the absence of missing values. Looking at the correlation matrix (table 6), we can see a strong correlation between euro and gold ($r=.40$, $p < 0.05$); hence, the USD/EUR exchange rate is a strong predictor for the gold price.

The value of $R^2$ (table 7) indicates that the variable USD/EUR exchange rate accounts for 16.3% of the variation in gold price. [$F(1, 96) = 18.633$; $p < 0.001$]

Looking at the coefficients table (table 8), we find the value of the un-standardized USD/EUR exchange rate to be 0.547 (significant) which means that every 1 percent depreciation of the US Dollar against the Euro will cause gold prices to increase 0.547 percent.

Moreover, it was proved that the residuals were independently distributed since Durbin Watson is 1.890, close to 2. Looking at the Durbin-Watson statistics table of critical values (1% significance level) with n=98 and D-L and D-U equaling 1.51759 and 1.55805, respectively, it is proved that there is no positive serial correlation of residuals, since the calculated Durbin-Watson falls between the upper limit and 2.

### 6. Testing for normality, linearity, and heteroscedasticity (by omitting insignificant variables)

To test for the normality of residuals, we looked at the histogram and the normal probability plot (Figure 4 and 5). The histogram should have a bell-shaped curve. Any deviation from this curve is a sign of non-normality. The normal probability plot also did not show up deviations from normality. The straight line represents a normal distribution, and the points represent the observed residuals. Therefore, in a perfectly normally distributed data set, all points will lie on the line. In our case, both the histogram and the probability plot showed a normally distributed data.

As for heteroscedasticity, we examined the scatter plot (Figure 6), the graph should look like a random array of dots evenly dispersed around zero. Since the graph doesn't funnel out, it means that there is no heteroscedasticity. Moreover, since there isn't any sort of curve in this graph then the data has not broken the assumption of linearity.

Thus, the assumptions of normality, linearity, and homoscedasticity were all met.

**7. Applying F-test on the R-Squares on removing the variables with insignificant coefficients**

An ANOVA F-test was calculated according to the following formula:

$$\text{Actual F-statistic}=\frac{\left(R_{UR}^{2}-R_{R}^{2}\right)/m}{\left((1-R_{UR}^{2}\right)/\left(n-k\right)}$$

Where $R^2$ is the coefficient of determination, denoted as R-Square, and not the adjusted R-Square

Where $R_{UR}^2$ is the (unrestricted) R-Square from the regression that includes all the independent variables.

Where $R_R^2$ is the (restricted) R-Square from the regression that omits the variables with insignificant coefficients, according to individual t-tests.

Where $m$ is the number of independent variables omitted (or number of constraints).

Where $n$ is the sample size.

Where $k$ is the number of coefficients estimated in the (unrestricted) regression that includes all variables, with both insignificant and significant coefficients. This number includes the constant.

The results showed that the omission of the three variables was indeed a good choice (F-test < F-critical; 0.6818 < 6.90; p > 0.01)

**8. Descriptive Statistics for the whole sample with all variables**

In our research we are interested in investigating the predictive significance of the following predictor(s): Oil price, USD/EUR exchange rate, DJIA, and CPI. To test our hypothesis, we conducted sequential multiple regressions using SPSS Regression.

The sample consisted of 302 records. Descriptive statistics for the four predictor variables are presented in the table below. Since we ran the regression as the difference between the log of the variable and the lag of the log, the values in the descriptive statistics table are percentage changes and must be multiplied by hundred. Hence, the mean of the variable dlllgoldus means that the monthly average percentage change of the variable is 0.48% which is equivalent to 5.76% per year (0.48% x 12). The mean of dllloil, dllleuro, dllldjia, and dlllcpi is 0.37%, 0.18%, 0.71%, and 0.23% change per month on average, respectively, and 4.44%, 2.16%, 8.52%, and 2.76% change per year on average, respectively. As for the standard deviation, it is calculated by taking the value in the table and multiplying it by the square root of 12 (12 months a year). The standard deviation of the variable dlllgoldus is 0.03533 which multiplied by the square root of 12 gives us 0.1224, which means that the yearly standard deviation is 12.24%. As for the independent variables dllloil, dllleuro, dllldjia, and dlllcpi the yearly standard deviation is 33.17%, 10.64%, 13.16%, and 1.12% respectively.

**Descriptive Statistics**

| | Mean (monthly) | Std. Deviation (monthly) | Mean (yearly) | Std. Deviation (yearly) |
|---|---|---|---|---|
| dlllgoldus | .0048 | .03533 | 0.0576 | 0.1224 |
| dllloil | .0037 | .09576 | 0.0444 | 0.3317 |
| dllleuro | .0018 | .03072 | 0.0216 | 0.1064 |
| dllldjia | .0071 | .03800 | 0.0852 | 0.1316 |
| dilllcpi | .0023 | .00323 | 0.0276 | 0.0112 |

### 9. Whole sample regression with all variables

The data revealed the absence of missing values. According to the correlation matrix (Table 9), the USD/EUR exchange rate seems to correlate best with the outcome of gold price ($r=.33$, $p < 0.001$); hence it's likely that the USD/EUR exchange rate will best predict gold price. The value of $R^2$ (table 10) indicates that the four variables USD/EUR exchange rate, price of oil, DJIA and the CPI account for 14.7% of the variation in gold price. [$F (4, 297) = 12.75$; $p < 0.001$] Looking at the coefficients table (Table 11), we found the corresponding values to be significant. *The un-standardized coefficient of oil is 0.06, which means that for every 1 percent* increase in the oil price, there's a 0.06 percent increase in the price of gold. As for the USD/EUR exchange rate, every 1 percent depreciation of the US Dollar against the Euro will cause gold prices to increase by 0.339 percent. As for the DJIA and CPI, they were not significant predictors of gold price.

Moreover, it was proved that the residuals were independently distributed since Durbin Watson is 1.812, close to 2. Looking at the Durbin-Watson statistics table of critical values (1% significance level) with n=300 and D-L and D-U equaling 1.70606 and 1.75975, respectively, it is proved that there is no positive serial correlation of residuals, since the calculated Durbin-Watson falls between the upper limit and 2.

**10.Testing for normality, linearity, and heteroscedasticity (with all variables)**

To test for the normality of residuals, we looked at the histogram and the normal probability plot (Figure 7 and 8). The histogram should have a bell shaped curve. Any deviation from this curve is a sign of non-normality. The normal probability plot also did not show up deviations from normality. The straight line represents a normal distribution, and the points represent the observed residuals. Therefore, in a perfectly normally distributed data set, all points will lie on the line. In our case, both the histogram and the probability plot showed a normally distributed data.

As for heteroscedasticity, we look at the scatter plot (Figure 9), the graph should look like a random array of dots evenly dispersed around zero. Since our graph doesn't funnel out, it means that there is no heteroscedasticity. Moreover, since there isn't any sort of curve in this graph then the data has not broken the assumption of linearity.

Thus, the assumptions of normality, linearity, and homoscedasticity were all met.

The values in the correlation matrix were all below 0.8, VIF*, and tolerance** values all indicated that the assumption of absence of multicollinearity and singularity was met.

**11. Whole sample regression by omitting insignificant variables**

The data revealed the absence of missing values. According to the correlation matrix (table 12), the USD/EUR exchange rate seems to correlate best with the outcome of gold price ($r=.33$, $p < 0.05$) and it's likely that the USD/EUR exchange rate will best predict gold price. The value of $R^2$ (table 13) indicates that the two variables USD/EUR exchange rate and price of oil account for 13.6% of the variation in gold price. [$F(2, 299) = 23.559$; $p < 0.001$] Looking at the coefficients table (table 14), we find the corresponding values to be significant. The un-standardized coefficient of oil is 0.064, which means that for every 1 percent increase in the oil price, there's a 0.064 percent increase in the price of gold. As for the USD/EUR exchange rate, every 1 percent depreciation of the US Dollar against the Euro will cause gold prices to increase 0.342 percent.

Moreover, it was proved that the residuals were independently distributed since Durbin Watson is 1.827, close to 2. Looking at the Durbin-Watson statistics table of critical values (1% significance level) with n=300 and D-L and D-U equaling 1.71279 and 1.75293, respectively, it is proved that there is no positive serial correlation of residuals, since the calculated Durbin-Watson falls between the upper limit and 2.

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* According to Myers (1990), variance inflation factors above 10 should be considered as potential sign for multicollinearity. In this analysis VIF had a value of extremely close to 1 indicating that there is no multicollinearity.

** According to Field (2005), tolerance values below 0.1 are a potential sign of multicollinearity. In this analysis, VIF had a value of extremely close to 1 indicating that there is no multicollinearity.

**12. Testing for normality, linearity, and heteroscedasticity (by omitting insignificant variables)**

To test for the normality of residuals, we looked at the histogram and the normal probability plot (Figure 10 and 11). The histogram should have a bell-shaped curve. Any deviation from this curve is a sign of non-normality. The normal probability plot also did not show up deviations from normality. The straight line represents a normal distribution, and the points represent the observed residuals. Therefore, in a perfectly normally distributed data set, all points will lie on the line. In our case, both the histogram and the probability plot showed a normally distributed data. As for heteroscedasticity, we examined the scatter plot (Figure 12), the graph should look like a random array of dots evenly dispersed around zero. Since our graph doesn't funnel out, it means that there is no heteroscedasticity. Moreover, since there isn't any sort of curve in this graph then the data has not broken the assumption of linearity. Thus, the assumptions of normality, linearity, and homoscedasticity were all met.

The values in the correlation matrix were all below 0.8, VIF, and tolerance values all indicated that the assumption of absence of multicollinearity and singularity was met.

**13. Applying F-test on the R-Squares on removing the variables with insignificant coefficients**

An F-test was conducted to examine whether the omission of the variables was a good choice. The results showed that the omission of the two variables was a good choice (F-test < F-critical; 1.92 < 4.68; p > 0.01)

**14. Documenting instability in the regressions and the estimated coefficients**

Table 14.1 Mean and standard deviation comparison table

| | September 1985- November 2010 | January 1997- March 2005 |
|---|---|---|
| Mean (yearly) | | |
| dlllgoldus | 5.76% | 2.52% |
| dllloil | 4.44% | 9.96% |
| dllleuro | 2.16% | 1.08% |
| dllldjia | 8.52% | 5.88% |
| Standard deviation (yearly) | | |
| dlllgoldus | 12.24% | 11.41% |
| dllloil | 33.17% | 33.54% |
| dllleuro | 10.64% | 8.40% |
| dllldjia | 13.16% | 14.03% |
| $R^2$ | 14.7% | 18.1% |

The above table compares the values of descriptive statistics of the full sample and in first differences of our and Toros sample. As one can observe, the mean percentage changes are quite different between the two samples whereas the standard deviations are somehow close to each other. Coming to the $R^2$, it shows that the four independent variables in Toros' sample somehow better indicated for the variation in gold price. In our sample only oil and USD/EUR exchange rate were significant variables, whereas only the USD/EUR exchange rate was the significant variable in the sample of Toros. Our results showed that every 1 percent depreciation of the US Dollar against the Euro will cause gold prices to increase by 0.339 percent, whereas in the case of Toros sample it was apparent that for every 1 percent depreciation of the US Dollar against the Euro gold prices will increase by 0.559 percent. Therefore, as it is obvious, the results diverged and hence, there was instability in averages, standard deviations, and in the number and magnitude of the significant coefficients in the regressions.

Therefore, taking into consideration the F-test [$F = 23.559$; $p < 0.001$] and the ANOVA F-test on the R-Squares, we reject the null hypothesis that the regression is not statistically significant. Furthermore, removing the variables with insignificant variables (F-test < F-critical; $1.92 < 4.68$; $p > 0.01$), we fail reject the null hypothesis that the omitted variables have zero coefficients. However, using the same F-test and ANOVA F-test, there is at least one variable that explains significantly gold prices. The variables that explained significantly gold prices are the USD/EUR exchange rate and oil prices. Hence, omitting the other two variables, DJIA and CPI, was appropriate.

# V. Regressions for Lebanon

## 1. Definition of the variables: PPP and DJIA in Lebanese terms and USD/LBP exchange rate

We used the PPP (purchasing power parity) to estimate the CPI in Lebanon. The theory of PPP is an important factor that should be considered in our study. This notion is mainly based on a principle called the law of one price. This law asserts that a good must be sold at the same price in all locations. Otherwise, there would be opportunities for profit left unexploited. In our case, we can state that a currency must have the same purchasing power in all countries. In other words, the theory states that a unit of a currency must have the same real value in every country. Therefore, prices in Lebanon are expected to equal prices in the US, adjusted for the foreign exchange rate of the *dollar against the Lebanese pound. This holds very* true in the Lebanese economy and marketplace since the Lebanese pounds is pegged to the US dollar. By using the USD/LBP exchange rate we estimated the DJIA in Lebanese Pounds.
The USD/LBP exchange rate was found by dividing the price of gold per ounce in Lebanese Pounds (obtained from BDL website) by the gold price per ounce in US Dollars (obtained from kitco.com)

**2. Stationarity tests**

The following table represents the unit root tests (in LBP) with a constant and a trend.

Table 5.1

| | ADF test | KPSS test | DF-GLS (ERS) test |
|---|---|---|---|
| ln(goldlbp) | -5.289972 (0.0001) | 0.260606 | -0.68985 |
| dlllgoldlbp | - | 0.280965 | -6.94066 |
| ln(cpilbp) | -5.400440 (<0.0001) | 0.376299 | -2.93431 |
| dlllcpilbp | - | 0.246134 | -6.68769 |
| ln(oillbp) | -3.312072 (0.0662) | 0.234148 | -1.23909 |
| dllloillbp | -12.22710 (<0.0001) | 0.098566 | -12.0259 |
| ln(eurolbp) | -5.749920 (<0.0001) | 0.336775 | -0.45878 |
| dllleurolbp | - | 0.260213 | -7.50178 |
| ln(djialbp) | -5.194733 (0.0001) | 0.437777 | -0.15114 |
| dllldjialbp | - | 0.208482 | -7.27001 |

Definition of the variables is presented in Appendix A. In parenthesis are the p-values of the ADF tests. The number of lags in all tests is selected by minimizing the Schwarz Information

Criterion (SIC). The null hypothesis of the ADF and DF-GLS (ERS) tests is non-stationarity, or the presence of a unit root. The null hypothesis of the KPSS test is stationarity, or the absence of a unit root. The critical values for the KPSS test are 0.216000 (1%), 0.146000 (5%), and 0.119000 (10%). The critical values for the DF-GLS (ERS) test are -3.470300 (1%), -2.909400 (5%), and -2.603950 (10%).

Looking at the ADF test column we can see that all the probabilities are less than or equal to 0.0001 except for the logarithm of the variable oillbp, meaning that all the variables are stationary except for oil. This is against the random walk theory.

Furthermore, in order to support our decision, we carried out KPSS and DF-GLS (ERS) tests. In the case of KPSS test if the calculated value is greater than the critical value, then it is non-stationary. As for the DF-GLS (ERS) test it's the opposite. If the calculated value is less than the critical value then it is non-stationary.

Looking at the KPSS results, we can see that all the results of each of the variables are greater than the critical value of 0.119000 (10%) except for the first difference of log of the variable oil. It is 0.098566 which is less than the critical value of 0.119000 (10%) which proves that all the values are non-stationary. Coming to the DF-GLS (ERS) tests all the logs of the variables are non-stationary, whereas the first differences of the logs are stationary. This is proved by looking at the figures which imply that the logs of each of the variables are less negative than the critical value of -2.60395 (10%), which means that they are non-stationary. As for the first difference of the log of each variable it is proved by the fact that the values are more negative than -3.470300, which means that they are stationary. Thus we will adopt the results of this last test.

Consequently, and since all asset prices are random walks, we cannot run a normal linear regression. For this reason, we calculate the first difference for each of the variables and their respective probabilities. Therefore, we reject the null hypothesis that there is a unit root and thus, our values are stationary. Hence, this allows us to run a linear regression.

In this section of our research we are interested in investigating the predictive significance of the following predictor(s): Oil price (LBP), LBP/EUR exchange rate, DJIA, and CPI. We used the Lebanese Pounds as the base currency of gold price and oil price, as well as the LBP/EUR exchange rate. To test our hypothesis, we conducted sequential multiple regressions using SPSS Regression.

**3. Descriptive statistics with all variables**

The sample consisted of 302 records. Descriptive statistics for the four predictor variables are presented in the table below. Since we ran the regression as the difference between the log of the variable and the lag of the log, the values in the descriptive statistics table are percentage changes and must be multiplied by hundred. Hence, the mean of the variable dlllgoldlbp means that the monthly average percentage change of the variable is 1.94% which is equivalent to 23.28% per year (1.94% x 12). The mean of dlllоillbp, dllleurolbp, dllldjialbp, and dlllcpilbp is 1.83%, 1.64%, 2.17%, and 1.69% change per month on average, respectively, and 21.96%, 19.68%, 26.04%, and 20.28% change per year on average, respectively. As for the standard deviation, it is calculated by taking the value in the table and multiplying it by the square root of 12 (12 months a year). The standard deviation of the variable dlllgoldlbp is 0.07693 which multiplied by the square root of 12 gives us 0.26649, which

**means that the yearly standard deviation is 26.65%. As for the independent variables dllloillbp, dllleurolbp, dllldjialbp, and dlllcpilbp the yearly standard deviation is 41.05%, 26.39%, 26.36%, and 24.03% respectively.**

**Descriptive Statistics**

| | Mean (monthly) | Std. Deviation (monthly) | Mean (yearly) | Std. Deviation (monthly) |
|---|---|---|---|---|
| dlllgoldlbp | .0194 | .07693 | 0.2328 | 0.2665 |
| dllloillbp | .0183 | .11851 | 0.2196 | 0.4105 |
| dllleurolbp | .0164 | .07619 | 0.1968 | 0.2639 |
| dllldjialbp | .0217 | .07612 | 0.2604 | 0.2636 |
| dlllcpilbp | .0169 | .06938 | 0.2028 | 0.2403 |

**4. Regression results with all variables**

The data revealed the absence of missing values. According to the correlation matrix (Table 15), the CPI in Lebanese Pounds seems to correlate best with the outcome of gold price in LBP ($r=.89$, $p < 0.001$) and it's likely that the CPI (in LBP) will best predict gold price. The value of $R^2$ (table 16) indicates that the four variables LBP/EUR exchange rate, price of oil, DJIA and the CPI (all in Lebanese Pounds) account for 81.8% of the variation in gold price. [F (4, 297) = 338.39; p < 0.001]

Looking at the coefficients table (table 17), we find the corresponding values to be significant. The un-standardized coefficient of oil is 0.054, which means that for every 1 percent increase in the price of oil, gold prices will increase 0.054 percent. As for the LBP/EUR exchange rate, a one percent depreciation of the Lebanese Pounds against Euro, gold prices will increase 0.343 percent. As for the variable CPI (in LBP) a one percent increase in the CPI (in LBP) will cause gold prices to increase 0.675 percent. As for the DJIA, this variable was insignificant. Moreover, it was proved that the residuals were independently distributed since Durbin Watson is 1.796, close to 2. Looking at the Durbin-Watson statistics table of critical values (1% significance level) with n=300 and D-L and D-U equaling 1.70606 and 1.75975, respectively, it is proved that there is no positive serial correlation of residuals, since the calculated Durbin-Watson falls between the upper limit and 2.

**5. Testing for normality, linearity, and heteroscedasticity (with all variables)**

To test for the normality of residuals, we looked at the histogram and the normal probability plot (figure 13 and 14). The histogram should have a bell-shaped curve. Any deviation from this curve is a sign of non-normality. The normal probability plot also did not show up deviations from normality. The straight line represents a normal distribution, and the points represent the observed residuals. Therefore, in a perfectly normally distributed data set, all points will lie on the line. In our case, both the histogram and the normal probability plot showed a quasi normally distributed data.

As for heteroscedasticity, we look at the scatter plot (figure 15); the graph should look like a random array of dots evenly dispersed around zero. Since the graph doesn't funnel out, it means that there is no heteroscedasticity. Moreover, since there isn't any sort of curve in this graph then the data has not broken the assumption of linearity. Thus, the assumptions of normality, linearity, and homoscedasticity were all met.

Not all values in the correlation matrix were below 0.8; in addition, VIF and tolerance values indicate that the assumption of absence of multicollinearity and singularity was not met.

**6. Regression results by omitting the insignificant variable**

The data revealed the absence of missing values. According to the correlation matrix (Table 18), the CPI in Lebanese Pounds seems to correlate best with the outcome of gold price in LBP ($r=.89$, $p < 0.001$) and it's likely that the CPI (in LBP) will best predict gold price. The value of $R^2$ (table 19) indicates that the three variables LBP/EUR exchange rate, CPI, and price of oil (all in LBP) account for 81.8% of the variation in gold price. [$F(3, 298) = 446.332$; $p < 0.001$]

Looking at the coefficients table (table 20), we find the corresponding values to be significant. The un-standardized coefficient of oil is 0.056, which means that for every 1 percent increase in the price of oil (in LBP), gold prices will increase 0.056 percent. As for the LBP/EUR exchange rate, a one percent depreciation of the Lebanese Pounds against Euro, gold prices will increase 0.344 percent. As for the variable CPI (in LBP) a one percent increase in the CPI (in LBP) will cause gold prices to increase 0.583 percent.

Moreover, it was proved that the residuals were independently distributed since Durbin Watson is 1.80, close to 2. Looking at the Durbin-Watson statistics table of critical values

(1% significance level) with n=300 and D-L and D-U equaling 1.71279 and 1.75293, respectively, it is proved that there is no positive serial correlation of residuals, since the calculated Durbin-Watson falls between the upper limit and 2.

**7. Testing for normality, linearity, and heteroscedasticity (by omitting the insignificant variable)**

To test for the normality of residuals, we looked at the histogram and the normal probability plot (Figure 16 and 17). The histogram should have a bell-shaped curve. Any deviation from this curve is a sign of non-normality. The normal probability plot also did not show up deviations from normality. The straight line represents a normal distribution, and the points represent the observed residuals. Therefore, in a perfectly normally distributed data set, all points will lie on the line. In our case, both the histogram and the probability plot showed a quasi normally distributed data. As for heteroscedasticity, we examined the scatter plot (Figure 18), the graph should look like a random array of dots evenly dispersed around zero. Since our graph doesn't funnel out, it means that there is no heteroscedasticity. Moreover, since there isn't any sort of curve in this graph then the data has not broken the assumption of linearity. Thus, the assumptions of normality, linearity, and homoscedasticity were all met.

All the values in the correlation matrix were not below 0.8; in addition, VIF and tolerance values did not indicate that the assumption of absence of multicollinearity and siñgularity was met.

**8. Applying F-test on the R-Squares for the removal of the variable with insignificant coefficient**

F-test was conducted to examine whether the omission of the variables was a good choice. The results showed that the omission of one variable was indeed a good choice (F-test < F-critical; 3.28 < 3.78; $p > 0.01$).This also implies the result of the t-statistic.

Therefore, taking into consideration the F-test [$F = 446.322$; $p < 0.001$] and the ANOVA F-test on the R-Squares, we reject the null hypothesis that the regression is not statistically significant. Furthermore, removing the variables with insignificant variables (F-test < F-critical; 3.28 < 3.78; $p > 0.01$), we fail reject the null hypothesis that the omitted variables have zero coefficients. However, using the same F-test and ANOVA F-test, there is at least one variable that explains significantly gold prices. The variables that explained significantly gold prices are the LBP/EUR exchange rate, oil prices (in LBP), and CPI (in LBP). Hence, the omission of the variable DJIA (in LBP) was appropriate.

## VI. Conclusion

This study has manifested numerous findings. Our findings indicated the interesting and important relationship of gold price and the four independent variables which are the following: USD/EUR exchange rate, Brent oil price, Dow Jones Industrial Average, and Consumer Price Index and as well as the LBP/EUR exchange rate, Brent oil price, Dow Jones Industrial Average, and the Consumer Price Index in Lebanese Pounds.

After we replicated Toros's results with his own sample and after we calculated regressions in levels (with and without lagged variable) and log-levels (with and without lagged variable) for our own sample, we found our estimates to be close to the estimates of Toros. In the case of no lagged variables, we used the Durbin-Watson statistic to test our hypothesis. The Durbin-Watson in our sample was 0.54745 and in Toros' sample was 0.4950., indicating that the successive error terms were positively correlated which hindered us in reaching a substantial and confident conclusion in this context. In case where lag variables existed, we calculated and interpreted the Durbin's h statistic, because Durbin-Watson statistic cannot be used when lagged variables exist. We found the Durbin's h statistic to be 2.0116 for the log-levels with lagged dependent variables which is greater than 1.96 at 95% confidence interval. As for the levels with lagged dependent variables, Durbin's h statistic was 2.0052 which, again, is greater than the 95% confidence interval. In Toros' sample the Durbin's h was also greater than the 95% confidence interval (2.1099 for log-levels with lagged dependent variables and 2.1901 for levels with lagged dependent variables). Thus, in all cases, we rejected the null hypothesis that there is no serial correlation in residuals. Furthermore, we conducted the Augmented Dickey-

**Fuller test on the sample of Toros. All the values and their respective probabilities indicated that we do not reject the null hypothesis that there is a unit root. In other words, we did not reject the fact that the values are non-stationary. Since all asset prices were random walks, we couldn't run a normal linear regression; and for this reason, we took the first difference of the logs and based upon those values we conducted a linear regression.**

Toros' results are not reliable because of their non-stationarity. Therefore, as we mentioned earlier, we estimated regressions in first differences of the logs. When we did that, we found instability between our sample and Toros sample (January 1997 till March 2005) because unlike our sample where we found two significant variables (oil prices and USD/EUR exchange rate) whereas Toros sample had only one significant variable (USD/EUR exchange rate) which means that the relationship is unstable. Furthermore, our results showed that every 1 percent depreciation of the US Dollar against the Euro will cause gold prices to increase by 0.339 percent, whereas in the case of Toros every 1 percent depreciation of the US Dollar against the Euro caused gold prices to increase by 0.559 percent. Coming to the descriptive statistics of his sample, the yearly mean percentage change of the dependent variable dlllgoldus was 2.52% and that of the independent variable dllleuro was 1.08% and the yearly standard deviation of both variables were 11.41% and 8.40% respectively. The value of the un-standardized USD/EUR exchange rate was 0.547 which means that every 1 percent depreciation of the US Dollar against the Euro will cause gold prices to increase 0.547 percent. The residuals were independently distributed and positive serial correlation was nonexistent since the Durbin-Watson was 1.890 which is close to 2 and, concurrently, it lied in the upper critical value and 2. We also tested for normality, linearity and heteroscedasticity by using the histogram, normal probability plot, and scatter plot. Only one case, which was the case of October 1999, was considered as an outlier in Toros sample, but it was not removed because its removal did not materially affect our results. We also carried out an ANOVA F-test to test whether the omission of the insignificant variables was a good choice. We calculated it 0.6818 which is less than the critical value 6.90 ($p > 0.01$) which proved that the omission of the three variables was indeed a good choice.

In the next section we conducted the regression on our sample, which ranged from September 1985 till November 2010 and found the DJIA and CPI to be insignificant predictors of gold price; both oil prices and the USD/EUR exchange rate were significant. The yearly mean percentage change of the dependent variable gold was 5.76% while for the independent variables oil and euro was 4.44% and 2.16% respectively. The yearly standard deviation for gold was 12.24% and for oil and euro 33.17% and 10.64% respectively. We found that for every 1 percent increase in the oil price, there's a 0.064 percent increase in the price of gold. As for the USD/EUR exchange rate, every 1 percent depreciation of the US Dollar against the Euro will cause gold prices to increase 0.342 percent. The residuals were independently distributed and positive serial correlation was nonexistent since the Durbin-Watson was 1.827 which is close to 2 and, concurrently, it lied in the upper critical value and 2. We also tested for normality, linearity and heteroscedasticity by using the histogram, normal probability plot, and scatter plot. We also carried out an ANOVA F-test to test whether the omission of the insignificant variable was a good choice. We calculated it 1.92 which is less than the critical value 4.68 ($p > 0.01$) which proved that the omission of the three variables was indeed a good choice.

In the next part of our analysis, we used the Lebanese Pounds as the base currency in conducting the regression. The Dow Jones Industrial Average was the only insignificant predictor in using the LBP as the base currency, hence, gold prices in Lebanon are dependent from the LBP/EUR exchange rate, the Brent oil prices (in LBP), and the Consumer Price Index (in LBP). The yearly mean percentage change of the dependent variable gold (in LBP) was 23.28% while for the independent variables oil (in LBP), LBP/EUR exchange rate, and CPI (in LBP) was 21.96%, 19.68%, and 20.28% respectively. The yearly standard deviation for gold (in LBP) was 26.65% and for oil (in LBP), LBP/EUR exchange rate, and CPI (in LBP) was 41.05%, 26.39%, and 24.03% respectively. We also found that for every 1 percent increase in the price of oil, gold prices will increase 0.056 percent. As for the LBP/EUR exchange rate, a one percent depreciation of the Lebanese Pounds against Euro, gold prices will increase 0.344 percent. As for the variable CPI (in LBP) a one percent increase in the CPI (LBP) will cause gold prices to increase 0.583 percent. The residuals were independently distributed and positive serial correlation was nonexistent since the Durbin-Watson was 1.80 which is close to 2 and, concurrently, it lied in the upper critical value and 2. We also tested for normality, linearity and heteroscedasticity by using the histogram, normal probability plot, and scatter plot. We also carried out an ANOVA F-test to test whether the omission of the insignificant variable was a good choice. We calculated it 3.28 which is less than the critical value 3.78 ($p > 0.01$) which provēd that the omission of the variable DJIA (in LBP) was indeed a good choice. The common predictor of gold price that gathers among all the regression analyses in our study is the USD/EUR exchange rate, and the LBP/EUR exchange rate at the same time since the Lebanese Pounds is pegged to the US Dollars.

In both, US Dollar and Lebanese Pound regressions, we tested for the hypothesis whether there is at least one independent variable that explains gold price in US Dollars and Lebanese Pounds. Looking at the F-tests [$F = 23.559$; $p < 0.001$ in case of US Dollars and $F = 446.322$; $p < 0.001$ in case of LBP] and the ANOVA F-tests, the regressions significantly explain the dependent variable. Thus, there is at least one variable that explains significantly gold prices. On removing the insignificant variables for each of the regressions in the first differences of the logs ($1.92 < 4.68$; $p > 0.01$ in case of US Dollars and $1.92 < 4.68$; $p > 0.01$ in case of LBP), we fail to reject the null hypothesis that the omitted variables have zero coefficients.

Besides the four independent variables that we used in our study, there are several other indicators that could be taken into consideration in future research, such as world political situation (disturbances, wars, threats, invasions, etc), supply and demand factors, market interest rates, tax rates, jewellery demand. All these are factors that could, most probably, affect gold prices.

# Appendix A

Definition of variables

| | |
|---|---|
| dlllgoldus: | the first difference of the log of the price of gold (in ounce) in US Dollars |
| dllleuro: | the first difference of the log of the USD/EUR exchange rate |
| dlllcpi: | the first difference of the log of the CPI |
| dllldjia: | the first difference of the log of the Dow Jones Industrial Average |

| | |
|---|---|
| dlllgoldlbp: | the first difference of the log of the prices of gold (in ounces) in Lebanese Pounds |
| dllleurolbp: | the first difference of the log of the LBP/EUR exchange rate |
| dlllcpilbp: | the first difference of the log of the CPI estimated in Lebanese Pounds |
| dllldjialbp: | the first difference of the log of the Dow Jones Industrial Average estimated in Lebanese Pou |
| dllloillbp: | the first difference of the log of Brent oil prices estimated in Lebanese Pounds |

# Appendix B

**Table One: Elasticities (Log and Levels)**

| | | Log | | Levels | |
|---|---|---|---|---|---|
| | | Elasticity 1 Longrun | Elasticity 2 Longrun | Elasticity 1 Longrun | Elasticity 2 Longrun |
| OIL | elasticity | 0.12743 | 0.10053 | 0.13666 | 0.10321 |
| DJIA | elasticity | -0.27342 | -0.28125 | -0.26412 | -0.26319 |
| CPI | elasticity | 0.91602 | 1.43750 | 0.93277 | 1.51033 |
| USEURO | elasticity | 0.79608 | 0.77055 | 0.79411 | 0.78709 |

**Table Two: Toros Elasticities**

**Toros model**

Levels without lag

| | | |
|---|---|---|
| Elasticity | OIL | 0.153668 |
| | DJIA | -0.267554 |
| | CPI | 0.880477 |
| | USEURO | 0.788273 |

Levels with lag

| | |
|---|---|
| OIL | 0.140248 |
| DJIA | -0.207888 |
| CPI | 1.319395 |
| USEURO | 0.780031 |

Log with lag

| | |
|---|---|
| OIL | 0.085919 |
| DJIA | -0.533602 |
| CPI | 1.317807 |
| USEURO | 0.034961 |

**Table Three: Correlations**

**Correlations**

| | | dlllgoldus | dllleuro | dlllcpi | dllldjia |
|---|---|---|---|---|---|
| Pearson Correlation | | | | | |
| | dllleuro | .403** | | | |
| | dlllcpi | .067 | -.130 | | |
| | dllldjia | -.109 | -.141 | -.191 | |
| | dllloil | .091 | -.014 | .346 | -.072 |

**Table Four: Model Summary**

**Model Summary[b]**

| | | | | | Change Statistics | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | R Square Change | F Change | df1 | df2 | Sig. F Change | Durbin-Watson |
| 1 | .426[a] | .181 | .146 | .03043 | .181 | 5.144 | 4 | 93 | .001 | 1.932 |

a. Predictors: (Constant), dllloil, dllleuro, dllldjia, dlllcpi

** $p < .001$

**Model Summary[b]**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics: R Square Change | F Change | df1 | df2 | Sig. F Change | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | .426[a] | .181 | .146 | .03043 | .181 | 5.144 | 4 | 93 | .001 | 1.932 |

b. Dependent Variable: dlllgoldus

**Table Five: Coefficients**

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | 95% Confidence Interval for B | | Correlations | | | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Lower Bound | Upper Bound | Zero-order | Partial | Part | Tolerance | VIF |
| 1 | (Constant) | .000 | .004 | | -.181 | .857 | -.009 | .007 | | | | | |
| | dllloil | .021 | .034 | .062 | .622 | .536 | -.046 | .089 | .091 | .064 | .058 | .879 | 1.137 |
| | dllleuro | .559 | .130 | .412 | 4.289 | .000 | .300 | .819 | .403 | .406 | .402 | .954 | 1.049 |
| | dllldjia | -.023 | .079 | -.029 | -.296 | .768 | -.180 | .133 | -.109 | -.031 | -.028 | .935 | 1.069 |
| | dlllcpi | 1.121 | 1.238 | .093 | .905 | .368 | -1.338 | 3.580 | .067 | .093 | .085 | .830 | 1.205 |

a. Dependent Variable: dlllgoldus

**Table Six: Correlations**

**Correlations**

| | | dlllgoldus |
|---|---|---|
| Pearson Correlation | dlllgoldus | |
| | dllleuro | .403** |

**Table Seven: Model Summary**

**Model Summary[b]**

| R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | | Durbin-Wa |
|---|---|---|---|---|---|---|---|---|---|
| | | | | R Square Change | F Change | df1 | df2 | Sig. F Change | |
| .403[a] | .163 | .154 | .03029 | .163 | 18.633 | 1 | 96 | .000 | 1 |

**Table Eight: Coefficients**

**Coefficients[a]**

| | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | 95% Confidence Interval for B | | Collinearity Statistic | |
|---|---|---|---|---|---|---|---|---|---|
| | B | Std. Error | Beta | | | Lower Bound | Upper Bound | Tolerance | VIF |

** p < .001

| (Constant) | .002 | .003 | | .517 | .606 | -.004 | .008 | | |
|---|---|---|---|---|---|---|---|---|---|
| dllleuro | .547 | .127 | .403 | 4.317 | .000 | .296 | .799 | 1.000 | 1.00 |

endent Variable: dlllgoldus

**Table Nine: Correlations**

**Correlations**

| | | dlllgoldus | dllloil | dllleuro | dllldjia |
|---|---|---|---|---|---|
| Pearson Correlation | | | | | |
| | dllloil | .224** | | | |
| | dllleuro | .326** | .165 | | |
| | dllldjia | -.110 | -.022 | -.021 | |
| | dlllcpi | .128 | .459 | .094 | -.027 |

**Table Ten: Model Summary**

** $p < .001$

| Model Summary[b] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Change Statistics | | | | | |
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | R Square Change | F Change | df1 | df2 | Sig. F Change | Durbin-Watson |
| 1 | .383[a] | .147 | .135 | .03286 | .147 | 12.750 | 4 | 297 | .000 | 1.8 |

a. Predictors: (Constant), dlllcpi, dllldjia, dllleuro, dllloil

b. Dependent Variable: dlllgoldus

**Table Eleven: Coefficients**

| Coefficients[a] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Model | Unstandardized Coefficients | | Standardized Coefficients | | | 95% Confidence Interval for B | | Correlations | | | Collinearity Statistics | |
| | B | Std. Error | Beta | t | Sig. | Lower Bound | Upper Bound | Zero-order | Partial | Part | Tolerance | VIF |
| 1 (Constant) | .004 | .002 | | 1.639 | .102 | .000 | .009 | | | | | |
| dllloil | .060 | .022 | .162 | 2.665 | .008 | .016 | .104 | .224 | .153 | .143 | .775 | 1.291 |
| dllleuro | .339 | .063 | .295 | 5.428 | .000 | .216 | .463 | .326 | .300 | .291 | .972 | 1.029 |
| dllldjia | -.093 | .050 | -.100 | -1.858 | .064 | -.191 | .005 | -.110 | -.107 | -.100 | .999 | 1.001 |
| dlllcpi | .251 | .660 | .023 | .381 | .703 | -1.047 | 1.549 | .128 | .022 | .020 | .789 | 1.267 |

a. Dependent Variable: dlllgoldus

**Table Twelve: Correlations**

**Correlations**

| | | dlllgoldus | dllloil |
|---|---|---|---|
| Pearson Correlation | | | |
| | dllloil | .224** | |
| | dllleuro | .326** | .165* |

**Table Thirteen: Model Summary**

**Model Summary[b]**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df1 | df2 | Sig. F Change | |
| 1 | .369[a] | .136 | .130 | .03295 | .136 | 23.559 | 2 | 299 | .000 | 1.827 |

a. Predictors: (Constant), dllleuro,dllloil

b. Dependent Variable: dlllgoldus

**Table Fourteen: Coefficients**

**Coefficients[a]**

| Model | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | 95% Confidence Interval for B | | Correlations | | | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B | Std. Error | Beta | | | Lower Bound | Upper Bound | Zero-order | Partial | Part | Tolerance | VIF |

---

** p < .001

* p < .05

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 (Constant) | .004 | .002 | | 2.060 | .040 | .000 | .008 | | | | | |
| dllloil | .064 | .020 | .175 | 3.205 | .001 | .025 | .104 | .224 | .182 | .172 | .973 | 1.028 |
| dllleuro | .342 | .063 | .297 | 5.456 | .000 | .219 | .465 | .326 | .301 | .293 | .973 | 1.028 |

a. Dependent Variable: dlllgoldus

**Table Fifteen: Correlations**

**Correlations**

| | | dlllgoldlbp | dllloillbp | dllleurolbp | dllldjia |
|---|---|---|---|---|---|
| Pearson Correlation | | | | | |
| | dllloillbp | .607* | | | |
| | dllleurolbp | .873* | .593 | | |
| | dllldjialbp | .745* | .503 | .790 | |
| | dlllcpilbp | .890* | .606 | .916 | .866 |

**Table Sixteen: Model Summary**

**Model Summary[b]**

* p < .001

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df1 | df2 | Sig. F Change | |
| 1 | .906[a] | .820 | .818 | .03285 | .820 | 338.390 | 4 | 297 | .000 | 1.796 |

a. Predictors: (Constant), dlllcpilbp, dllloillbp, dllldjialbp, dllleurolbp

b. Dependent Variable: dlllgoldlbp

**Table Seventeen: Coefficients**

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | 95% Confidence Interval for B | | Correlations | | | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Lower Bound | Upper Bound | Zero-order | Partial | Part | Tolerance | VIF |
| 1 | (Constant) | .003 | .002 | | 1.705 | .089 | .000 | .007 | | | | | |
| | dllloillbp | .054 | .020 | .083 | 2.648 | .009 | .014 | .094 | .607 | .152 | .065 | .622 | 1.607 |
| | dllleurolbp | .343 | .062 | .340 | 5.498 | .000 | .220 | .466 | .873 | .304 | .135 | .159 | 6.297 |
| | dllldjialbp | -.093 | .050 | -.092 | -1.864 | .063 | -.191 | .005 | .745 | -.108 | -.046 | .249 | 4.012 |
| | dlllcpilbp | .675 | .085 | .609 | 7.947 | .000 | .508 | .842 | .890 | .419 | .196 | .103 | 9.681 |

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | | | 95% Confidence Interval for B | | Correlations | | | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | t | Sig. | Lower Bound | Upper Bound | Zero-order | Partial | Part | Tolerance | VIF |
| 1 | (Constant) | .003 | .002 | | 1.705 | .089 | .000 | .007 | | | | | |
| | dllloillbp | .054 | .020 | .083 | 2.648 | .009 | .014 | .094 | .607 | .152 | .065 | .622 | 1.607 |
| | dllleurolbp | .343 | .062 | .340 | 5.498 | .000 | .220 | .466 | .873 | .304 | .135 | .159 | 6.297 |
| | dllldjialbp | -.093 | .050 | -.092 | -1.864 | .063 | -.191 | .005 | .745 | -.108 | -.046 | .249 | 4.012 |
| | dlllcpilbp | .675 | .085 | .609 | 7.947 | .000 | .508 | .842 | .890 | .419 | .196 | .103 | 9.681 |

a. Dependent Variable: dlllgoldlbp

**Table Eighteen: Correlations**

**Correlations**

| | | dlllgoldlbp | dllloillbp | dllleurolbp |
|---|---|---|---|---|
| Pearson Correlation | | | | |
| | dllloillbp | .607* | | |
| | dllleurolbp | .873* | .593 | |
| | dlllcpilbp | .890* | .606 | .916 |

**Table Nineteen: Model Summary**

* p < .001

**Model Summary**[b]

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df1 | df2 | Sig. F Change | |
| 1 | .904[a] | .818 | .816 | .03299 | .818 | 446.322 | 3 | 298 | .000 | 1.804 |

a. Predictors: (Constant), dlllcpilbp, dllloillbp, dllleurolbp

b. Dependent Variable: dlllgoldlbp

**Table Twenty: Coefficients**

**Coefficients**[a]

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | 95% Confidence Interval for B | | Correlations | | | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Lower Bound | Upper Bound | Zero-order | Partial | Part | Tolerance | VIF |
| 1 | (Constant) | .003 | .002 | | 1.449 | .148 | -.001 | .007 | | | | | |
| | dllloillbp | .056 | .020 | .086 | 2.740 | .007 | .016 | .096 | .607 | .157 | .068 | .624 | 1.603 |
| | dllleurolbp | .344 | .063 | .341 | 5.494 | .000 | .221 | .467 | .873 | .303 | .136 | .159 | 6.296 |
| | dlllcpilbp | .583 | .070 | .526 | 8.383 | .000 | .446 | .720 | .890 | .437 | .207 | .155 | 6.448 |

a. Dependent Variable: dlllgoldlbp

**Figure One**

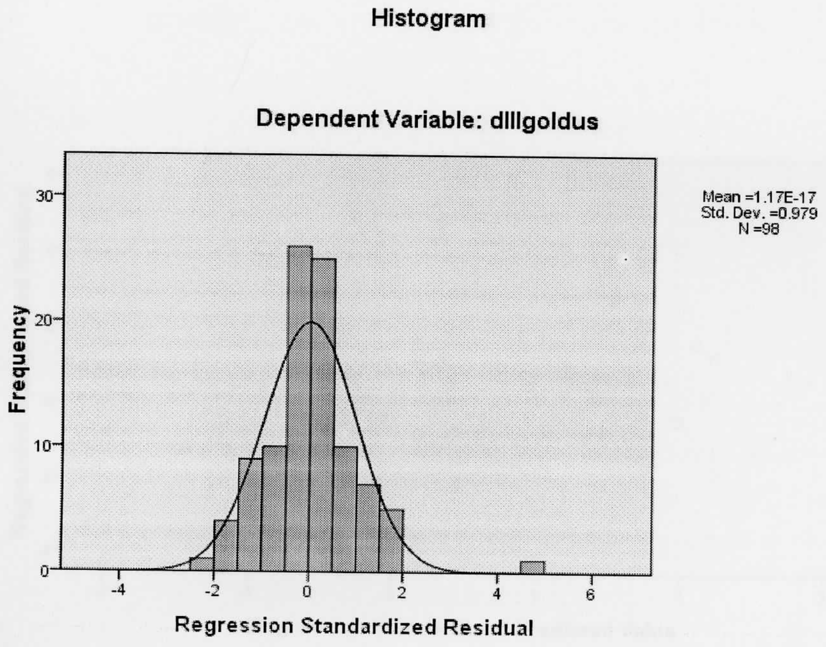



**Figure Two**

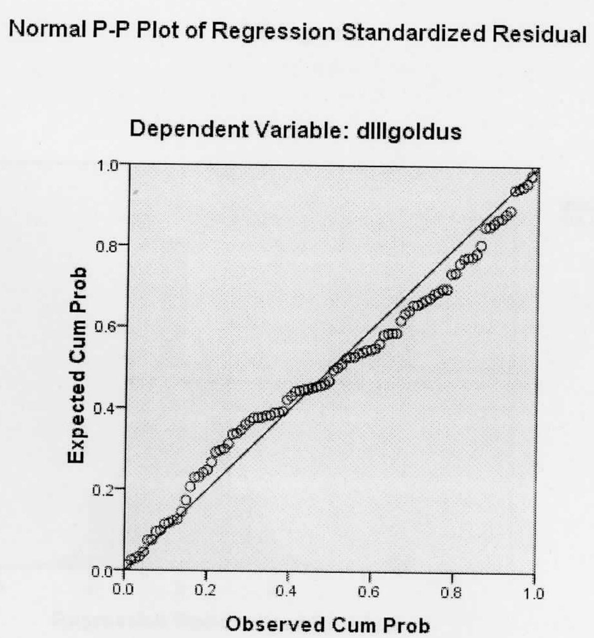



**Figure Three**

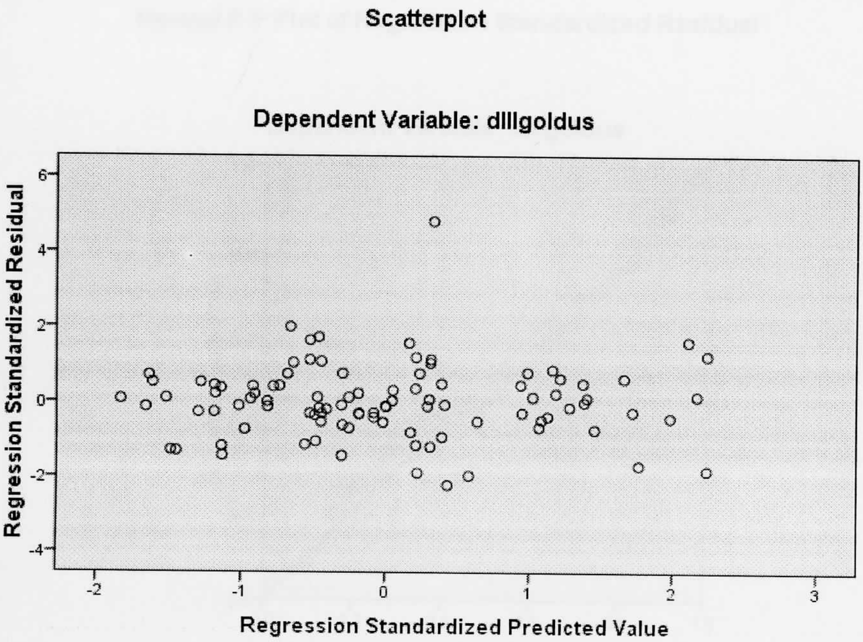



**Figure Four**

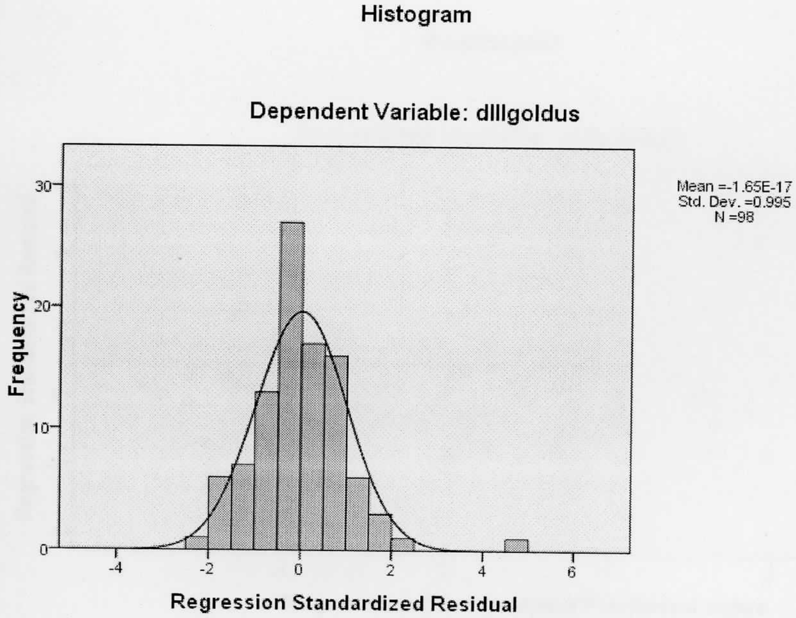



**Figure Five**

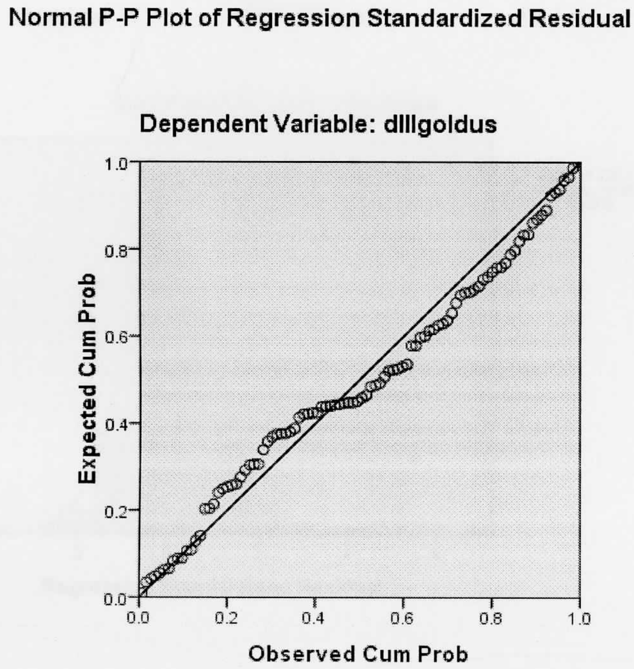



Figure Six

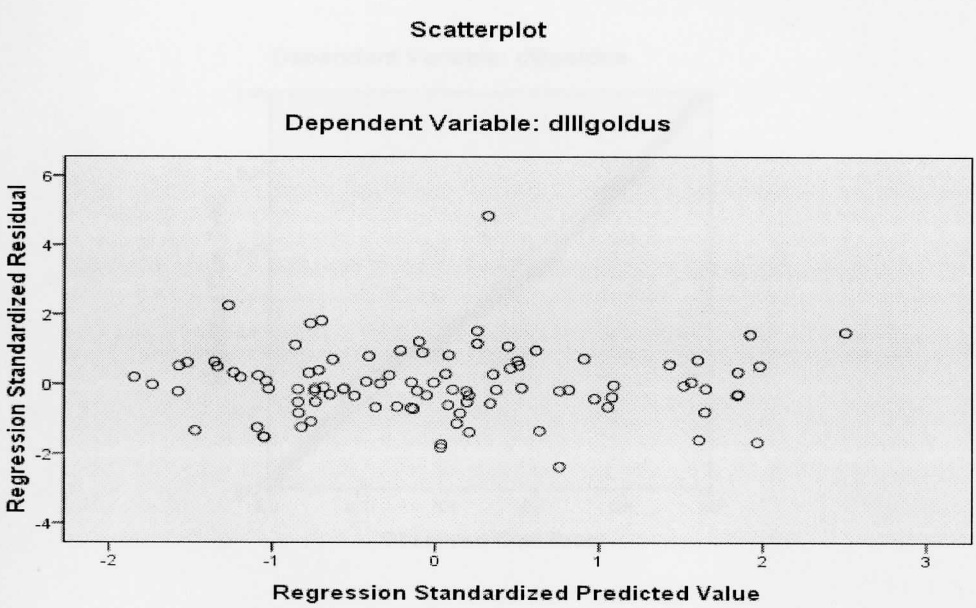



Figure Seven

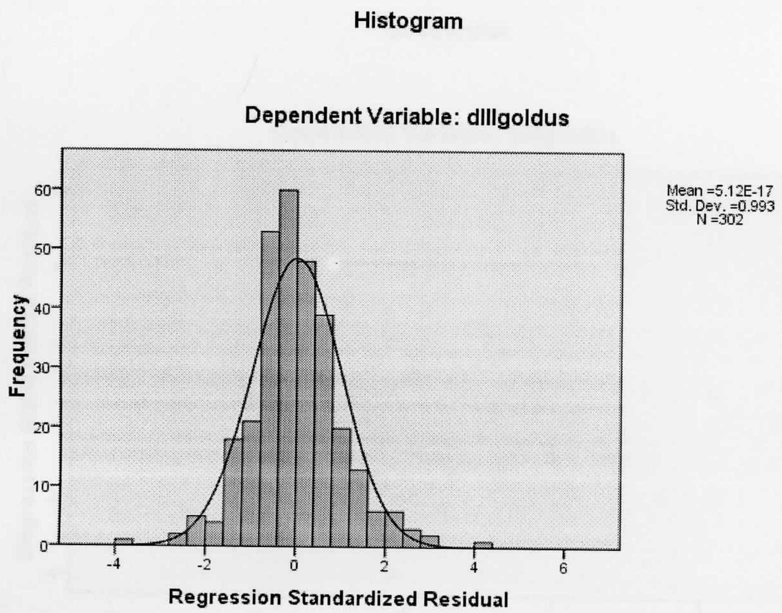



**Figure Eight**

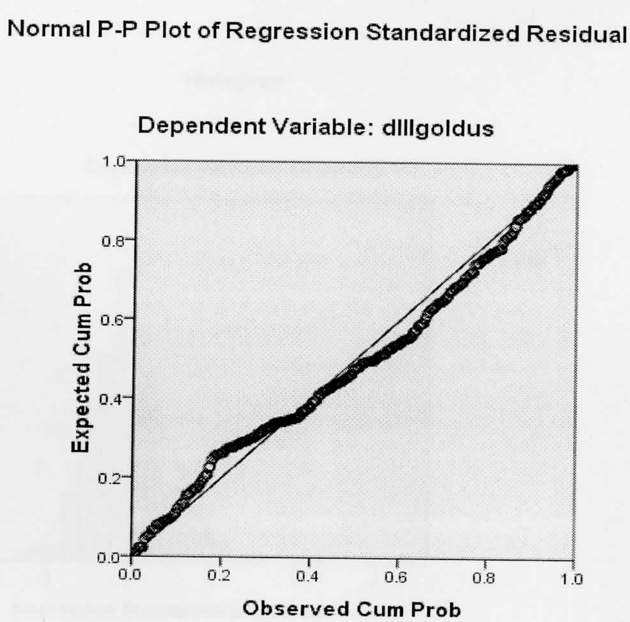



**Figure Nine**

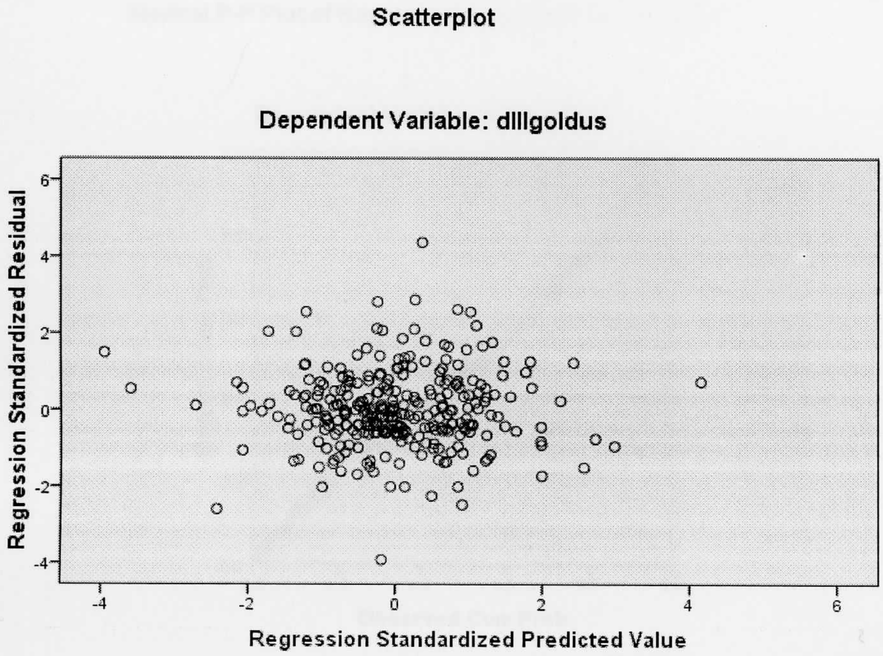



**Figure Ten**

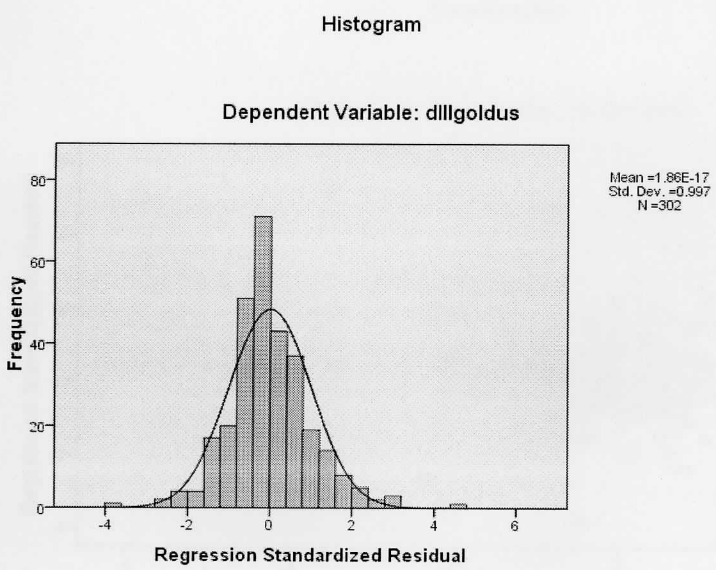



**Figure Eleven**

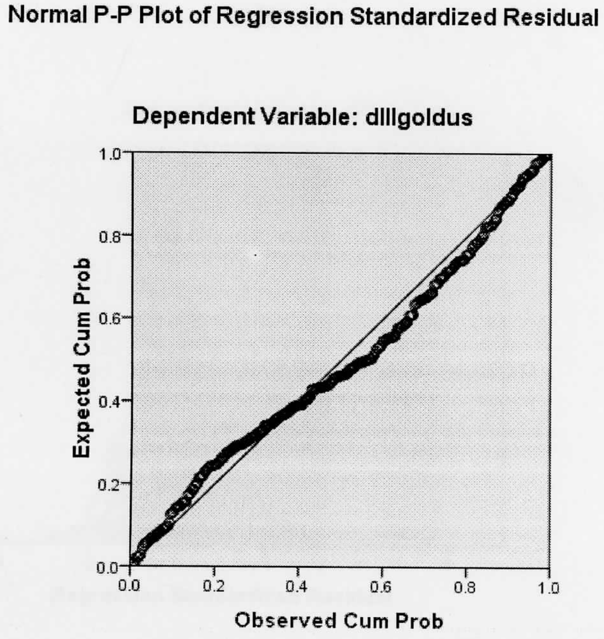



**Figure Twelve**

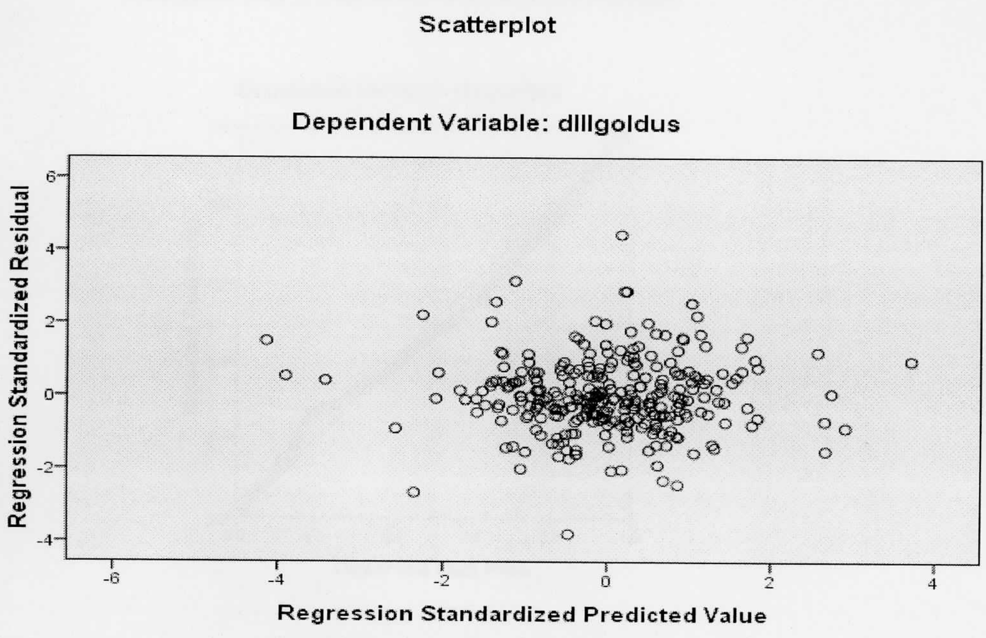



**Figure Thirteen**

Histogram

Dependent Variable: dlllgoldlbp

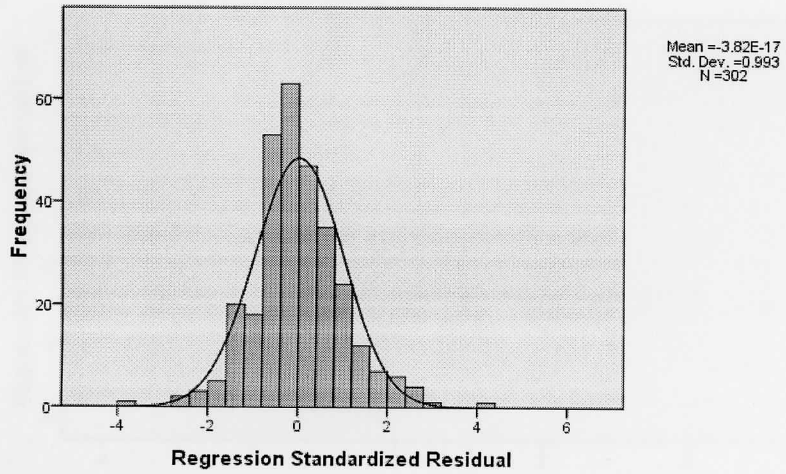



**Figure Fourteen**

Normal P-P Plot of Regression Standardized Residual

Dependent Variable: dlllgoldlbp

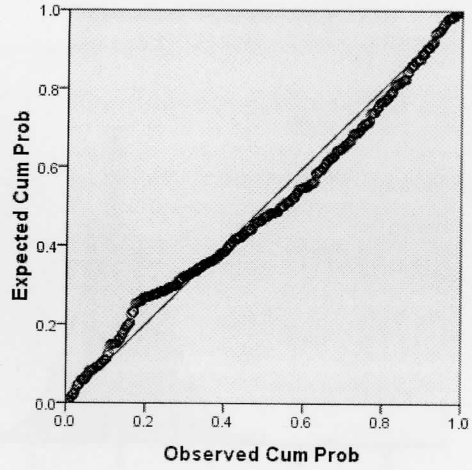



**Figure Fifteen**

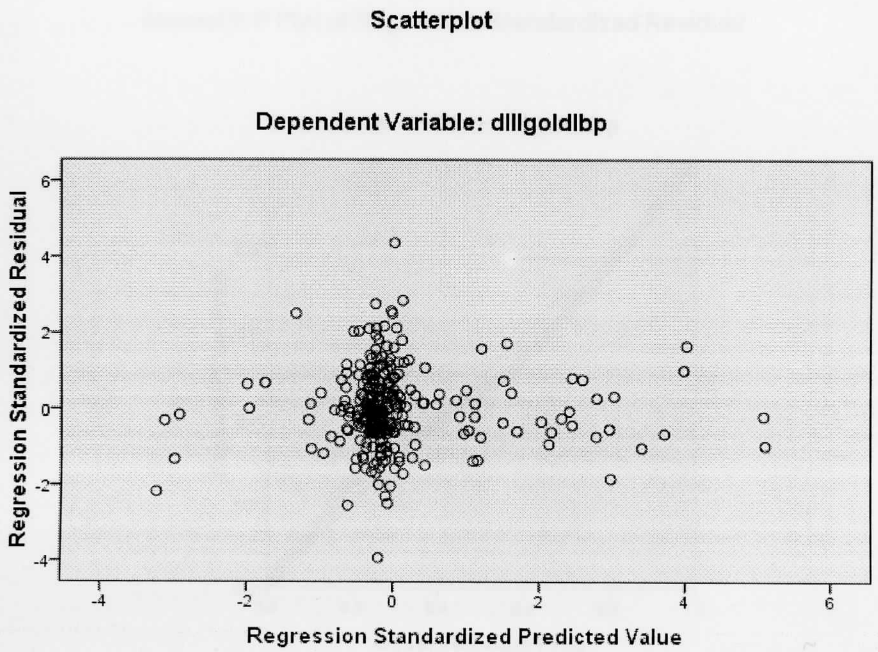



**Figure Sixteen**

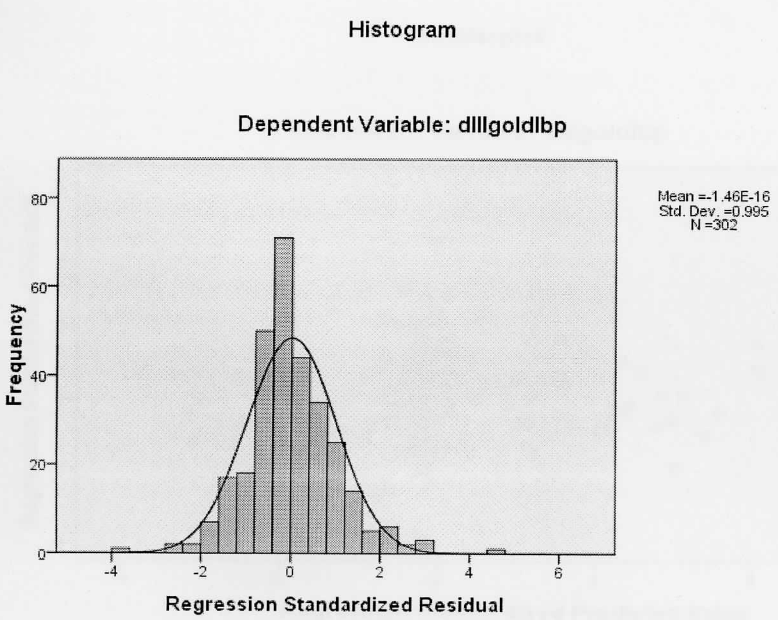



**Figure Seventeen**

**Normal P-P Plot of Regression Standardized Residual**

**Dependent Variable: dlllgoldlbp**

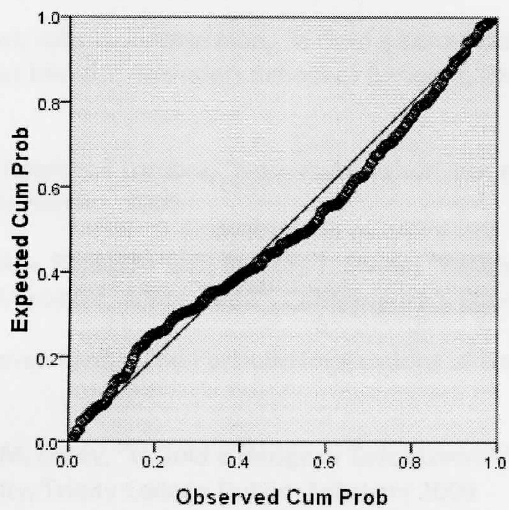
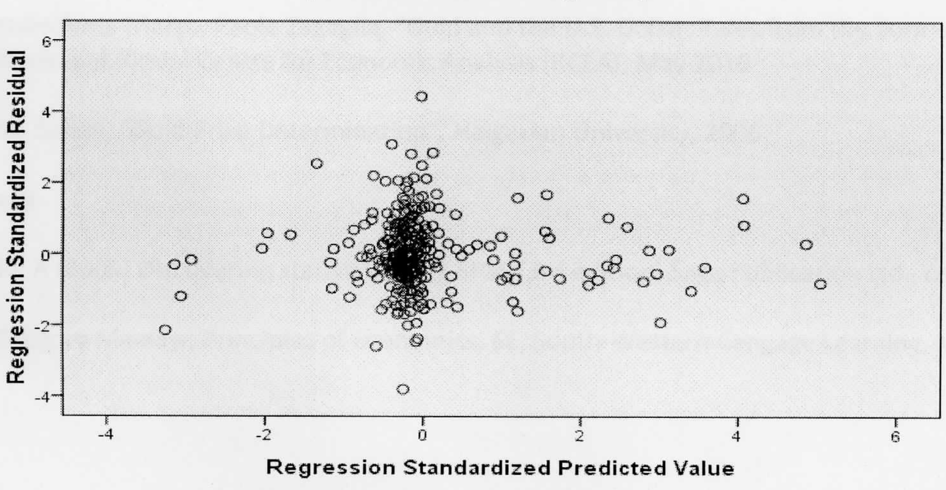



**Figure Eighteen**

**Scatterplot**

**Dependent Variable: dlllgoldlbp**



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