

The Financial Interrelationship: Are Oil and U.S. Dollar Affecting Gold Market?

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Abstract :

The precious metal gold has been used as money for many centuries till the breakdown of the "Breton Woods" agreement. In addition to its use as jewelry and electrical components, gold is now used as an asset investment and a hedging strategy against inflation, this leads us to consider the gold market as a financial market .The price of gold has known small changes over the period: 1833 to 1973 (before the breakdown of Breton Woods agreement) ,from 20,65 \$ per ounce in 1833 to 42 \$ per ounce in 1971.After 1973 , gold has fluctuated , it was about 384 \$ per ounce in 1982 and 283 \$ per ounce in 1999. The gold price has risen dramatically since 2001 from its low level of 250 \$ per ounce, then it reached a peak in 2011 with a level of 1700 per ounce.

The main objective of this paper is to focus on the gold market and try to analyze empirically the trend of gold price and the causes behind its fluctuations. The paper provides first the literature review highlighting the factors that affect the gold price and its trend. Second, using a Multivariate-GARCH model, we search for the effect of the different economic indicators on the movements of the gold price and if they are a real cause beyond its volatility. Finally, a concluding section is provided to compare the results with the existent literature.

Key words: *Gold market; volatility; M-GARCH.*

المُلخَص:

أُستخدم معدن الذهب كعملة نقدية لعدة قرون إلى غاية انهيار اتفاقية "بروتن وودز". بالإضافة إلى استخدامه كمجوهرات ومكونات كهربائية، ويستخدم الذهب حاليا كأصل استثماري واستراتيجي للتحوط من التضخم، وهذا يقودنا لاعتبار سوق الذهب كسوق مالية. في حين أن سعر الذهب عرف تغيرات طفيفة خلال الفترة: 1833-1973 (قبل انهيار اتفاقية بروتن وودز)، من 20,65 دولار للأوقية في 1833 إلى 42 دولار للأوقية في 1971. وبعد سنة 1973 عرف سوق الذهب عدة تقلبات، حيث أنه قارب سنة 1982 سعر 384 دولار للأوقية و 283 دولار للأوقية سنة 1999. بينما ارتفع سعر الذهب بشكل لافت بداية من سنة 2001 حيث أنه وبعد انخفاضه إلى مستوى 250 دولار للأوقية، وصل إلى ذروته سنة 2011 بسعر 1700 للأوقية.

تَحَدَد الهدف الرئيسي لهذه الورقة في التركيز على سوق الذهب، ومحاولة التحليل القياسي لاتجاه سعر الذهب، وأسباب تقلباته. وتقدم الورقة في البداية مراجعة للأدبيات السابقة للموضوع، مع تسليط الضوء على العوامل التي تؤثر على سعر الذهب واتجاهه. كما تعتمد على أنموذج (GARCH) المتعدد المتغيرات، ونسعى للبحث في تأثير المؤشرات الاقتصادية المختلفة على حركة سعر الذهب، وهل هي السبب الحقيقي وراء تقلباته. وأخيرا، يقدم الجزء الأخير من الدراسة محاولة لمقارنة النتائج مع الأدبيات السابقة للدراسة.

الكلمات المفتاحية: سوق الذهب، التقلب، أنموذج GARCH.

I -Introduction:

The price of gold has been an interest for many portfolio investors due to the special characteristics that has acquired, since the end of the Gold Standard and Bretton Woods agreement, as a financial asset (portfolio diversifier, a hedge against inflation and a safe haven). The gold price has risen dramatically since 2001 from its low level of 250 \$ per ounce , then it reached a peak in 2011 with a level of 1700 per ounce . Since the breakdown of the gold standard and the vital role of gold in economic life and financial investment, many researchers tried to estimate the factors that affect the price of gold then to forecast its price using different methods for analyzing the gold market movements, the investment role of gold and its reactions to global financial changes. (V.Tassel (1985), Lawrence (2003), Levin and Wright (2006), Truck and Liang (2012), Ewing and Malik (2013)...)

Gold as a financial asset is characterized also by a high volatility. The main objective of this paper is to focus on the gold market and try to analyze empirically the trend of gold price and the causes behind its fluctuations. The paper provides first the literature review highlighting the factors that affect the gold price and its trend. Second, using a Multivariate-GARCH model, we seek in the effect of the different economic indicators on the movements of the gold price and are they a real cause beyond its volatility. Finally, a concluding section is provided to compare the results with the existent literature.

II- An overview of gold market :

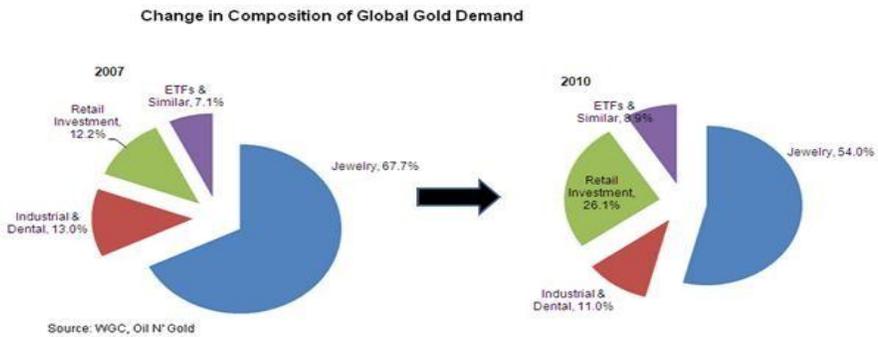
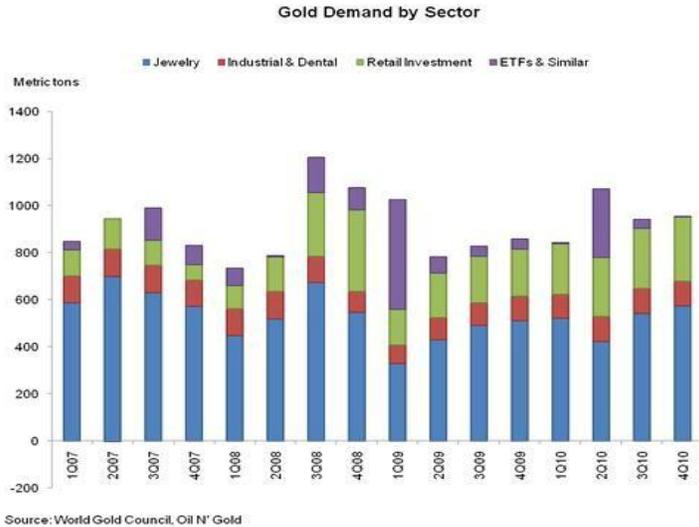
Although its important role in economic life and its large evolution among centuries, gold is still a precious metal. Today there are 165000 metric tonnes of stocks in existence above ground and if every single ounce were placed next to each other, the resulting cube of pure gold would only measure 20 metres in any direction (WORLD GOLD CONCIL) .

The demand for gold can be divided into two parts: the first is the « use demand »: jewelry, metals, coins electrical components..., the second is the « asset demand » (Levin et al.(2002)). In addition to the money characteristics which possess gold, it is also used as an asset investment, an inflation hedge and is considered as a high liquid metal.

The price of gold has known small changes over the period: 1833 to 1973 (before the breakdown of Breeton Woods agreement) ,from 20,65 \$ per ounce in 1833 to 42 \$ per ounce in 1971.After 1973 , gold has fluctuated , it was about 384 \$ per ounce in 1982 and 283 \$ per ounce in 1999.(Levin et al 2002).

The gold price has risen dramatically since 2001 from its low level of 250 \$ per ounce, then it reached a peak in 2011 with a level of 1700 per ounce before a gradual decrease since the beginning of 2012 till now.

Figure1: Gold demand by sector



Source: international business time <http://www.ibtimes.com>

The figure above shows clearly the increase of the investment demand for gold after 2007. If we link this with the financial events, we notice that the investment demand for gold has been a response to the decline in financial markets and global financial crisis.

II.1. Gold characteristics:

It is obvious that the increase in the price of gold during the last decade was due to the special characteristics that acquired this commodity after the breakdown of gold standard and Breeten Woods agreement.

II.1.2. Gold as a portfolio diversifier¹:

¹ A diversifier is defined as an asset with returns that are positively (but not

Many previous studies have argued the portfolio's role of gold as a good diversifier, its return has low correlation with other assets' returns in the portfolio. In fact, portfolios containing a moderate weighting of gold perform better than portfolios consisting only of financial assets.

II.1.3. Gold as a hedge against inflation:

Theoretically gold demand increases when expected inflation rises; investors start buying gold to hedge against the expected decline in value of money. This fact leads investors to gain from buying and selling gold.

II.1.4. Gold as a safe haven²:

The gold price trend during the recent financial crisis confirmed the findings of several researches that gold is really a safe haven asset. The price of gold registered a large increase while most financial assets and indices declined sharply responded to the crisis.

II.2. Literature review:

Since the breakdown of the gold standard and the vital role of gold in economic life and financial investment, many researchers tried to estimate the factors that affect the price of gold then to forecast its price using different methods for analyzing the gold market movements, the investment role of gold and its reactions to global financial changes.

Baker and V.Tassel (1985) argued that the price of gold depends on a set of economic variables and it will go up in the long run in real terms .Lawrence (2003) showed no significant relationship between gold and other macroeconomic and financial indicators which makes gold as a good portfolio diversifier.

In a study using co-integration regression techniques, Levin et al (2002) argued that gold is an effective hedge of inflation. In other paper, Levin and Wright (2006) examined the short run and long run fluctuations of gold price, the authors found that the short changes are caused by : political and financial turmoil , exchange rates, real interest rate ,while the long run variables would be: US and world inflation , world income , US/World exchange rate, the gold lease rate , alternative investment opportunities , credit risk and time specific uncertainty.

Tully and Lucey (2006) investigated macroeconomic influence on gold using the asymmetric power GARCH model, authors confirmed that the US dollar is the main macroeconomic variable which influences gold.

perfectly) correlated with returns on another asset or portfolio on average.(Pullen, Benson and Faff 2010)

² A strong (weak) safe haven is defined as an asset with returns that are negatively correlated (uncorrelated) with returns on another asset or portfolio in certain periods of market stress or turmoil (e.g. a financial crisis).(Pullen et al. 2010)

In their paper, Dunis and Nathani (2007) provided a set of non-linear methods (HONN- MLP- Nearest Neighbors) to forecast the prices of gold and silver using the linear ARMA model for comparison .The researchers concluded that it was possible to forecast successfully the daily price of those two metals and they confirmed the nonlinearity of commodity markets. S.K. Mishkra, Das and P.K.Mishkra (2010) examined the gold price volatility and the causality between domestic gold price and stock market return in India .Johansen's cointegration test and Granger causality were used ,hence, a long run equilibrium relationship was found. Thus, each variable contains some significant information so that one can be used to predict the other.

In 2011, Sopipan , Sttaayathan and Premanode forecasted the volatility of gold prices using Markov Regim Switching GARCH models, they found that MRS-GARCH got the most cumulative return.

Using monthly data covering the period June-1992 to March-2010, Toraman, Basarir and Bayramoglu (2011) studied the factors affecting the price of gold by estimating a CCC MGARCH model. According to their empirical findings, highest correlation is found between gold prices and USA exchange rate negatively while a positive correlation is found between gold prices and oil prices.

Truck and Liang (2012) investigated the volatility dynamics of gold markets. They used a large number of statistical models to model and then forecast daily volatility and VaR. Both in sample and out-of-sample forecasts are evaluated using appropriate evaluation measures. Mensi et al. (2013) employed other GARCH type model (VAR-GARCH) to investigate the return links and the volatility transmission between the S&P 500 and commodity price indices for energy, food, gold and beverages. The empirical results of the volatility spillover mechanism between the markets analyzed in this study showed significant correlation and volatility transmission across commodity and equity markets.

In the same context, Ewing and Malik (2013) found strong evidence of significant transmission of volatility between gold and oil returns when structural breaks in variance are accounted.

III -Data and methodology:

Volatility has been extensively analyzed in the field of finance, and the tools developed in this research have in turn been applied to commodity prices. The goal of this paper is to show the factors determining the gold price. A multivariate GARCH model is used while we choose the diagonal BEKK model as the most popular to detect the volatility transmission among these two markets.

III-1 Overview on ARCH and GARCH models to measure volatility:

Homoscedasticity, one of the least squares (OLS) assumptions which means that the expected value of all error terms when squared is the same at any

given point. In some cross sectional and financial time series, this assumption is violated and the problem of heteroscedasticity is present.

Instead of concerning this phenomenon as a problem to be corrected, Robert Engle (1982) suggested a model in which this problem is a variance to be modelled.

The model suggested by Engle is: ARCH (Autoregressive conditional heteroscedasticity) model, is used to model and forecast variance of the error terms.

An ARCH model is defined as follow (Engle 1982):

$$Y_t / \Psi_{t-1} \sim N(x_t \beta, h_t)$$

$$h_t = h(\alpha - 1, \alpha - 2, \dots, \alpha - p, \alpha)$$

$$\alpha = Y_t - x_t \beta$$

Where:

Ψ_{t-1} : a set of information available at (t-1)

β : a vector of unknown parameters

h_t : the conditional variance of the error term

α : error term

α : an unknown parameters

P : the order of the ARCH process.

In order to simplify, the model can be defined:

$$\sigma^2 = \alpha_0 + \sum \alpha_i \varepsilon^{2-t-i} \quad : i=1, \dots, p$$

Where: $h_t = \sigma^2$.

In 1986, Bollerslev developed a generalized ARCH (GARCH) model which can be defined in the equation below:

$$\sigma^2 = \alpha_0 + \sum \alpha_i \varepsilon^{2-t-i} + \sum \beta_j \sigma^{2-t-j} \quad : i=1, \dots, p \quad j=1, \dots, q$$

This equation means that the conditional variance depends not only on the squared lagged error terms but also on the variance itself.

ARCH and GARCH models are right if:

$$\forall i, j : \alpha_0 > 0, \beta_j \geq 0, \alpha_i \geq 0$$

III-2 Multivariate GARCH and volatility transmission:

According to the univariate ARCH and GARCH models demonstrated above, the current value of a variable depends only on its past value regarding the set of past information. However, the financial reality shows that a price and return movement in one market can spread very quickly to other market, i.e. financial markets are interrelated. Consequently, a set of multivariate GARCH type models have been specified to test for the covariances between the asset returns over time: the VECH model (Bollerslev, Engle and Wooldridge (1988)); the BEKK model (Baba, Engle, Kraft and Kroner (1990)) and the CCC (Bollerslev (1990)) and DCC (Engle (2002)); constant and dynamic conditional correlations, respectively.

In our case, we use the diagonal BEKK model to test for the volatility transmission between oil; U.S.Dollar and gold markets. The BEKK model has the form³:

$$H_t = C\hat{C} + \sum_{j=1}^q \sum_{k=1}^k A_{kj}r_{t-j}r_{t-j}A_{kj} + \sum_{j=1}^p \sum_{k=1}^k B_{kj}H_{t-j}B_{kj}$$

Where:

A_{kj} , B_{kj} and C are $N*N$ parameter matrices and C is triangular. $H_t = [h_{ijt}]$ is the conditional covariance matrix of r_t and r_t is a $N*1$ stochastic vector process. q and p are ARCH and GARCH orders.

The several parameterizations that contain the above form make the estimation of the model more difficult. Thus, Engle and Kroner (1995) give conditions for eliminating redundant, observationally equivalent representations.

$$H_t = C\hat{C} + A_{kj}r_{t-j}r_{t-j}A_{kj} + B_{kj}H_{t-j}B_{kj}$$

In order to restrict the number of parameters and simplify their interpretation, we use the diagonal form of the BEKK model as shown in the above matrix form. The estimated parameters of the own lagged innovations quantify the effects of “news” on the variances (ARCH effects), while the parameters of the lagged variances measure the extent of volatility clustering (GARCH effects) and thus reveal the persistence of volatility. This paper estimates the following variance and covariance equations:

$$h_{11,t} = c_{11}^2 + a_{11}^2 r_{1,t-1}^2 + b_{11}^2 h_{11,t-1}$$

$$h_{22,t} = c_{22}^2 + a_{22}^2 r_{2,t-1}^2 + b_{22}^2 h_{22,t-1}$$

$$h_{33,t} = c_{33}^2 + a_{33}^2 r_{3,t-1}^2 + b_{33}^2 h_{33,t-1}$$

$$h_{21,t} = c_{21}^2 + a_{11}^2 a_{22}^2 r_{1,t-1}^2 r_{2,t-1}^2 + b_{11}^2 b_{22}^2 h_{11,t-1} h_{22,t-1}$$

$$h_{31,t} = c_{31}^2 + a_{11}^2 a_{33}^2 r_{1,t-1}^2 r_{3,t-1}^2 + b_{11}^2 b_{33}^2 h_{11,t-1} h_{33,t-1}$$

$$h_{23,t} = c_{23}^2 + a_{22}^2 a_{33}^2 r_{2,t-1}^2 r_{3,t-1}^2 + b_{22}^2 b_{33}^2 h_{22,t-1} h_{33,t-1}$$

The conditional covariance matrix H_t in MGARCH model is estimated using quasi maximum likelihood (QML) by maximizing the Gaussian log likelihood function.

The time series treated in MGARCH-BEKK should be stationary and the distribution of its residual is pre-defined as a conditional Gaussian distribution (normal).

³Silvenoinen A. and Terasvirta T. (2008); « multivariate GARCH models »; To appear in T. G. Andersen, R. A. Davis, J.-P. Kreiss and T. Mikosch, eds. Handbook of Financial Time Series. New York: Springer.

III-3 Data:

In order to determine the factors influencing the gold market, we test the interrelations between crude oil; the exchange rate of the U.S. Dollar against DTS and the gold prices, thus, monthly data have been used covering the period 1972-January to 2014-November. The returns of U.S. dollar; gold and oil prices expressed in logarithm have been used. $R_t = \log\left(\frac{P_t}{P_{t-1}}\right)$. For all

the series, we used data from the UNCTAD.

VI- Empirical results:**VI-1 Descriptive statistics and stationarity tests:**

From the histogram and descriptive statistics of the return series of U.S.D.; Gold and oil prices, we observe that the mean and the median are positive for all of the series which indicates the increasing trend of the variables during the period of the study. The positive skewness indicates that the return series is asymmetric. The Jack Bera test and its probability equals to 0 reject the hypothesis of the normal distribution which confirms that the return series is not normally distributed. (table 1).

The augmented Dickey-Fuller and Philip ePerron tests for unit roots showed that either the series of U.S.D.; gold or oil price returns are stationary in their levels; (table2), thus, we use them to estimate the GARCH models.

Table1: Descriptive statistics

	GOLD	OIL	DOLLAR
Mean	1.007782	1.012632	1.000672
Median	1.000590	1.000000	1.000000
Maximum	1.483937	3.936364	1.070922
Minimum	0.832051	0.687993	0.952950
Std. Dev.	0.055597	0.151937	0.013222
Skewness	2.040788	14.03936	0.369161
Kurtosis	16.41688	268.7817	5.007454
Jarque-Bera	4212.059	1529757.	97.98111
Probability	0.000000	0.000000	0.000000
Sum	517.9998	520.4927	514.3456
Sum Sq. Dev.	1.585703	11.84254	0.089680
Observations	514	514	514

source: author's construction using Eviews outputs

Table2: Unit root test (ADF and PP)

	ADF	PP	Result
	Level	Level	
Gold	-18.29 (0.00)	-18.20 (0.00)	I(0)
Oil	-21.13 (0.00)	-21.09 (0.00)	I(0)
Dollar	-17.22 (0.00)	-17.09 (0.00)	I(0)

source: author's construction using Eviews outputs

VI-2 Diagonal BEKK- MGARCH estimation results:

The estimations results are provided in table3. It shows that most of the parameters are significant indicating the existence of ARCH and GARCH effects and volatility persistence. The significant and positive parameters of h_{11} and h_{22} mean that the current conditional variances of U.S. dollar and gold returns respectively are affected by their own previous variances in the previous time. i.e. the existence of volatility in the dollar and gold markets.

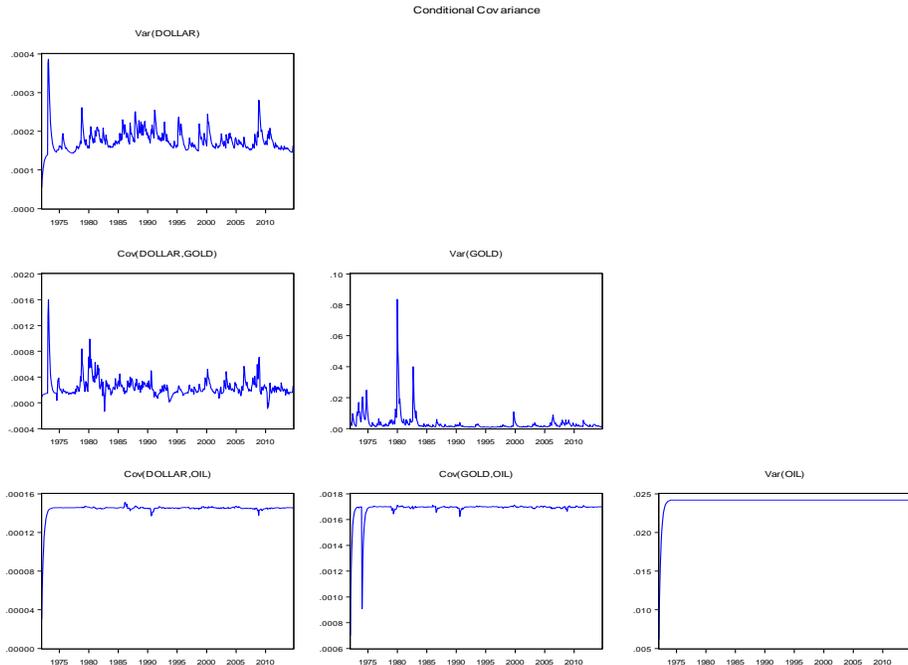
The covariance equation h_{21} indicates a strong positive and significant interrelation between volatilities in dollar and gold markets (volatility spillover); the significant parameters mean that the variances in the gold market are affected by the fluctuations in the dollar exchange rate (significant a_{21}) and vice versa, while the covariance equation h_{23} indicates a strong negative and significant interrelation between volatilities in oil and gold markets; the significant a_{23} means that the volatility in the gold price is affected negatively by a shock in the oil market.

Table3: Diagonal BEKK estimation results

	C	A	B
h11,t	3.4*e-05 (0.0443)**	0.2173 (0.0001)**	0.8726 (0.00)*
h22,t	0.000298 (0.00)***	0.5682 (0.00)***	0.7788 (0.00)*
h33,t	0.005369 (0.407)	-0.0023 (0.98)	0.882 (0.00)*
h21,t	4.72*e-05 (0.00)***	0.1234 (0.03)**	0.6796 (0.062)*
h23,t	0.00053 (0.047)**	-0.0012 (0.063)*	0.6869 (0.122)
h31,t	3.3529 (0.41)	-0.00049 (0.024)**	0.7697 (0.13)

source: author’s construction using Eviews outputs

In order to confirm the estimation results, the figures below plot the conditional variances of the oil and food series individually and the conditional covariance of the model.

Figure2: variances and co-variances representations

source: author's construction using Eviews outputs

V- Conclusion:

This paper tried to analyze empirically the trend of gold price and the causes behind its fluctuations. Using the Diagonal BEKK GARCH model, the paper tested econometrically the gold price volatility and the impact of oil and U.S. dollar volatilities on this market attempting to determine the causes behind such volatility in the gold market. Thus, the estimation results have given the following conclusions:

- the existence of ARCH and GARCH effects and volatility persistence in the three markets;
- the current conditional variances of U.S. dollar and gold returns respectively are affected by their own previous variances in the previous time. i.e. the existence of volatility in the dollar and gold markets;
- the variances in the gold market are affected by the fluctuations in the dollar exchange rate;
- the volatility in the gold price is affected negatively by a chock in the oil market.

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