Gold Price Volatility in Recessionary Period

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Abstract

This paper analyses price movement of gold and examines if it's an appropriate option for investment for the next 3 to 6 months. The major factors such as soaring oil prices, subprime impacts, depreciation of dollar, ongoing recession etc may lead the high gold price in the near future. Autoregressive conditional heteroscedasticity (ARCH) type of models is used for analyzing the volatility of data and forecasting the time varying variance. Other methods like trend fitting and exponential smoothing for price forecasting were also used. The findings suggest it would be wise idea to invest as it may give 3%-12% half yearly return.

Keywords: *Gold price, return, volatility, ARCH, Holt's Linear Exponential Smoothing.*

1. Introduction and Objectives

It is well known that investment in gold is known as "safe-haven" investment. It plays as an inflation hedge and reduce the portfolio risk. The reason behind this are increasing industrial demand, decreasing supply of gold, persistent upward trend and increasing investment demand. Other alternative investment options such as crude oil which also has all the above features but crude oil price is highly volatile and hence not that much predictable. Some basic facts may be of interest in this context are

i) Crude oil price has strong positive correlation with gold price

ii) Euro-dollar exchange rate and gold price has strong negative correlation.

The present communication can be broadly divided into two parts. First part is analysis and forecasting of volatility using ARCH model. Second part is forecasting the future price of gold using Holt linear exponential smoothing. We use daily closing price for analysis of volatility and monthly average data for price forecast.

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Monthly gold price data up-to December, 2007 was used for analysis and remaining six month data was used for validation.

2. Data and Methodology

The daily gold closing price (US $) data from January, 1990 to June, 2008 collected from the URL http://www.usagold.com/reference/prices/history.html is used for the study. The data set contain 4606 observations.

Let p_t denotes daily gold closing price and the corresponding return is r_t, where r_t is defined as

$$r_t = \log(p_t) - \log(p_{t-1}). \quad (2.1)$$

A time plot of daily closing spot price and daily return of gold is given in Figure 1 and 2 respectively. From Figure 1, it is evident that 2003 onwards, gold price has persistent upward trend. Figure 2 reveals some sudden spurts in return data indicating volatility in return from gold. Volatility clustering is also there in the data from Figure-2

Figure-1 Daily closing Price of gold

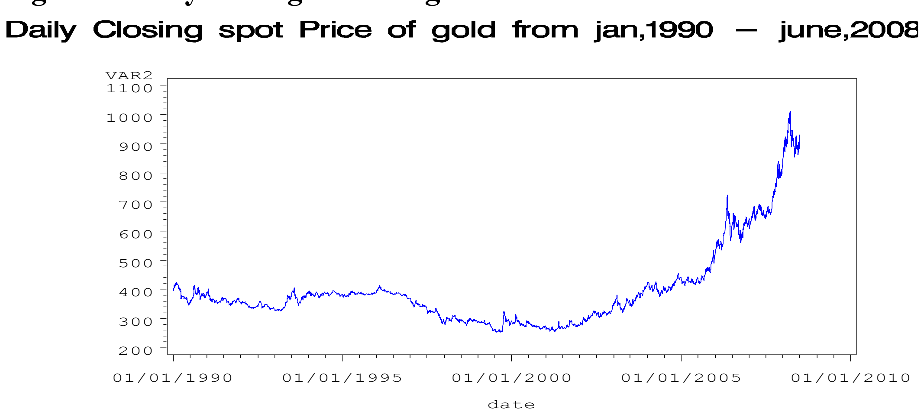
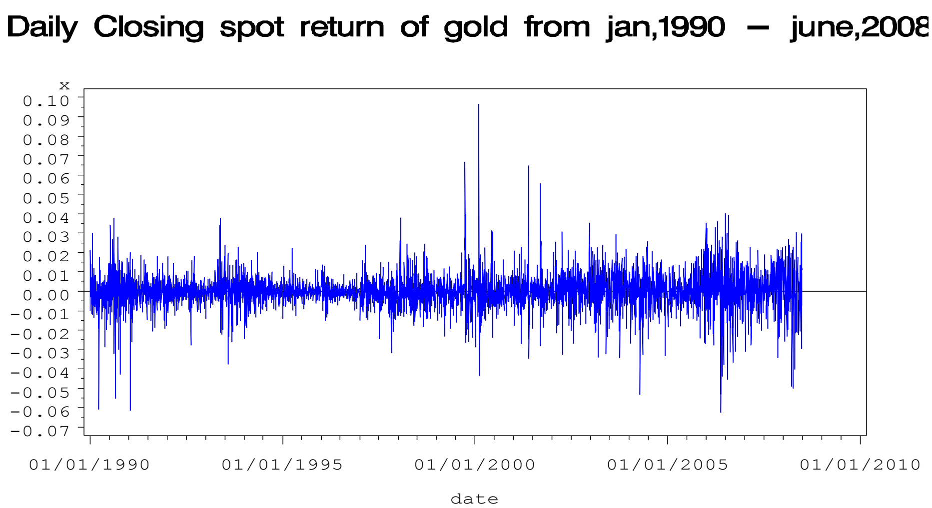


Figure-2 Daily closing spot return of gold



From Figure-2, return can be model as:

$r_t = \mu + \varepsilon_t$ where $\boldsymbol{\varepsilon_t}$ has time varying variance. (2.2)

where μ is the mean of the series and ε_t is random noise t indicates time with increment of a trading day.

ARCH model

The ARCH (q) process introduced by Engle (1982) assumes that $\varepsilon_t | \psi_{t-1} \sim N(0, h_t)$ where h_t is time varying variance and ψ_{t-1} is the information set up to time t - 1. ARCH model assumes conditional variance as a function of squared past errors i.e.

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 . \quad (2.3)$$

where $\alpha_0 > 0$ and $\alpha_i \geq 0$ and $\sum_{i=1}^{q} \alpha_i < 1$. q is the order of the ARCH model and α_i's are unknown parameters.

Holt linear exponential smoothing

The Holt linear exponential smoothing model for the variable p_t is given by

$$p_t = (a_t + b_t * t)S(t) + \varepsilon_t \quad (2.4)$$

where a_t and b_t are the trend parameter and $S(t)$ is seasonal parameter corresponding to time t. Updating parameters are given by:

$$a_t = w_1 \frac{p_t}{s_{t-1}(t)} + (1 - w_1)(a_{t-1} + b_{t-1}) \tag{2.5}$$

$$b_t = w_2(a_t - a_{t-1}) + (1 - w_2)b_{t-1} \tag{2.6}$$

$$S(t) = w_3 \frac{p_t}{a_t} + (1 - w_3)S(t-1) \tag{2.7}$$

where w_1, w_2, w_3 are smoothing weights and it depends on the user choice. All 'w' lies between zero and one.

All the parameters are updated using the iterative procedure and considering some initial values. Following are the calculation of initial values (See Chatfield and Yar (1988) for details):

$$a_0 = \sum_{t=1}^{s} \frac{p_t}{s} \tag{2.8}$$

$$b_0 = \frac{\sum_{t=1}^{s} \frac{p_t}{s} - \sum_{t=s+1}^{2s} \frac{p_t}{s}}{s} \tag{2.9}$$

$$s(0) = \{\frac{p_t - \frac{(k-1)b_0}{2}}{a_0}\} \text{ for k=1, 2, ….s} \tag{2.10}$$

n period ahead forecast is given by:

$$p_{t+n} = (a_t + b_t n)S(t+n) \tag{2.11}$$

Through the iterations, the values converge closer to actual estimates. See Hamilton (1994) for details.

3. Result and Discussion

Data is negatively skewed and excess kurtosis is seen. It is clear that returns does not follow normal distribution from skewness (-0.0167) and kurtosis (8.30437) and it is also clear from Jarque-Bera test from Table-1 Appendix-2. Augmented Dickey-Fuller Unit Root Tests and Phillips-Perron Unit Root Test clarify that data is stationary. ARCH tests (Portmanteau Q and Engel's LM Test) suggest that, ARCH effect is there in the data.

So far model fitment is concerned, ARCH (9) is fitting quite well with the data (Table-1 Appendix-2); all the estimated parameter values are significant at 1% level of significance. GARCH is not fitting well because; sum of the estimated parameters is equal to one. EGARCH also not a good fit for the data, the leverage parameter is non negative that means data is not too much asymmetrical. Based on the estimated parameter we make the volatility forecast also.

The fitted ARCH model is

$$h_t = .0000184 + .1377\varepsilon_{t-1}^2 + .0631\varepsilon_{t-2}^2 + .1263\varepsilon_{t-3}^2 + .1215\varepsilon_{t-4}^2 + .0435\varepsilon_{t-5}^2 + .135\varepsilon_{t-6}^2 + .022\varepsilon_{t-7}^2 + .1761\varepsilon_{t-8}^2 + .0968\varepsilon_{t-9}^2 \quad (3.1)$$

Estimated volatility of daily spot return is shown in Figure 3. Using model (2.2) along with (3.1), 150 trading day ahead volatility forecasts are obtained and is shown in Figure 4.

Figure-3: Time vs. estimated volatility of daily spot return

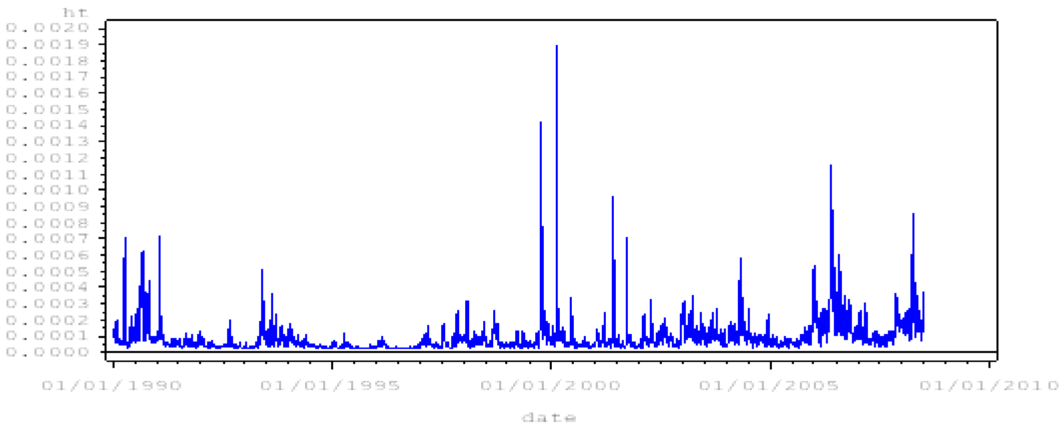
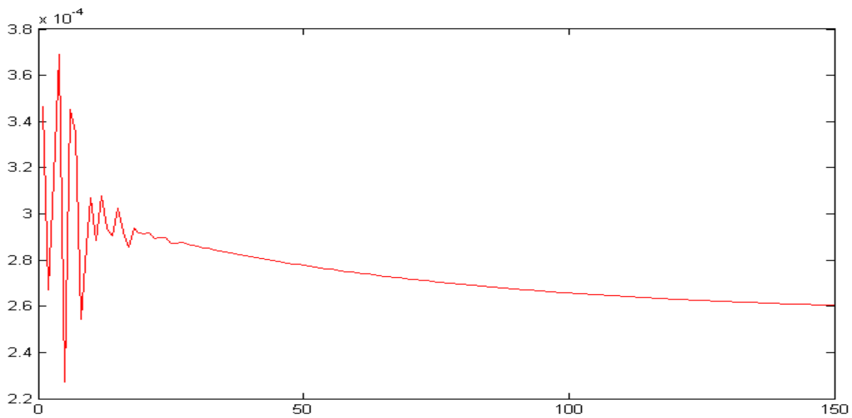


Figure-4: 150 trading day ahead Volatility forecast of spot return



Holt linear exponential smoothing has been used for forecasting the monthly average price of gold. There are different types of exponential smoothing in literature. Holt-Winters method is widely used for modeling time series data with trend. For this data set, Holt's method gives very good fit and forecast. The model fits well to the data (R^2 = 0.968436), mean error is 0.514 and mean percent error is 0.0672.

The parameter estimates for Holt-linear exponential model for price data are a_t = 810.2806 and b_t = 24.432834. $S(t)$ is the seasonal parameter for each month and it has calculated for 12 months. For $n = 1, 2, \ldots, h$ the forecasting formula:

$$p_t = (810.2806 + 24.4328 * n)S(t) \qquad (3.2)$$

Using model (3.2), gold price forecast is obtained and is plotted in Figure 5. A validation study of gold price is conducted and the same is represented through Figure 6.

Figure-5: Holt linear exponential smoothing and forecast

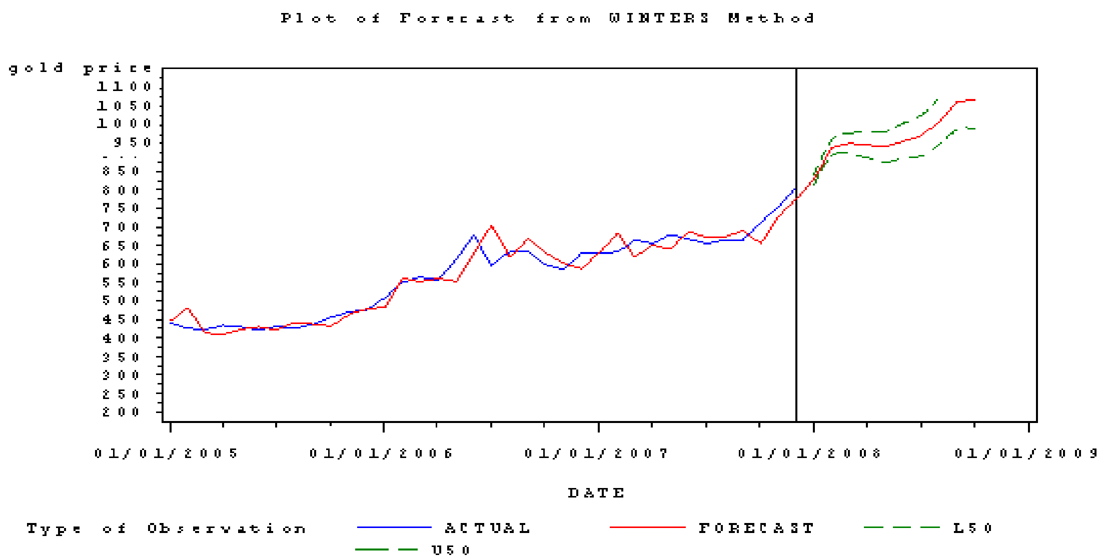
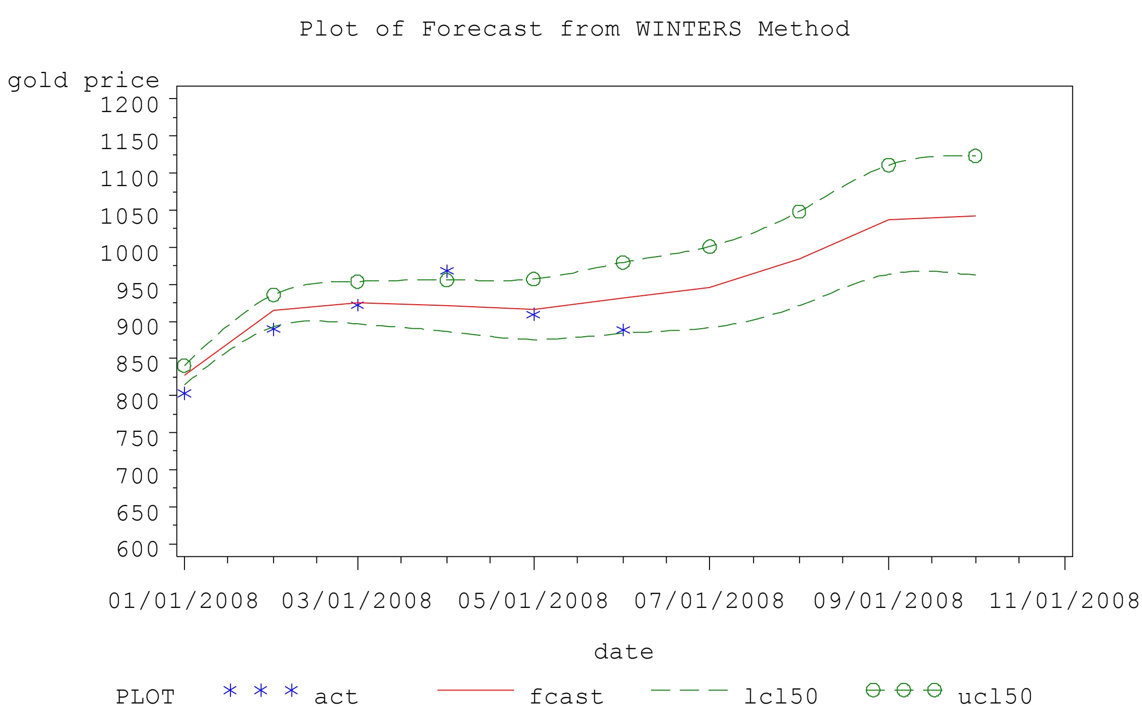


Figure-6: Forecast validation



4. Conclusion

Gold price movement is very closely related to some factors as discussed earlier. Gold return follows an ARCH (9) process and all the estimated parameter are significant in 1% level of significance. This model has been used to forecast the future volatility, proxy to the squared return. 150 days ahead volatility forecast calculated here. From the graph, it is seen that after some time volatility is decreasing. After some period forecasted variance is flat, it is because of long forecasting horizon.

From the trend of the price data, it is clear that, data has positive upward trend. Holt exponential smoothing suggests that one can expect some positive return from the investment in gold. By December, 2008 one can expect a 3% - 12% returns from gold, the average price may remain above $965 and the average volatility will remain 0.0002835.

References

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Appendix-1

Table-1 Basic statistics

Variable used: r_t (Gold Price return)	
N of Cases	4605
Minimum	-0.0625
Maximum	0.09642
Range	0.15889
Arithmetic Mean	0.00018
Standard Deviation	0.00917
Variance	8.4E-05
Skewness(G1)	-0.0167
Kurtosis(G2)	8.30473

Table-2 Phillips-Perron Unit Root Test

Phillips-Perron Unit Root Test					
Type	**Lags**	**Rho**	**Pr < Rho**	**Tau**	**Pr < Tau**
Zero Mean	13	-4735.2730	0.0010	-68.5825	0.0010
Single Mean	13	-4727.3407	0.0020	-68.6024	0.0010
Trend	13	-4695.5582	0.0010	-68.6974	0.0010

Table-3: Augmented Dickey-Fuller Unit Root Tests of gold return

Augmented Dickey-Fuller Unit Root Tests							
Type	**Lags**	**Rho**	**Pr < Rho**	**Tau**	**Pr < Tau**	**F**	**Pr > F**
Zero Mean	0	-4654.11	0.0001	-68.58	<.0001		
	1	-4751.18	0.0001	-48.71	<.0001		
	2	-4675.92	0.0001	-39.32	<.0001		
Single Mean	0	-4655.97	0.0001	-68.61	<.0001	2353.39	0.0010
	1	-4756.99	0.0001	-48.74	<.0001	1187.60	0.0010
	2	-4687.00	0.0001	-39.35	<.0001	774.28	0.0010
Trend	0	-4662.88	0.0001	-68.70	<.0001	2359.96	0.0010
	1	-4778.57	0.0001	-48.84	<.0001	1192.82	0.0010
	2	-4730.36	0.0001	-39.47	<.0001	779.12	0.0010

Table-4: Portmanteau Q and Engel's LM Test

Q and LM Tests for ARCH Disturbances				
Order	**Q**	**Pr > Q**	**LM**	**Pr > LM**
1	98.0671	<.0001	97.9947	<.0001
2	119.0146	<.0001	108.0137	<.0001
3	156.9110	<.0001	134.1324	<.0001
4	219.3803	<.0001	173.0340	<.0001
5	241.3815	<.0001	178.3137	<.0001
6	270.9161	<.0001	190.8913	<.0001
7	292.9102	<.0001	196.1425	<.0001
8	332.0720	<.0001	211.9136	<.0001
9	347.2951	<.0001	213.3841	<.0001
10	354.6329	<.0001	213.5076	<.0001
11	363.8257	<.0001	214.3611	<.0001
12	368.7749	<.0001	214.3656	<.0001

Appendix-2

Table-1: GARCH Estimates

GARCH Estimates			
SSE	0.38690489	**Observations**	4605
MSE	0.0000840	**Uncond Var**	0.00023758
Log Likelihood	15550.6859	**Total R-Square**	0.0000
SBC	-31017.023	**AIC**	-31081.372
Normality Test	12996.1132	**Pr > ChiSq**	<.0001
NOTE: No intercept term is used. R-squares are redefined.			

Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
ARCH0	1	0.0000184	7.9262E-7	23.17	<.0001
ARCH1	1	0.1377	0.0141	9.80	<.0001
ARCH2	1	0.0631	0.0117	5.39	<.0001
ARCH3	1	0.1263	0.008296	15.22	<.0001
ARCH4	1	0.1215	0.0100	12.13	<.0001
ARCH5	1	0.0435	0.0115	3.79	0.0001

ARCH6	1	0.1357	0.009142	14.84	<.0001
ARCH7	1	0.0220	0.009605	2.29	0.0221
ARCH8	1	0.1761	0.0103	17.07	<.0001
ARCH9	1	0.0968	0.0117	8.27	<.0001

Appendix-3

Forecast and Results of Holt exponential smoothing:

Table-1

Date	Forecast	L50	U50
1/1/2008	827.58468	814.6616	840.5078
2/1/2008	914.28588	892.6315	935.9402
3/1/2008	925.289826	896.6801	953.8995
4/1/2008	921.290197	886.4302	956.1502
5/1/2008	916.420344	875.5444	957.2963
6/1/2008	931.791109	884.0063	979.5759
7/1/2008	946.334963	891.5392	1001.131
8/1/2008	984.88338	921.3807	1048.386
9/1/2008	1037.40934	963.7426	1111.076
10/1/2008	1042.83148	962.0091	1123.654
11/1/2008	1070.17843	980.3325	1160.024
12/1/2008	1097.98385	998.7668	1197.201

Table-2

N	215	S_JUL	0.964342
NRESID	215	S_AUG	0.979264
DF	201	S_SEP	1.007047
WEIGHT1	0.999	S_OCT	0.988746
WEIGHT2	0.2	S_NOV	0.991733
WEIGHT3	0.2	S_DEC	0.994995
SIGMA	19.3327	SST	2380078
CONSTANT	810.2806	SSE	75124.39
LINEAR	24.43283	MSE	373.7532
S_JAN	0.991436	RMSE	19.3327
S_FEB	1.064291	MAPE	3.442918
S_MAR	1.047122	MPE	0.0672
S_APR	1.014553	MAE	13.37275
S_MAY	0.982733	ME	0.514761
S_JUN	0.973738	RSQUARE	0.968436