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The analysis of volatility of gold coin price fluctuations in Iran using ARCH & VAR models

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A B S T R A C T

The aim of this study is to investigate the changes in gold price and modeling of its return volatility and conditional variance model. The study gathers daily prices of gold coins as the dependent variable and the price of gold in world market, the price of oil in OPEC, exchange rate USD to IRR and index of Tehran Stock Exchange from March 2007 to July 2013 and using ARCH family models and VAR methods, the study analysis the data. The study first examines whether the data are stationary or not and then it reviews the household stability, Arch and Garch models. The proposed study investigates the causality among variables, selects different factors, which could be blamed of uncertainty in the coin return. The results indicate that the effect of sudden changes of standard deviation and after a 14-day period disappears and gold price goes back to its initial position. In addition, in this study we observe the so-called leverage effect in Iran's Gold coin market, which means the good news leads to more volatility in futures market than bad news in an equal size. Finally, the result of analysis of variance implies that in the short-term, a large percentage change in uncertainty of the coin return is due to changes in the same factors and volatility of stock returns in the medium term, global gold output, oil price and exchange rate fluctuation to some extent will show the impact. In the long run, the effects of parameters are more evident.

1. Introduction

The first decades of the new millennium has witnessed different world's challenges such as infamous September 11 incident, Iraq and Afghanistan war, etc. These incidents have created tremendous uncertainties and many investors moved to safe side in order to protect their investment, switching to gold from stock exchange. The world gold price went up from 600$ level to a historical record of 1900$ (Lawrence, 2003). Melvin and Sultan (1990) investigated South African political unrest, oil prices, and the time varying risk premium in the gold futures market and reported that while gold prices did not have any relationship with oil price but fluctuations on oil and stock exchange both influence on gold price, significantly.

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Bollerslev (1986) presented a natural generalization of the Autoregressive Conditional Heteroskedastic (ARCH) process to show for past conditional variances in the current conditional variance equation is proposed. Cai et al. (2001) provided a comprehensive characterization of the intraday return volatility in gold futures contracts traded on the COMEX division of the New York Mercantile Exchange. They detected employment reports, gross domestic product, consumer price index, and personal income as having the biggest impact. They also detected that the high-frequency returns disclosed long-memory volatility dependencies in the gold market, which had important implications on the pricing of long-term gold options and the determination of optimal hedge ratios.

Tully and Lucey (2007) investigates macroeconomic influences on gold using the asymmetric power GARCH model (APGARCH) of Ding et al. (1993). They investigated both cash and futures prices of gold and substantial economic variables over the period 1983–2003, with special concentration on two periods, around the 1987 and 2001 equity market crashes. Their results indicated that APGARCH model could provide the most sufficient description for the data, with the inclusion of a GARCH term, free power term and unrestricted leverage impact term.

Glosten et al. (1993) detected some support for a negative relationship between conditional expected monthly return and conditional variance of monthly return, using a GARCH-M model. Using the modified GARCH-M model, they also demonstrated that monthly conditional volatility could not be as persistent as was thought. Positive unanticipated returns seemed to result in a downward revision of the conditional volatility whereas negative unanticipated returns yield in an upward revision of conditional volatility.

Ivanova and Ausloos (1999) presented a forecast of the low q-moment values of the assumed multifractal spectrum of Gold price, Dow Jones Industrial Average (DJIA) and Bulgarian Lev - USA Dollar (BGL-USD) exchange rate. The analysis demonstrated that these three financial data were not likely fractal but rather multifractal indeed.

2. The proposed model

The aim of this study is to investigate the changes in gold price and modeling of its return volatility and conditional variance model. There are two main hypotheses associated with the proposed study of this paper as follows,

1. The change on gold coin is a function of macro-economic factors and there are some meaningful relationships among them.
2. The change on gold coin is a function of micro-economic factors and there are some meaningful relationships among them.

The study also considers whether there is some causality among various factors and whether the effects of positive and negative pulses are equal or not. The study gathers daily prices of gold coins as the dependent variable and the price of gold in world market, the price of oil in OPEC, exchange rate USD to IRR and index of Tehran Stock Exchange from March 2007 to July 2013 and using ARCH family models and VAR methods, the study analysis the data. The study first examines whether the data are stationary or not and then it reviews the household stability, ARCH and GARCH models (Engle et al., 1987; Engle & Kroner, 1995).

2.1. The effects of TARCH model on gold price

The proposed study investigates the causality among variables, selects different factors, which could be blamed of uncertainty in the coin return. Table 1 demonstrates the summary of some basic statistics.

Table 1
The summary of some basic statistics on gold price

Statistics	Daily index	Daily growth
Mean	6100742	0.00156
Median	4580000	0
Max	15680000	0.294872
Min	2570000	-0.262376
Standard deviation	3522954	0.020369
Skewness	1.122627	1.643171
Kurtosis	3.179537	72.80547
Number of observations	1301	1301

In this paper, we have performed Dickey Fuller test to see whether the data are stationary or not and Table 2 demonstrates the results of our investigation on price of gold (PCOIN).

Table 2
The summary of Dickey Fuller test

Variable	ADF statistics	Critical value	Sig. level
PCOIN	-0.96	-48.3 -89.2 -57.2	%1 %5 %10
$Y = \frac{PCOIN - PCOIN(-1)}{PCOIN(-1)}$	**-10.92**	-2.56 -1.94 -1.62	%1 %5 %10

The results of Table 2 clearly specify that *Y* is a stationary variable. The proposed study of this paper uses ARCH method with GARCH(1,1) as follows,

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \theta_2 u_{t-2} + \varepsilon_t \quad (1)$$

$$\text{GARCH} = C(8) + C(9)*\text{RESID}(-1)^2 + C(10)*\text{RESID}(-1)^2*(\text{RESID}(-1)<0)+C(11)*\text{GARCH}(-1) \quad (2)$$

Table 3 shows details of our results of the TARCH model for gold price.

Table 3
The results of TARCH model on gold price

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000963	0.000328	2.932536	0.0034
AR(3)	0.564977	0.170445	3.314710	0.0009
AR(7)	0.090843	0.025675	3.538148	0.0004
AR(6)	0.050391	0.029879	1.686468	0.0917
AR(4)	-0.053208	0.028470	-1.868889	0.0616
MA(2)	-0.035900	0.028003	-1.281980	0.1998
MA(3)	-0.608933	0.171070	-3.559555	0.0004
	Variance Equation			
C	1.06E-05	1.56E-06	6.785952	0.0000
RESID(-1)^2	0.165094	0.021081	7.831421	0.0000
RESID(-1)^2*(RESID(-1)<0)	-0.056281	0.022847	-2.463346	0.0138
GARCH(-1)	0.757948	0.022145	34.22662	0.0000
R-squared	0.122545	Mean dependent var		0.001579
Adjusted R-squared	0.117604	S.D. dependent var		0.020427
S.E. of regression	0.020246	Akaike info criterion		-5.955488
Sum squared resid	0.486560	Schwarz criterion		-5.908640
Log likelihood	3566.426	Hannan-Quinn criter.		-5.937836
Durbin-Watson stat	2.336173			

The results of Table 3 indicate that the effects of bad news $(\varepsilon_t < 0)$ compared with the effects of good news $(\varepsilon_t > 0)$ are different. In other words, bad news maintains the effects of $\alpha_i + \gamma_i$ while good news maintains the effects of α_i.

2.2. The effect of TARCH model on oil price

Table 4 demonstrates the summary of some basic statistics.

Table 4
The summary of some basic statistics on oil price

Statistics	Daily index
Mean	98.55116
Median	105.9100
Max	124.6400
Min	66.84000
Standard deviation	16.02263
Skewness	-0.493347
Kurtosis	1.805026
Number of observations	1301

In addition, we have performed Dickey Fuller test to see whether the oil prices are stationary or not and Table 5 demonstrates the results of our investigation on price of oil (PROIL).

Table 5
The summary of Dickey Fuller test

Variable	ADF Statistics	Critical value	Sig.
PROIL	-1.806657	-48.3	%1
		-89.2	%5
		-57.2	%10
After first difference	**-28.07275**	-3.48	%1
		-2.89	%5
		-2.57	%10

The results of Table 5 indicate that oil data become stationary after taking one difference. Here TARCH model for oil price is studied through the following relationship.

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \theta_2 u_{t-2} + \varepsilon_t \quad (3)$$

$$\text{GARCH} = C(6) + C(7)*\text{RESID}(-1)^2 + C(8)*\text{RESID}(-1)^2*(\text{RESID}(-1)<0) + C(9)*\text{GARCH}(-1) \quad (4)$$

Table 6 shows details of our results of the TARCH model for oil price.

Table 6
The results of TARCH model on oil price

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.041807	0.033591	1.244597	0.2133
AR(1)	0.209104	0.030141	6.937545	0.0000
AR(2)	0.820662	0.112129	7.318913	0.0000
AR(3)	-0.146558	0.042561	-3.443482	0.0006
MA(2)	-0.852475	0.098928	-8.617147	0.0000
	Variance Equation			
C	0.059623	0.011859	5.027601	0.0000
RESID(-1)^2	0.079971	0.012956	6.172774	0.0000
RESID(-1)^2*(RESID(-1)<0)	0.056735	0.017186	3.301293	0.0010
GARCH(-1)	0.831104	0.019431	42.77309	0.0000

R-squared	0.040655	Mean dependent var	0.029624
Adjusted R-squared	0.037436	S.D. dependent var	1.007642
S.E. of regression	0.988601	Akaike info criterion	2.692073
Sum squared resid	1164.979	Schwarz criterion	2.730325
Log likelihood	-1602.205	Hannan-Quinn criter.	2.706484
Durbin-Watson stat	2.007959		

The results of Table 6 indicate that the effects of bad news $(\varepsilon_t < 0)$ compared with the effects of good news $(\varepsilon_t > 0)$ are different. In other words, bad news maintains the effects of $\alpha_i + \gamma_i$ while good news maintains the effects of α_i.

2.3. The effects of nonlinear EGARCH model on currency

The proposed study investigates the causality among variables, selects different factors, which could be blamed of uncertainty in the coin return. Table 7 demonstrates the summary of some basic statistics on currency data.

Table 7
The summary of some basic statistics on currency

Statistics	Daily index
Mean	16393
Median	12048
Max	38857
Min	9965
Standard deviation	8121.243
Skewness	1.379390
Kurtosis	3.632674
Number of observations	1301

Besides, we have performed Dickey Fuller test to see whether the oil prices are stationary or not and the proposed model find the following two equations as appropriate models,

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \theta_2 u_{t-2} + \varepsilon_t \quad (12)$$

$$\text{LOG(GARCH)} = \text{C(8)} + \text{C(9)*ABS(RESID(-1).@SQRT(GARCH(-1}))) + \text{C(10) *LOG(GARCH(-1))} \quad (13)$$

Table 8 shows details of our results of the EGARCH model for currency changes.

Table 8
The results of EGARCH model on currency changes

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-73.84457	101.4598	-0.727821	0.4667
AR(1)	-0.051314	0.004610	-11.13157	0.0000
AR(2)	0.652898	0.004792	136.2473	0.0000
AR(4)	0.118855	0.000651	182.4633	0.0000
AR(3)	0.280775	0.000801	350.4952	0.0000
MA(2)	-0.682999	0.014618	-46.72425	0.0000
MA(3)	-0.315580	0.014214	-22.20273	0.0000
	Variance Equation			
C(8)	-0.113505	0.035345	-3.211381	0.0013
C(9)	0.527244	0.013860	38.03962	0.0000
C(10)	0.979076	0.003306	296.1927	0.0000
R-squared	0.07256	Mean dependent var		20.67977
Adjusted R-squared	0.02247	S.D. dependent var		426.8862
S.E. of regression	426.4064	Akaike info criterion		13.24324
Sum squared resid	2.16E+08	Schwarz criterion		13.28577
Log likelihood	-7909.455	Hannan-Quinn criter.		13.25926
Durbin-Watson stat	1.947996			

Finally, we have performed augmented Dickey Fuller (ADF) to verify whether time series of gold price, oil price and currency are stationary or not and Table 9 shows details of our findings.

Table 9
The results ADF test

Variable	ADF result	Critical value %1	Critical value %5	Critical value %10
GARCHCOIN	-19.3167	-2.566902	-1.941089	-1.616521
GARCHDR	-5.3985	-3.48	-2.89	-2.57
GARCHPOIL	-6.511983	-3.48	-2.89	-2.57

The results of Table 9 specify that all data are stationary when the level of significance is one or five percent.

3. The VAR method

In this section, we present details of the implementation of VAR method. The proposed method uses the following time series equation,

$$X_t = \Pi_1 X_{t-1} + \Pi_2 X_{t-2} + \ldots . \Pi_k X_k + U_t \quad (14)$$

Table 10 demonstrates the results to find the optimum number of Inertia.

Table 10
The results of regression analysis

Lag	LogL	LR	FPE	AIC	SC	HQ
0	13074.08	NA	3.15e-15	-22.04060	-22.02348	-22.03415
1	14361.31	2563.614	3.69e-16	-24.18434	**-24.09870***	-24.15206*
2	14385.50	48.00791	3.64e-16	-24.19814	-24.04400	-24.14004
3	14409.09	46.65533	3.59e-16*	-24.21094*	-23.98828	-24.12701
4	14414.02	9.721563	3.66e-16	-24.19227	-23.90110	-24.08253
5	14419.36	10.50557	3.73e-16	-24.17431	-23.81463	-24.03874
6	14435.98	32.52966	3.72e-16	-24.17535	-23.74715	-24.01396
7	14456.59	40.22156*	3.69e-16	-24.18313	-23.68643	-23.99592
8	14463.60	13.62845	3.75e-16	-24.16797	-23.60275	-23.95493

* indicates lag order selected by the criterion
AIC: Akaike information criterion
SC: Schwarz Baysian criterion
HQ: Hannan-Quinn criterion
LR: Maximized log-likelihood Ratio
AR: Auto Regressive

According to Table 10, the best lag is determined as one based on Schwartz Baysian criterion. In addition, Fig. 1 demonstrates the stability of the VAR method.

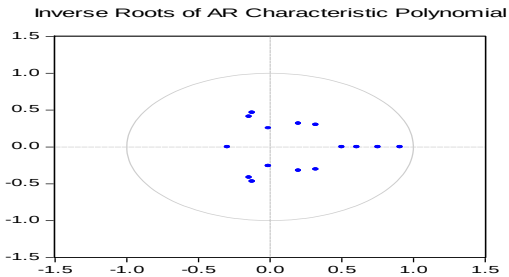

Fig. 1. The results of inverse roots of AR characteristics polynomial

The results of Fig. 1 clearly show that the VAR model preserve sufficient stability. We now consider the effects of a shock on price of gold and these effects are shown in Fig. 2 as follows,

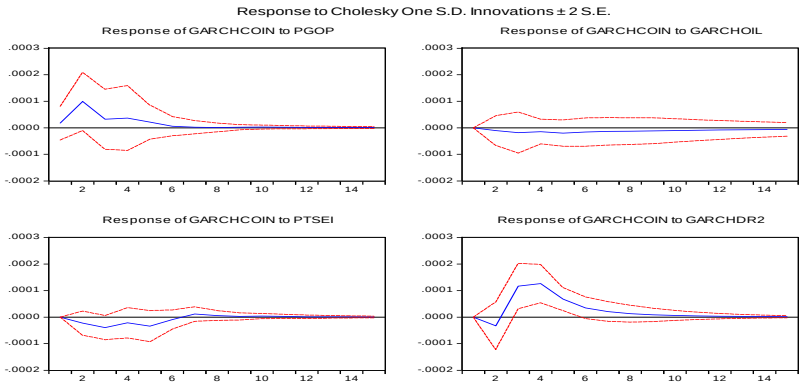

Fig. 2. The summary of the coin gold responses against changes on TSE exchange, oil, etc.

As we can observe from the results of Fig. 2, the changes on local currency, world gold price, oil price have instance effects on gold coin. Next, we present details of analysis of variance for fluctuation of gold coin prices in different periods. Table 11 summarizes the results of our findings.

Table 11
The summary of analysis of variance

Period	S.E.	PGOP	GARCHCOIN	GARCHOIL	PTSEI	GARCHDR2
1	0.008807	0.024172	**99.97583**	0.000000	0.000000	0.000000
2	0.008831	0.585894	99.31768	0.006220	0.029465	0.060743
3	0.008840	0.619151	98.43190	0.023490	0.114047	0.811408
4	0.008848	**0.677157**	97.50715	**0.033927**	**0.135380**	**1.646385**
5	0.008849	0.696751	97.17282	0.054776	0.196369	1.879286
6	0.008849	0.697559	97.09142	0.068687	0.200481	1.941857
7	0.008849	0.697420	97.05230	0.078142	0.207545	1.964592
8	0.008849	0.697285	97.03343	0.086690	0.209442	1.973154
9	0.008849	0.697423	97.02276	0.093322	0.209776	1.976719
10	0.008849	**0.697781**	97.01449	**0.098605**	**0.210554**	**1.978575**

As we can observe from the results of Table 11, during the first period, nearly all changes on gold coin fluctuations are associated with the gold coin price itself and world gold price as well as oil price did not influence on gold price, significantly. However, in other periods, other parameters such as world gold price, currency de-evaluation and stock exchange start influencing the gold price.

4. Conclusion

In this paper, we have presented an empirical investigation to study the effects of different factors such as world gold price, stock exchange, oil price and currency exchange on Iranian gold coin price. The proposed study has gathered the historical information from March 2007 to July 2013 and using ARCH family models and VAR methods, the study analysis the data. The results have indicated that the effect of sudden changes of standard deviation and after a 14-day period disappears and gold price goes back to its initial position. In addition, in this study we have observed the so-called leverage effect in Iran's Gold coin market, which means the good news leads to more volatility in futures market than bad news in an equal size. Finally, the result of analysis of variance implied that in the short-term, a large percentage change in uncertainty of the coin return was due to changes in the same factors and volatility of stock returns in the medium term, global gold output, oil price and exchange rate fluctuation to some extent will show the impact. In the long run, the effects of parameters are more evident.

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