DSC5211C Workshop 4

A0122250B LIN DU

(a) Dicky-Fuller Tests

(i) no, it is not stationary, there is a big spike towards the end of the plot

(ii) null hypothesis is H_0: γ =0.

Yes, it should be rejected for the exchange rate series, because from the t-statistics shown below, the p-value is 0.3988>0.05, so we should accept the null hypothesis.

And the series is Not stationary.

Series: COPPER Workfile: SESSION 4 WORKSHOP::Untitled\

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Augmented Dickey-Fuller Unit Root Test on COPPER

Null Hypothesis: COPPER has a unit root
Exogenous: None
Lag Length: 1 (Automatic - based on SIC, maxlag=19)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.733304	0.3988
Test critical values:	1% level	-2.568242	
	5% level	-1.941272	
	10% level	-1.616398	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(COPPER)
Method: Least Squares
Date: 02/13/19 Time: 19:42
Sample (adjusted): 1960M03 2018M12
Included observations: 706 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COPPER(-1)	-0.001762	0.002403	-0.733304	0.4636
D(COPPER(-1))	0.335927	0.035588	9.439353	0.0000

R-squared	0.111507	Mean dependent var	7.573839
Adjusted R-squared	0.110245	S.D. dependent var	243.9988
S.E. of regression	230.1563	Akaike info criterion	13.71822
Sum squared resid	37292239	Schwarz criterion	13.73114
Log likelihood	-4840.533	Hannan-Quinn criter.	13.72321
Durbin-Watson stat	1.964526		

(iii) with p-value for the t-statistics 0.0683 > 0.05, H_0: γ =0 should be accepted at level 0.05. So it is still non-stationary when test at level 0.05. But since 0.0683<0.01, we can consider the model to be stationary if we test at level 0.1.

Series: COPPER Workfile: SESSION 4 WORKSHOP::Untitled\

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Augmented Dickey-Fuller Unit Root Test on COPPER

Null Hypothesis: COPPER has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=19)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.292650	0.0683
Test critical values:	1% level	-3.971104	
	5% level	-3.416195	
	10% level	-3.130392	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(COPPER)
Method: Least Squares
Date: 02/13/19 Time: 20:02
Sample (adjusted): 1960M03 2018M12
Included observations: 706 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COPPER(-1)	-0.020058	0.006092	-3.292650	0.0010
D(COPPER(-1))	0.343349	0.035445	9.686863	0.0000
C	-2.992700	17.33630	-0.172626	0.8630
@TREND("1960M01")	0.181759	0.067408	2.696395	0.0072

R-squared	0.124816	Mean dependent var	7.573839
Adjusted R-squared	0.121076	S.D. dependent var	243.9988
S.E. of regression	228.7512	Akaike info criterion	13.70880
Sum squared resid	36733624	Schwarz criterion	13.73463
Log likelihood	-4835.205	Hannan-Quinn criter.	13.71878
F-statistic	33.37245	Durbin-Watson stat	1.971804
Prob(F-statistic)	0.000000		

(iv) From the augmented Dickey-Fuller test, the series doesn't look stationary. Because neither Autocorrelation nor Partial Correlation doesn't goes to 0 fast.

Date: 02/12/19 Time: 23:16
Sample: 1960M01 2018M12
Included observations: 706

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.014	0.014	0.1372	0.711
		2	-0.030	-0.031	0.7918	0.673
		3	-0.021	-0.020	1.0975	0.778
		4	-0.028	-0.028	1.6539	0.799
		5	0.070	0.070	5.1854	0.394
		6	-0.052	-0.056	7.0883	0.313
		7	0.002	0.007	7.0918	0.419
		8	-0.169	-0.173	27.567	0.001
		9	-0.030	-0.022	28.218	0.001
		10	0.014	-0.006	28.349	0.002
		11	0.180	0.189	51.674	0.000
		12	0.071	0.053	55.268	0.000
		13	-0.104	-0.074	63.049	0.000
		14	-0.003	-0.016	63.054	0.000
		15	0.013	0.017	63.169	0.000
		16	0.005	-0.047	63.185	0.000
		17	0.052	0.059	65.147	0.000
		18	-0.021	-0.006	65.470	0.000
		19	-0.054	0.000	67.624	0.000
		20	-0.003	0.022	67.632	0.000
		21	0.078	0.062	72.074	0.000
		22	0.059	0.008	74.594	0.000
		23	0.054	0.051	76.734	0.000
		24	-0.050	-0.031	78.556	0.000
		25	-0.009	0.024	78.621	0.000
		26	-0.037	-0.068	79.653	0.000
		27	-0.024	-0.019	80.064	0.000
		28	-0.029	-0.055	80.699	0.000
		29	-0.041	-0.009	81.912	0.000
		30	0.036	0.065	82.863	0.000
		31	-0.081	-0.062	87.749	0.000
		32	0.016	-0.031	87.946	0.000
		33	0.020	0.002	88.244	0.000
		34	-0.015	-0.048	88.404	0.000
		35	0.045	0.043	89.927	0.000
		36	0.061	0.082	92.721	0.000

(v) the unit root tests give me probability close to 0 for t-statistics. And the correlogram of the D(copper) plot is random and close to 0 for ACF and PACF, therefore it is stationary

Series: D(COPPER) Workfile: SESSION 4 WORKSHOP::U...

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Augmented Dickey-Fuller Unit Root Test on D(COPPER)

Null Hypothesis: D(COPPER) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=17)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-14.13802	0.0000
Test critical values:	1% level	-3.980823	
	5% level	-3.420930	
	10% level	-3.133194	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(COPPER,2)
Method: Least Squares
Date: 02/14/19 Time: 23:50
Sample (adjusted): 1985M03 2018M12
Included observations: 406 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(COPPER(-1))	-0.663312	0.046917	-14.13802	0.0000
C	9.686027	28.80670	0.336242	0.7369
@TREND("1985M01")	-0.010529	0.122185	-0.086174	0.9314

R-squared	0.331547	Mean dependent var	-0.369458
Adjusted R-squared	0.328230	S.D. dependent var	352.0480
S.E. of regression	288.5441	Akaike info criterion	14.17493
Sum squared resid	33552860	Schwarz criterion	14.20454
Log likelihood	-2874.512	Hannan-Quinn criter.	14.18665
F-statistic	99.94244	Durbin-Watson stat	1.973725
Prob(F-statistic)	0.000000		

Series: D(COPPER) Workfile: SESSION 4 WORKSHOP::U...

View | Proc | Object | Properties | Print | Name | Freeze | Sample | Genr | Sheet | Graph | Stats | Ident

Correlogram of D(COPPER)

Date: 02/14/19 Time: 23:49
Sample: 1985M01 2018M12
Included observations: 407

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.337	0.337	46.439	0.000
		2	0.079	-0.038	49.021	0.000
		3	-0.015	-0.034	49.115	0.000
		4	-0.043	-0.027	49.875	0.000
		5	0.012	0.042	49.933	0.000
		6	-0.086	-0.116	53.003	0.000
		7	-0.102	-0.047	57.357	0.000
		8	-0.226	-0.195	78.688	0.000
		9	-0.101	0.043	82.997	0.000
		10	0.025	0.049	83.254	0.000
		11	0.180	0.177	96.920	0.000
		12	0.078	-0.074	99.485	0.000
		13	-0.088	-0.114	102.77	0.000
		14	-0.034	0.004	103.27	0.000
		15	-0.002	0.010	103.27	0.000
		16	0.000	-0.065	103.27	0.000
		17	0.030	0.068	103.65	0.000
		18	-0.026	-0.023	103.94	0.000
		19	-0.067	0.001	105.89	0.000
		20	-0.007	0.027	105.91	0.000
		21	0.088	0.051	109.27	0.000
		22	0.095	-0.013	113.20	0.000
		23	0.047	0.018	114.14	0.000
		24	-0.066	-0.072	116.03	0.000
		25	-0.069	-0.008	118.11	0.000
		26	-0.089	-0.102	121.55	0.000
		27	-0.085	-0.023	124.71	0.000
		28	-0.075	-0.049	127.15	0.000
		29	-0.066	0.017	129.07	0.000
		30	-0.017	0.037	129.19	0.000
		31	-0.087	-0.116	132.58	0.000
		32	-0.016	-0.043	132.69	0.000
		33	0.003	-0.021	132.70	0.000
		34	-0.001	-0.038	132.70	0.000
		35	0.052	0.066	133.92	0.000
		36	0.064	0.053	135.78	0.000

(b) Arima Modelling

(i) Based on the correlagram ACF and PACF graph, the series is non-stationary because ACF graph stay close to 1 and there is big spike at lag 1 for Partial Correlation

Series: GOLD   Workfile: SESSION 4 WORKSHOP::Untitled\

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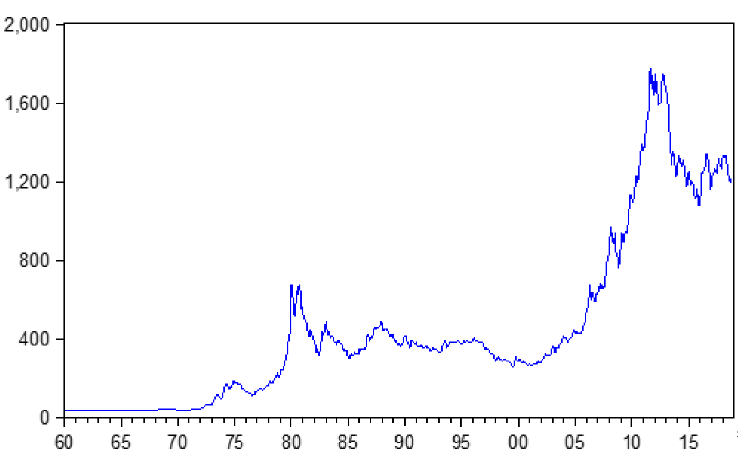
Correlogram of GOLD

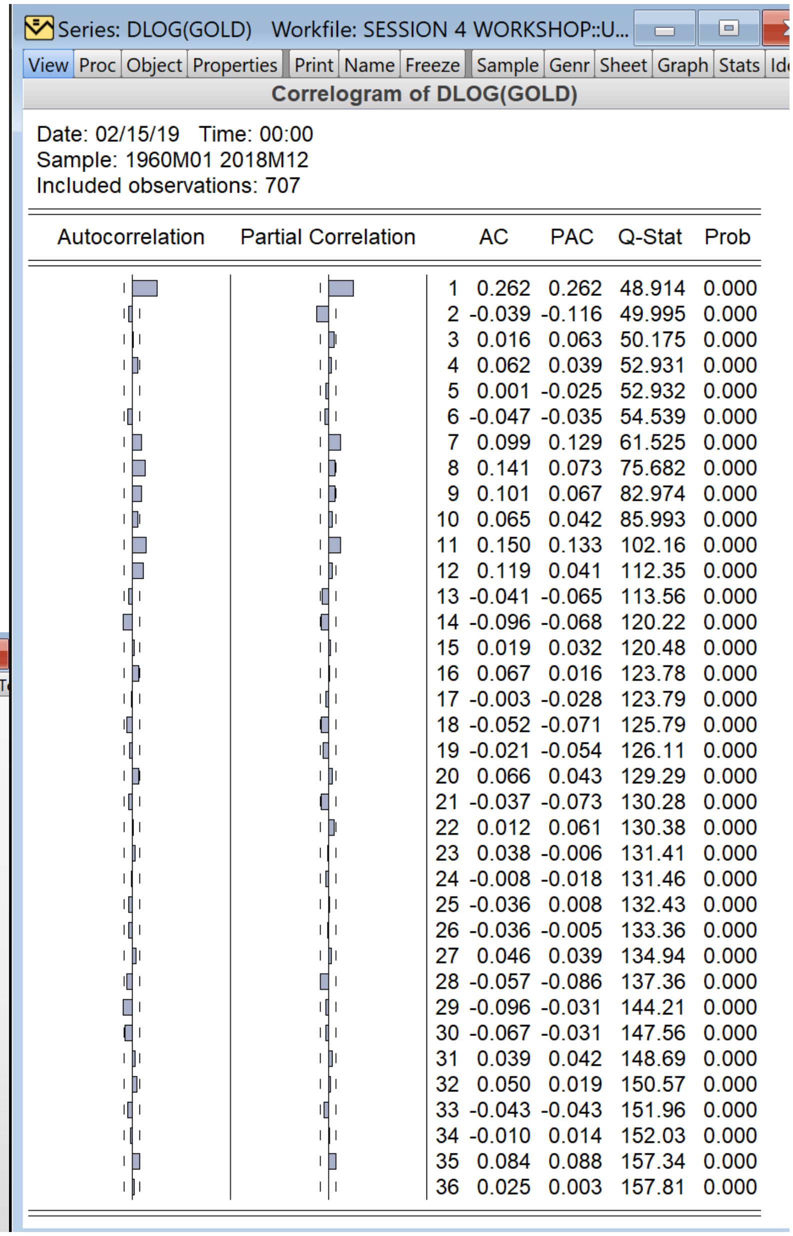
Date: 02/14/19   Time: 22:46
Sample: 1960M01 2018M12
Included observations: 708

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.995	0.995	704.08	0.000
		2	0.990	-0.052	1401.6	0.000
		3	0.985	0.023	2092.8	0.000
		4	0.980	0.008	2778.1	0.000
		5	0.975	-0.010	3457.1	0.000
		6	0.969	-0.071	4129.2	0.000
		7	0.963	-0.042	4793.6	0.000
		8	0.956	-0.028	5450.1	0.000
		9	0.950	-0.012	6098.5	0.000
		10	0.943	0.008	6739.2	0.000
		11	0.937	-0.005	7372.1	0.000
		12	0.930	-0.043	7996.5	0.000
		13	0.923	0.022	8612.9	0.000
		14	0.916	-0.013	9221.0	0.000
		15	0.909	-0.005	9820.9	0.000
		16	0.902	-0.043	10412.	0.000
		17	0.895	-0.009	10995.	0.000
		18	0.888	0.017	11569.	0.000
		19	0.880	-0.023	12134.	0.000
		20	0.873	0.018	12692.	0.000
		21	0.866	-0.028	13240.	0.000
		22	0.859	0.027	13780.	0.000
		23	0.851	-0.010	14312.	0.000
		24	0.844	0.015	14836.	0.000
		25	0.837	0.006	15353.	0.000
		26	0.830	-0.040	15860.	0.000
		27	0.823	-0.003	16360.	0.000
		28	0.815	-0.064	16851.	0.000
		29	0.807	0.005	17333.	0.000
		30	0.800	0.010	17807.	0.000
		31	0.792	0.030	18273.	0.000
		32	0.785	0.006	18732.	0.000
		33	0.778	0.019	19182.	0.000
		34	0.771	0.024	19626.	0.000
		35	0.765	0.046	20062.	0.000
		36	0.759	0.020	20493.	0.000

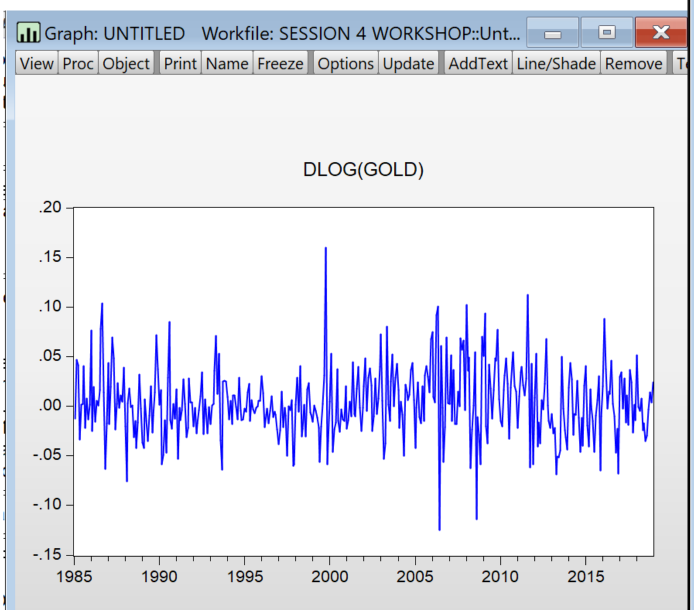
Gold ($/troy oz)



The log returns of the series looks stationary. The autocorrelation function of Dlog(gold) are not persistent which suggests stationary



	AC	PAC	Q-Stat	Prob
1	0.262	0.262	48.914	0.000
2	-0.039	-0.116	49.995	0.000
3	0.016	0.063	50.175	0.000
4	0.062	0.039	52.931	0.000
5	0.001	-0.025	52.932	0.000
6	-0.047	-0.035	54.539	0.000
7	0.099	0.129	61.525	0.000
8	0.141	0.073	75.682	0.000
9	0.101	0.067	82.974	0.000
10	0.065	0.042	85.993	0.000
11	0.150	0.133	102.16	0.000
12	0.119	0.041	112.35	0.000
13	-0.041	-0.065	113.56	0.000
14	-0.096	-0.068	120.22	0.000
15	0.019	0.032	120.48	0.000
16	0.067	0.016	123.78	0.000
17	-0.003	-0.028	123.79	0.000
18	-0.052	-0.071	125.79	0.000
19	-0.021	-0.054	126.11	0.000
20	0.066	0.043	129.29	0.000
21	-0.037	-0.073	130.28	0.000
22	0.012	0.061	130.38	0.000
23	0.038	-0.006	131.41	0.000
24	-0.008	-0.018	131.46	0.000
25	-0.036	0.008	132.43	0.000
26	-0.036	-0.005	133.36	0.000
27	0.046	0.039	134.94	0.000
28	-0.057	-0.086	137.36	0.000
29	-0.096	-0.031	144.21	0.000
30	-0.067	-0.031	147.56	0.000
31	0.039	0.042	148.69	0.000
32	0.050	0.019	150.57	0.000
33	-0.043	-0.043	151.96	0.000
34	-0.010	0.014	152.03	0.000
35	0.084	0.088	157.34	0.000
36	0.025	0.003	157.81	0.000



We carried out the Dickey-Fuller test, it also confirms stationary with zero probability

Series: DLOG(GOLD) Workfile: SESSION 4 WORKSHOP::U...

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Augmented Dickey-Fuller Unit Root Test on DLOG(GOLD)

Null Hypothesis: DLOG(GOLD) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=19)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-18.07234	0.0000
Test critical values:	1% level	-3.971123	
	5% level	-3.416204	
	10% level	-3.130397	

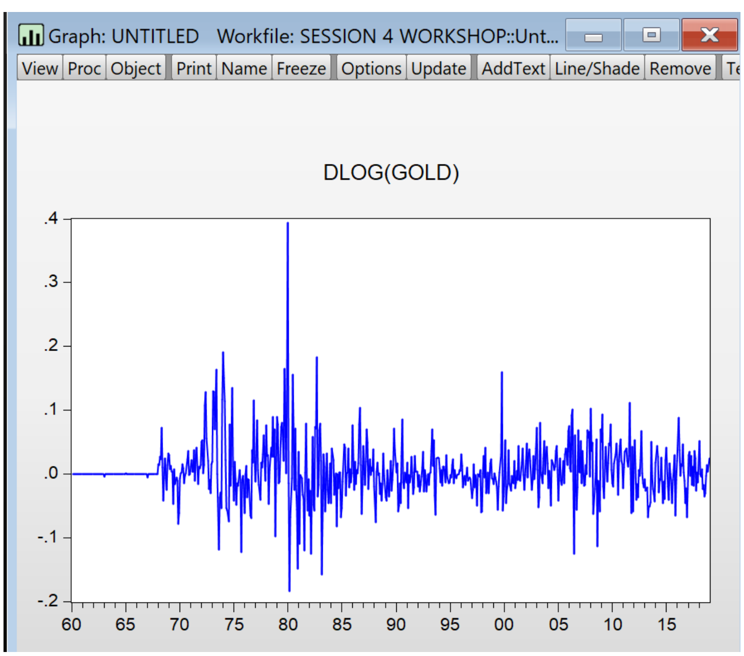
*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLOG(GOLD))
Method: Least Squares
Date: 02/15/19 Time: 00:05
Sample (adjusted): 1960M04 2018M12
Included observations: 705 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(GOLD(-1))	-0.823697	0.045578	-18.07234	0.0000
D(DLOG(GOLD(-1)))	0.116296	0.037518	3.099720	0.0020
C	0.005663	0.003268	1.733164	0.0835
@TREND("1960M01")	-4.19E-06	7.95E-06	-0.527468	0.5980

R-squared	0.377408	Mean dependent var	3.42E-05
Adjusted R-squared	0.374743	S.D. dependent var	0.054317
S.E. of regression	0.042950	Akaike info criterion	-3.451887
Sum squared resid	1.293157	Schwarz criterion	-3.426024
Log likelihood	1220.790	Hannan-Quinn criter.	-3.441893
F-statistic	141.6457	Durbin-Watson stat	1.985118
Prob(F-statistic)	0.000000		

Restructure the graph from Year 1985 and Taking DLOG(GOLD) graph below



(ii) Identification

Plot correlogram of DLOG(gold)

Date: 02/13/19 Time: 20:05
Sample: 1985M01 2018M12
Included observations: 407

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.136	0.136	7.6014	0.006
		2	-0.085	-0.106	10.580	0.005
		3	-0.000	0.028	10.580	0.014
		4	0.047	0.035	11.506	0.021
		5	0.018	0.009	11.647	0.040
		6	0.005	0.009	11.657	0.070
		7	0.072	0.074	13.829	0.054
		8	0.024	0.001	14.060	0.080
		9	-0.013	-0.004	14.130	0.118
		10	0.009	0.013	14.163	0.166
		11	0.154	0.148	24.152	0.012
		12	0.030	-0.017	24.534	0.017
		13	-0.001	0.027	24.534	0.027
		14	0.035	0.027	25.056	0.034
		15	0.045	0.027	25.923	0.039
		16	0.042	0.034	26.664	0.045
		17	0.019	0.015	26.820	0.061
		18	0.057	0.038	28.209	0.059
		19	0.021	0.002	28.390	0.076
		20	0.081	0.089	31.181	0.053
		21	0.027	-0.002	31.496	0.066
		22	0.036	0.020	32.060	0.076
		23	0.037	0.025	32.656	0.087
		24	0.047	0.037	33.608	0.092
		25	0.009	-0.016	33.647	0.116
		26	0.062	0.064	35.321	0.105
		27	-0.010	-0.056	35.367	0.130
		28	0.001	0.013	35.368	0.159
		29	-0.001	-0.030	35.368	0.193
		30	-0.024	-0.031	35.615	0.221
		31	0.052	0.025	36.817	0.218
		32	-0.005	-0.033	36.829	0.255
		33	-0.043	-0.052	37.634	0.265
		34	-0.047	-0.056	38.641	0.268
		35	0.051	0.038	39.790	0.265
		36	-0.032	-0.073	40.258	0.287

Verification of the four proposed models will be carried out in (iv) later.

(iii) Model MA(1)

Equation: UNTITLED Workfile: SESSION 4 WORKSHO...

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: DLOG(GOLD)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 02/15/19 Time: 00:16
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 16 iterations
Coefficient covariance computed using outer product of gradients

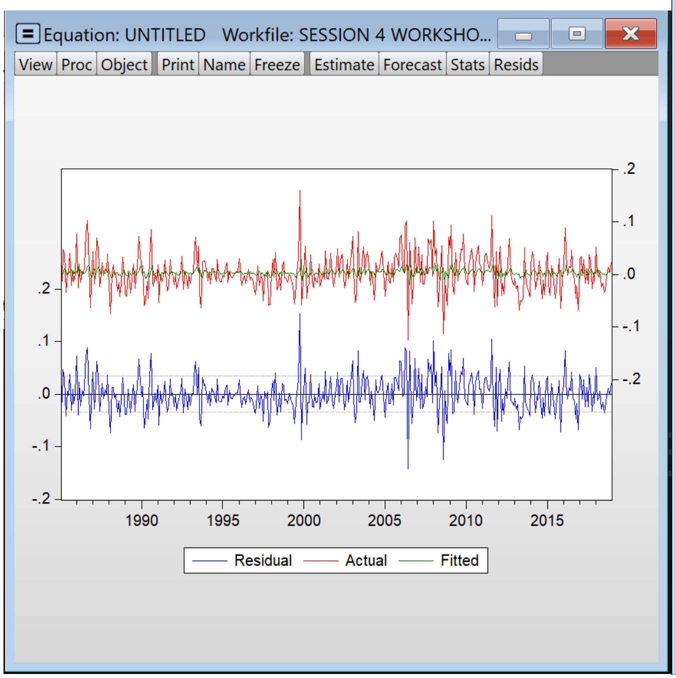
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003484	0.002086	1.670293	0.0956
MA(1)	0.167650	0.040449	4.144712	0.0000
SIGMASQ	0.001196	6.34E-05	18.84932	0.0000

R-squared	0.022957	Mean dependent var	0.003484
Adjusted R-squared	0.018120	S.D. dependent var	0.035029
S.E. of regression	0.034710	Akaike info criterion	-3.876179
Sum squared resid	0.486726	Schwarz criterion	-3.846630
Log likelihood	791.8023	Hannan-Quinn criter.	-3.864485
F-statistic	4.746237	Durbin-Watson stat	2.026107
Prob(F-statistic)	0.009174		

Inverted MA Roots	-.17

(iv) The residual plot looks random.

Furthermore, none of the Q-Statistic is over 5%, therefore none of the lag term is significant.
We have a stationary residual



Equation: UNTITLED Workfile: SESSION 4 WORKSHOP:...

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Correlogram of Residuals

Date: 02/15/19 Time: 00:20
Sample: 1985M01 2018M12
Included observations: 407
Q-statistic probabilities adjusted for 1 ARMA term

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.014	-0.014	0.0774	
		2	-0.083	-0.084	2.9417	0.086
		3	0.006	0.004	2.9572	0.228
		4	0.044	0.037	3.7588	0.289
		5	0.012	0.015	3.8229	0.431
		6	-0.009	-0.002	3.8558	0.570
		7	0.071	0.073	5.9516	0.429
		8	0.014	0.013	6.0305	0.536
		9	-0.013	-0.002	6.0984	0.636
		10	-0.014	-0.013	6.1854	0.721
		11	0.155	0.150	16.262	0.092
		12	0.006	0.005	16.277	0.131
		13	-0.007	0.020	16.296	0.178
		14	0.030	0.028	16.689	0.214
		15	0.034	0.025	17.181	0.247
		16	0.035	0.037	17.715	0.278
		17	0.004	0.014	17.723	0.340
		18	0.056	0.042	19.070	0.325
		19	-0.001	-0.006	19.071	0.387
		20	0.079	0.087	21.741	0.297
		21	0.009	0.011	21.778	0.353
		22	0.030	0.016	22.175	0.389
		23	0.025	0.021	22.446	0.434
		24	0.044	0.045	23.295	0.444
		25	-0.009	-0.021	23.332	0.500
		26	0.067	0.069	25.267	0.447
		27	-0.022	-0.047	25.478	0.492
		28	0.003	0.007	25.483	0.547
		29	0.004	-0.022	25.491	0.601
		30	-0.034	-0.040	25.989	0.626
		31	0.059	0.024	27.526	0.596
		32	-0.009	-0.021	27.565	0.644
		33	-0.032	-0.046	28.030	0.668
		34	-0.052	-0.071	29.253	0.654
		35	0.065	0.038	31.144	0.608
		36	-0.033	-0.054	31.638	0.631

We will now compare the following four models with MA(1), and see which gives the smallest RSS, SBC, AIC, and HQ

1. ARMA(2, 0): DLOG(gold) c AR(1) AR(2)
2. ARMA(0, 2): DLOG(gold) c MA(1) MA(2)
3. ARMA(1, 0): DLOG(gold) c AR(1)
4. ARMA(1, 1): DLOG(gold) c AR(1) MA(1)

From the table comparison below, MA(1) is very good model with smallest SBC, smallest HQ, and due to principal of parsimony, it's a very simple model and is really preferred.

Besides MA(1), ARMA(2,0) is the best out of the four models listed. It gives the smallest AIC, biggest Adjusted R-Square, no Q-Stats significance and have constant coefficient non-significant, and both AR(1), AR(2) coefficient significant.

	RSS	SBC	AIC	HQ	Adjusted R-square	Any Q-Stats significance at 5%?	Coefficient significance at 5%
MA(1)	0.486726	-3.846630	-3.876179	-3.864485	0.018120	None	MA(1) significant C not significant
ARMA(2,0)	0.483406	-3.838679	-3.878078	-3.862486	0.022398	None	AR(1) significant AR(2) significant C not significant
ARMA(0,2)	0.483500	-3.838487	-3.877886	-3.862294	0.022207	None	MA(1) significant MA(2) not significant C not significant
ARMA(1,0)	0.488914	-3.842168	-3.871717	-3.860024	0.013706	Yes, Q-stat significant at lag 2	AR(1) significant C not significant
ARMA(1,1)	0.484304	-3.836833	-3.876232	-3.860640	0.020581	None	AR(1) not significant C not significant MA(1) significant

1. Model ARMA(2,0)

Equation: UNTITLED Workfile: SESSION 4 WORKSHO...

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: DLOG(GOLD)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 02/15/19 Time: 00:23
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 15 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003473	0.001897	1.830899	0.0679
AR(1)	0.150628	0.039910	3.774163	0.0002
AR(2)	-0.105918	0.043571	-2.430929	0.0155
SIGMASQ	0.001188	6.36E-05	18.67461	0.0000

R-squared	0.029621	Mean dependent var	0.003484
Adjusted R-squared	0.022398	S.D. dependent var	0.035029
S.E. of regression	0.034634	Akaike info criterion	-3.878078
Sum squared resid	0.483406	Schwarz criterion	-3.838679
Log likelihood	793.1888	Hannan-Quinn criter.	-3.862486
F-statistic	4.100590	Durbin-Watson stat	1.992539
Prob(F-statistic)	0.006942		

Inverted AR Roots .08+.32i .08-.32i

Equation: UNTITLED Workfile: SESSION 4 WORKSH...

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Correlogram of Residuals

Date: 02/15/19 Time: 00:23
Sample: 1985M01 2018M12
Included observations: 407
Q-statistic probabilities adjusted for 2 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.003	0.003	0.0037	
		2	0.000	0.000	0.0037	
		3	0.023	0.023	0.2219	0.638
		4	0.039	0.038	0.8345	0.659
		5	0.018	0.018	0.9743	0.807
		6	-0.003	-0.003	0.9771	0.913
		7	0.073	0.071	3.1779	0.673
		8	0.016	0.014	3.2892	0.772
		9	0.006	0.004	3.3020	0.856
		10	-0.009	-0.012	3.3363	0.912
		11	0.156	0.151	13.578	0.138
		12	0.011	0.007	13.628	0.191
		13	0.010	0.010	13.667	0.252
		14	0.038	0.028	14.269	0.284
		15	0.037	0.026	14.843	0.317
		16	0.044	0.038	15.654	0.335
		17	0.011	0.012	15.703	0.402
		18	0.067	0.045	17.616	0.347
		19	0.004	-0.005	17.621	0.413
		20	0.088	0.085	20.926	0.283
		21	0.015	0.012	21.028	0.335
		22	0.041	0.013	21.760	0.354
		23	0.029	0.019	22.137	0.392
		24	0.053	0.048	23.343	0.383
		25	-0.006	-0.027	23.360	0.440
		26	0.071	0.065	25.592	0.374
		27	-0.021	-0.049	25.783	0.419
		28	0.007	0.000	25.804	0.474
		29	0.008	-0.018	25.831	0.528
		30	-0.034	-0.041	26.349	0.554
		31	0.056	0.021	27.716	0.533
		32	-0.015	-0.023	27.814	0.580
		33	-0.025	-0.046	28.096	0.616
		34	-0.056	-0.073	29.490	0.594
		35	0.056	0.036	30.918	0.571
		36	-0.038	-0.051	31.566	0.587

2. Model ARMA(0,2)

Equation: UNTITLED Workfile: SESSION 4 WORKSHO...

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: DLOG(GOLD)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 02/15/19 Time: 00:25
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 16 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003479	0.001948	1.786143	0.0748
MA(1)	0.151899	0.040588	3.742491	0.0002
MA(2)	-0.079066	0.043340	-1.824306	0.0688
SIGMASQ	0.001188	6.36E-05	18.67115	0.0000

R-squared	0.029432	Mean dependent var	0.003484
Adjusted R-squared	0.022207	S.D. dependent var	0.035029
S.E. of regression	0.034637	Akaike info criterion	-3.877886
Sum squared resid	0.483500	Schwarz criterion	-3.838487
Log likelihood	793.1497	Hannan-Quinn criter.	-3.862294
F-statistic	4.073607	Durbin-Watson stat	1.996835
Prob(F-statistic)	0.007200		

Inverted MA Roots	.22	-.37

Equation: UNTITLED Workfile: SESSION 4 WORKSHOP...

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Correlogram of Residuals

Date: 02/15/19 Time: 00:25
Sample: 1985M01 2018M12
Included observations: 407
Q-statistic probabilities adjusted for 2 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.001	0.001	0.0003	
		2	-0.004	-0.004	0.0086	
		3	-0.004	-0.004	0.0164	0.898
		4	0.045	0.045	0.8490	0.654
		5	0.018	0.018	0.9810	0.806
		6	-0.003	-0.003	0.9850	0.912
		7	0.073	0.074	3.1919	0.670
		8	0.012	0.010	3.2502	0.777
		9	0.005	0.004	3.2594	0.860
		10	-0.011	-0.011	3.3135	0.913
		11	0.156	0.150	13.484	0.142
		12	0.010	0.006	13.525	0.196
		13	0.008	0.010	13.552	0.259
		14	0.033	0.032	14.023	0.299
		15	0.036	0.024	14.565	0.335
		16	0.044	0.039	15.380	0.353
		17	0.007	0.011	15.402	0.423
		18	0.066	0.045	17.242	0.370
		19	0.001	-0.005	17.243	0.438
		20	0.087	0.085	20.496	0.306
		21	0.012	0.011	20.557	0.362
		22	0.042	0.014	21.311	0.379
		23	0.025	0.019	21.578	0.424
		24	0.053	0.048	22.808	0.413
		25	-0.008	-0.026	22.834	0.471
		26	0.070	0.066	25.001	0.406
		27	-0.021	-0.046	25.193	0.452
		28	0.006	-0.001	25.207	0.507
		29	0.006	-0.016	25.222	0.562
		30	-0.033	-0.042	25.698	0.590
		31	0.057	0.023	27.155	0.563
		32	-0.016	-0.025	27.276	0.609
		33	-0.024	-0.046	27.531	0.645
		34	-0.056	-0.070	28.937	0.622
		35	0.058	0.036	30.460	0.594
		36	-0.038	-0.053	31.108	0.610

3. ARMA(1, 0)

Equation: UNTITLED Workfile: SESSION 4 WORKSHO...

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: DLOG(GOLD)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 02/15/19 Time: 00:27
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 11 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003486	0.002101	1.659647	0.0978
AR(1)	0.136010	0.039860	3.412218	0.0007
SIGMASQ	0.001201	6.43E-05	18.67665	0.0000

R-squared	0.018565	Mean dependent var	0.003484
Adjusted R-squared	0.013706	S.D. dependent var	0.035029
S.E. of regression	0.034788	Akaike info criterion	-3.871717
Sum squared resid	0.488914	Schwarz criterion	-3.842168
Log likelihood	790.8945	Hannan-Quinn criter.	-3.860024
F-statistic	3.820989	Durbin-Watson stat	1.969347
Prob(F-statistic)	0.022702		

Inverted AR Roots .14

Equation: UNTITLED Workfile: SESSION 4 WORKSHOP:...

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Correlogram of Residuals

Date: 02/15/19 Time: 00:27
Sample: 1985M01 2018M12
Included observations: 407
Q-statistic probabilities adjusted for 1 ARMA term

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.015	0.015	0.0880	
		2	-0.107	-0.107	4.8075	0.028
		3	0.005	0.008	4.8175	0.090
		4	0.047	0.035	5.7146	0.126
		5	0.012	0.012	5.7721	0.217
		6	-0.008	0.001	5.7961	0.327
		7	0.071	0.074	7.8884	0.246
		8	0.016	0.011	7.9959	0.333
		9	-0.018	-0.004	8.1296	0.421
		10	-0.010	-0.008	8.1751	0.517
		11	0.155	0.149	18.214	0.051
		12	0.010	0.000	18.258	0.076
		13	-0.010	0.023	18.298	0.107
		14	0.030	0.027	18.686	0.133
		15	0.036	0.026	19.238	0.156
		16	0.034	0.036	19.744	0.182
		17	0.006	0.014	19.761	0.231
		18	0.054	0.040	20.987	0.227
		19	0.002	-0.004	20.989	0.280
		20	0.077	0.088	23.530	0.215
		21	0.012	0.008	23.593	0.261
		22	0.029	0.018	23.945	0.296
		23	0.027	0.023	24.265	0.334
		24	0.042	0.042	25.044	0.348
		25	-0.006	-0.019	25.058	0.403
		26	0.064	0.069	26.862	0.363
		27	-0.020	-0.049	27.030	0.408
		28	0.002	0.010	27.032	0.462
		29	0.002	-0.025	27.035	0.516
		30	-0.031	-0.038	27.472	0.546
		31	0.058	0.025	28.966	0.519
		32	-0.007	-0.022	28.986	0.570
		33	-0.037	-0.048	29.592	0.589
		34	-0.050	-0.067	30.720	0.581
		35	0.064	0.039	32.560	0.538
		36	-0.032	-0.059	33.006	0.565

4. ARMA(1,1)

Equation: UNTITLED Workfile: SESSION 4 WORKSHO...

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: DLOG(GOLD)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 02/15/19 Time: 00:29
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 14 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003484	0.002013	1.731338	0.0842
AR(1)	-0.330921	0.215195	-1.537772	0.1249
MA(1)	0.490279	0.203645	2.407521	0.0165
SIGMASQ	0.001190	6.33E-05	18.80114	0.0000

R-squared	0.027818	Mean dependent var	0.003484
Adjusted R-squared	0.020581	S.D. dependent var	0.035029
S.E. of regression	0.034666	Akaike info criterion	-3.876232
Sum squared resid	0.484304	Schwarz criterion	-3.836833
Log likelihood	792.8132	Hannan-Quinn criter.	-3.860640
F-statistic	3.843834	Durbin-Watson stat	2.011501
Prob(F-statistic)	0.009822		

Inverted AR Roots	-.33
Inverted MA Roots	-.49

Equation: UNTITLED Workfile: SESSION 4 WORKSHO...

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Correlogram of Residuals

Date: 02/15/19 Time: 00:29
Sample: 1985M01 2018M12
Included observations: 407
Q-statistic probabilities adjusted for 2 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.006	-0.006	0.0171	
		2	-0.031	-0.031	0.4172	
		3	-0.018	-0.019	0.5559	0.456
		4	0.051	0.049	1.6155	0.446
		5	0.013	0.012	1.6825	0.641
		6	-0.004	-0.001	1.6898	0.793
		7	0.072	0.075	3.8365	0.573
		8	0.010	0.009	3.8780	0.693
		9	-0.001	0.002	3.8789	0.794
		10	-0.014	-0.010	3.9594	0.861
		11	0.155	0.149	14.056	0.120
		12	0.008	0.006	14.083	0.169
		13	0.002	0.012	14.085	0.228
		14	0.030	0.034	14.464	0.272
		15	0.035	0.022	14.970	0.309
		16	0.041	0.040	15.683	0.333
		17	0.004	0.010	15.691	0.403
		18	0.062	0.044	17.335	0.364
		19	-0.001	-0.005	17.336	0.432
		20	0.084	0.086	20.396	0.311
		21	0.008	0.011	20.425	0.369
		22	0.039	0.015	21.084	0.392
		23	0.022	0.020	21.286	0.442
		24	0.051	0.048	22.416	0.435
		25	-0.009	-0.024	22.453	0.493
		26	0.069	0.067	24.508	0.433
		27	-0.021	-0.045	24.708	0.479
		28	0.004	-0.000	24.716	0.535
		29	0.004	-0.016	24.724	0.590
		30	-0.032	-0.043	25.186	0.618
		31	0.059	0.026	26.720	0.587
		32	-0.015	-0.025	26.822	0.633
		33	-0.026	-0.046	27.117	0.666
		34	-0.055	-0.069	28.481	0.645
		35	0.062	0.037	30.182	0.608
		36	-0.037	-0.054	30.786	0.626

(v) Forecast

The model gives the following result

Equation: UNTITLED Workfile: SESSION 4 WORKSHO...

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

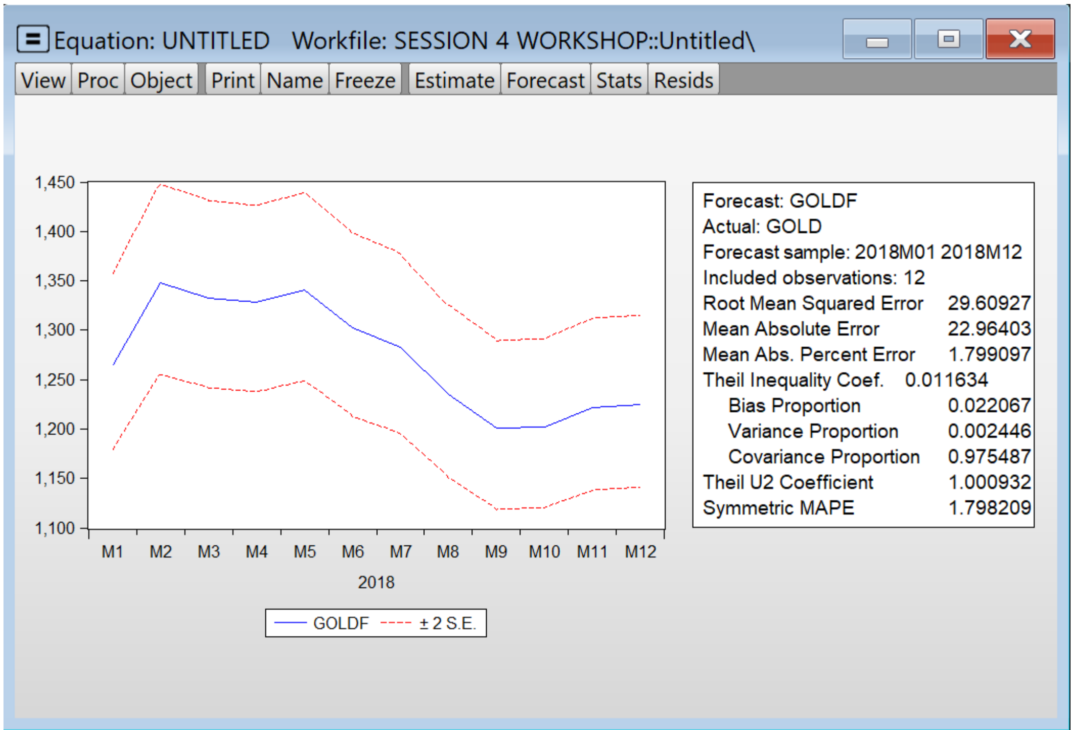
Dependent Variable: DLOG(GOLD)
Method: ARMA Generalized Least Squares (BFGS)
Date: 02/15/19 Time: 01:37
Sample: 1985M02 2017M12
Included observations: 395
Convergence achieved after 3 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003602	0.002054	1.753633	0.0803
MA(1)	0.168036	0.049747	3.377795	0.0008

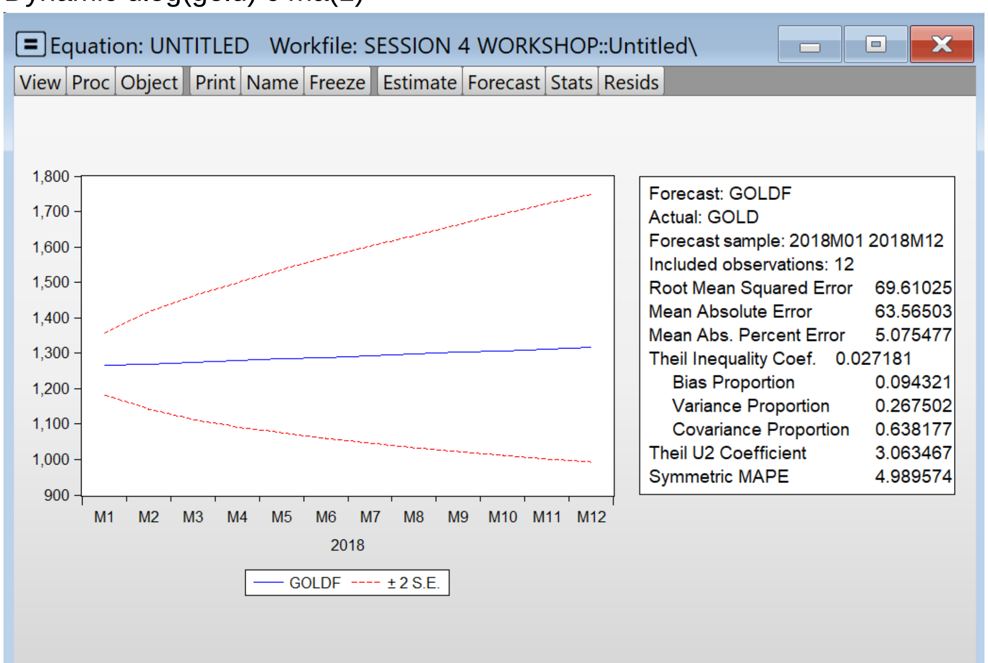
R-squared	0.022688	Mean dependent var	0.003619
Adjusted R-squared	0.020201	S.D. dependent var	0.035318
S.E. of regression	0.034959	Akaike info criterion	-3.864134
Sum squared resid	0.480310	Schwarz criterion	-3.843988
Log likelihood	765.1665	Hannan-Quinn criter.	-3.856152
F-statistic	9.123316	Durbin-Watson stat	2.028732
Prob(F-statistic)	0.002689		

Inverted MA Roots	-.17

Static dlog(gold) c ma(1)

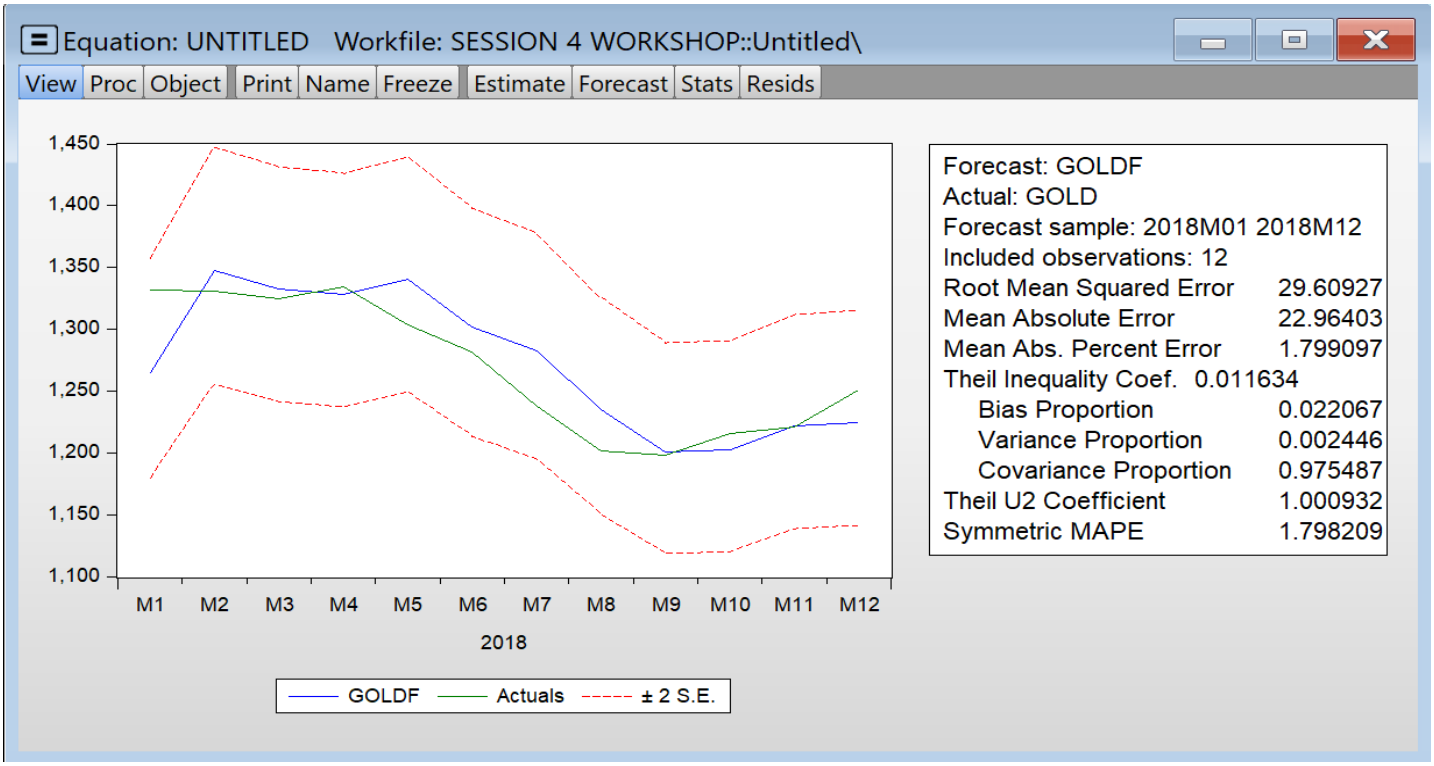


Dynamic dlog(gold) c ma(1)



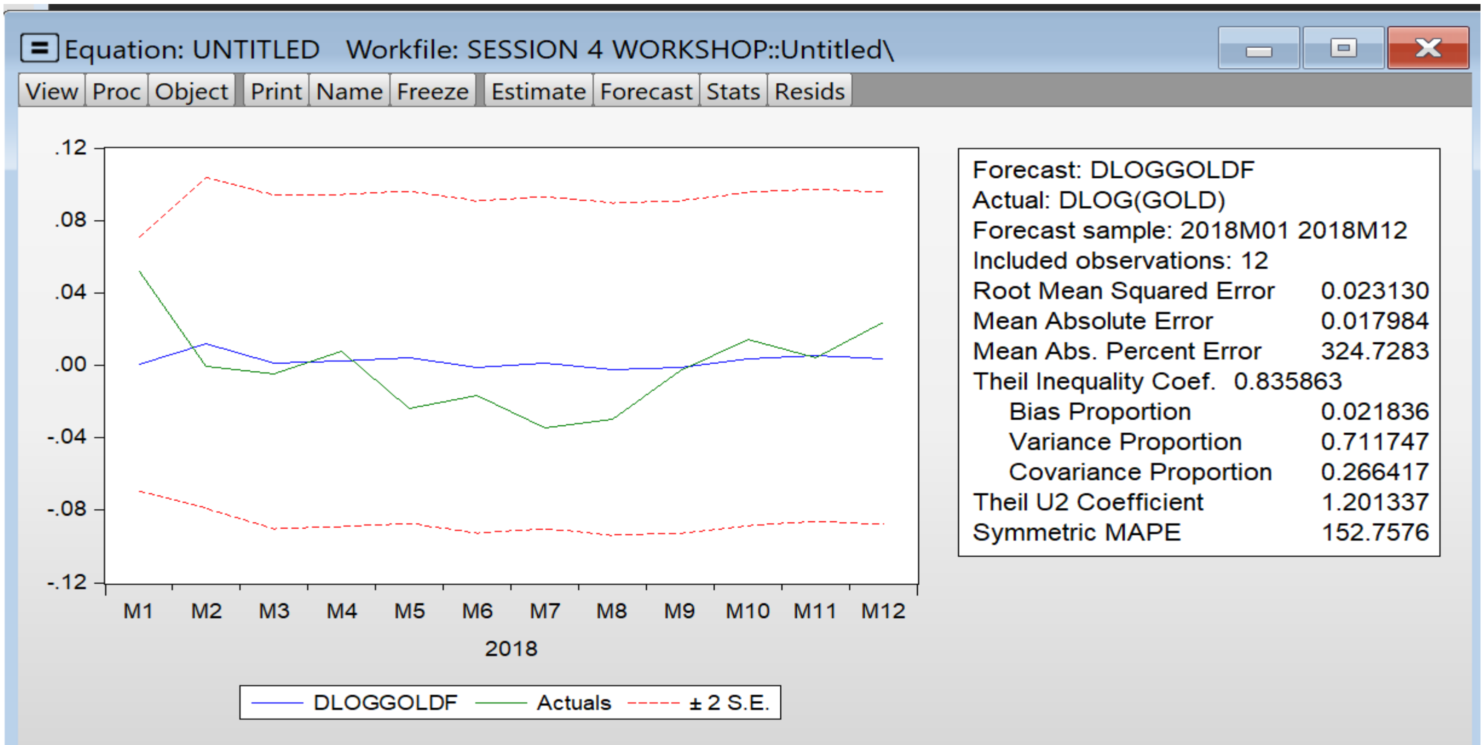
Produce Static forecasts for Gold and then plot these forecasts, goldF, and gold on the same graph by selecting Quick Graph.

Look at the blue and the green line, the forecast is fitting the actual really well and the root mean square error(RMSE) is around 29.6



Produce Static forecasts for DLOG(gold) by specifying this at the top left of the forecast dialog box. Plot the forecasts and DLOG(gold) on the same graph.

For Dlog(gold), the forecast smooths, the actual is more fluctuating.

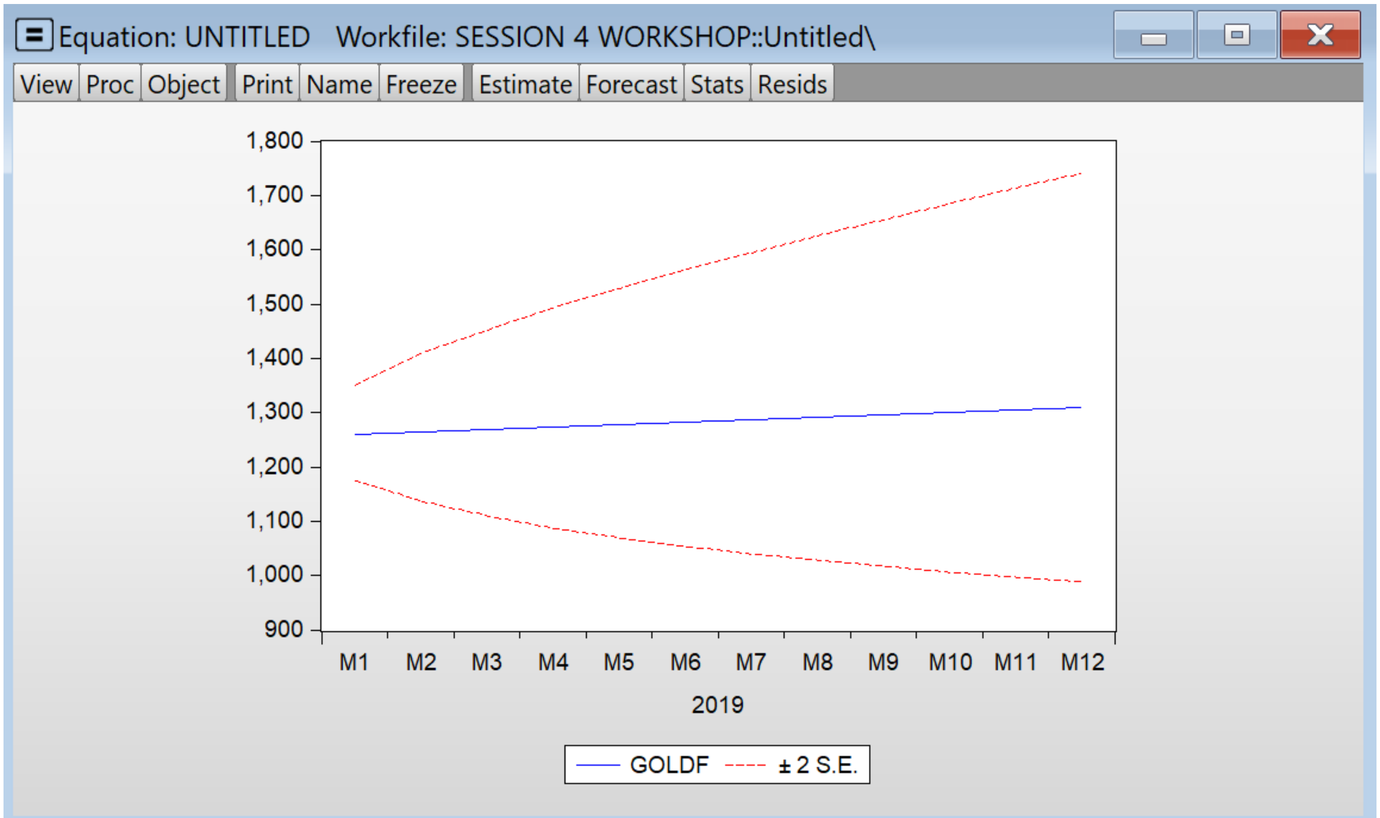


Use 2018M12 forecast as the next 12 months' monthly forecast.
I will expect the price to go up in 12 months, as the dlog(gold) shows rate of change at positive level indicating positive monthly gain of exp(0.003417)-1= 0.3%

2018M01	0.000588
2018M02	0.012160
2018M03	0.001486
2018M04	0.002584
2018M05	0.004444
2018M06	-0.001134
2018M07	0.000948
2018M08	-0.002409
2018M09	-0.000954
2018M10	0.003297
2018M11	0.005415
2018M12	0.003417

The risk of the model 0.02313 indicated by root mean squared error of the forecast.
95% Prediction Interval of DLOG(gold) for next month will be $E(y\_p) \pm t_{0.975} S_{E(y\_p)}$ = [0.003318 – 0.023130 * 2.16, 0.003318 + 0.023130 * 2.16] = [-0.0466428, 0.0532788]

Now forecast for 2019 full year based on all data we have till 2018 December. We have to use Dynamic forecasting here because we don't have 2019 data, dynamic method makes more sense because if produces a 1-step-ahead forecast, a 2-step-ahead forecast, a 3-step-ahead forecast, ……, and a 12-step-ahead forecast.



The dynamic forecast also suggests the gold price will go up. The predicted gold price in next 12 months is 1308. Here the Prediction Interval with 2SE is [978, 1734] from the figure above.