DSC5211C - Workshop 4

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1ai) Results suggest that the series is not stationary

Sample: 1960M01 2018M12
Included observations: 708

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.992	0.992	699.84	0.000
		2	0.980	-0.257	1384.0	0.000
		3	0.968	0.008	2051.6	0.000
		4	0.955	0.030	2703.3	0.000
		5	0.944	0.004	3339.9	0.000
		6	0.931	-0.037	3961.0	0.000
		7	0.919	0.027	4567.3	0.000
		8	0.909	0.068	5160.5	0.000
		9	0.901	0.111	5743.7	0.000
		10	0.893	-0.004	6318.5	0.000
		11	0.886	-0.055	6884.1	0.000
		12	0.876	-0.113	7438.2	0.000
		13	0.866	0.016	7980.0	0.000
		14	0.856	0.069	8510.8	0.000
		15	0.847	-0.008	9031.3	0.000
		16	0.838	0.019	9542.0	0.000
		17	0.830	0.021	10043.	0.000
		18	0.822	0.006	10535.	0.000
		19	0.814	0.010	11018.	0.000
		20	0.807	0.006	11494.	0.000
		21	0.800	-0.029	11963.	0.000
		22	0.792	-0.045	12423.	0.000
		23	0.783	-0.017	12873.	0.000
		24	0.774	0.002	13314.	0.000
		25	0.766	0.034	13745.	0.000
		26	0.758	0.031	14168.	0.000
		27	0.751	0.090	14585.	0.000
		28	0.746	0.012	14997.	0.000
		29	0.741	0.024	15404.	0.000
		30	0.738	0.000	15807.	0.000
		31	0.734	-0.002	16207.	0.000
		32	0.732	0.061	16605.	0.000
		33	0.729	0.008	17001.	0.000
		34	0.727	0.017	17395.	0.000
		35	0.724	0.048	17786.	0.000
		36	0.722	-0.045	18176.	0.000

1aii) Results show that t-stat is -0.733304 which has significance of 0.3988. This more than 0.05 hence there is no evidence to reject the null hypothesis that “COPPER” has unit root (γ=0). Hence it is also non-stationary.

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	

1aiii) Similarly, Results show that t-stat is -3.29265 which has significance of 0.0683. This more than 0.05 hence there is no evidence to reject the null hypothesis that "COPPER" has unit root (γ=0). Hence it is also non-stationary.

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	

1aiv) Only 1 lag term is significant.

Null Hypothesis: COPPER has a unit root
Exogenous: None
Lag Length: 1 (Fixed)

		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: 19:58
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

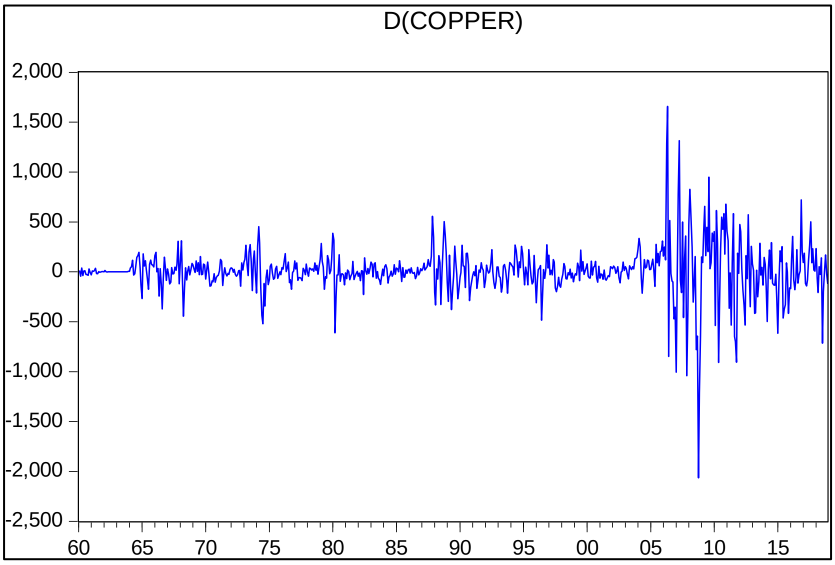
R-squared	0.111507	Mean dependent var	7.573839
Adjusted R-squared	0.110245	S.D. dependent var	243.9988
S.E. of regression	230.1563	Akaike info criterion	13.71822
Sum squared resid	37292239	Schwarz criterion	13.73114
Log likelihood	-4840.533	Hannan-Quinn criter.	13.72321
Durbin-Watson stat	1.964526		

Date: 02/13/19 Time: 20:04
Sample: 1960M01 2018M12
Included observations: 706

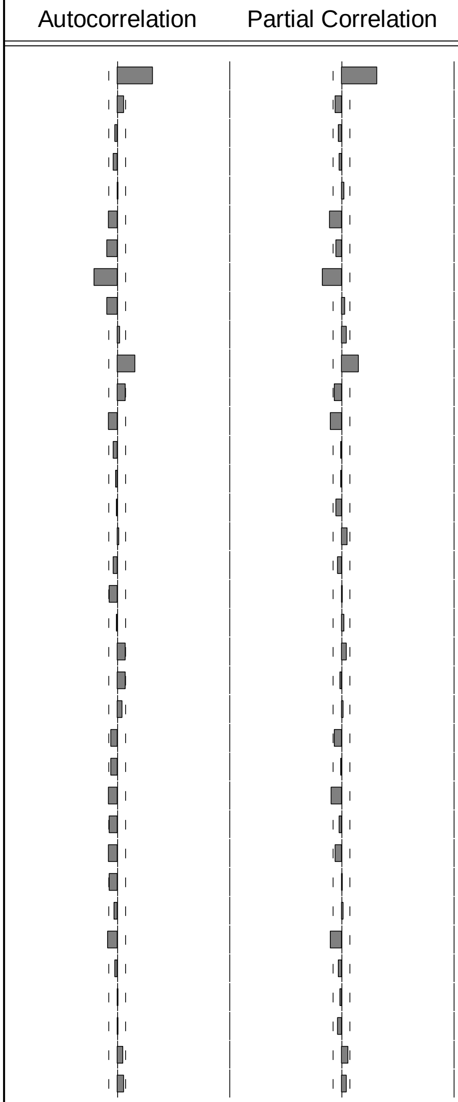
Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.016	0.016	0.1745	0.676
		2	-0.040	-0.040	1.3001	0.522
		3	-0.034	-0.033	2.1310	0.546
		4	-0.042	-0.042	3.3627	0.499
		5	0.056	0.055	5.5948	0.348
		6	-0.066	-0.072	8.6803	0.192
		7	-0.014	-0.010	8.8265	0.265
		8	-0.185	-0.190	33.231	0.000
		9	-0.045	-0.041	34.660	0.000
		10	0.003	-0.025	34.667	0.000
		11	0.171	0.171	55.738	0.000
		12	0.061	0.035	58.440	0.000
		13	-0.115	-0.091	67.902	0.000
		14	-0.015	-0.032	68.058	0.000
		15	0.002	0.001	68.060	0.000
		16	-0.005	-0.063	68.079	0.000
		17	0.042	0.044	69.347	0.000
		18	-0.031	-0.022	70.066	0.000
		19	-0.065	-0.014	73.118	0.000
		20	-0.012	0.008	73.229	0.000
		21	0.070	0.049	76.852	0.000
		22	0.052	-0.004	78.835	0.000
		23	0.046	0.040	80.400	0.000
		24	-0.058	-0.042	82.905	0.000
		25	-0.019	0.013	83.180	0.000
		26	-0.047	-0.080	84.831	0.000
		27	-0.034	-0.031	85.667	0.000
		28	-0.039	-0.069	86.797	0.000
		29	-0.050	-0.022	88.614	0.000
		30	0.026	0.049	89.129	0.000
		31	-0.089	-0.078	95.057	0.000
		32	0.008	-0.047	95.104	0.000
		33	0.013	-0.015	95.225	0.000
		34	-0.021	-0.066	95.551	0.000
		35	0.039	0.026	96.706	0.000
		36	0.056	0.065	99.007	0.000

Test shows that the residuals in the above model are not correlated (see above). Hence the model with one lag satisfies the residual assumptions. The augmented dickey fuller test indicates that this series is not stationary.

1av)



Date: 02/13/19 Time: 20:17
Sample: 1960M01 2018M12
Included observations: 707



	AC	PAC	Q-Stat	Prob
1	0.333	0.333	78.954	0.000
2	0.063	-0.055	81.743	0.000
3	-0.020	-0.027	82.020	0.000
4	-0.037	-0.021	82.987	0.000
5	0.009	0.033	83.043	0.000
6	-0.081	-0.107	87.696	0.000
7	-0.098	-0.045	94.588	0.000
8	-0.205	-0.176	124.70	0.000
9	-0.090	0.037	130.57	0.000
10	0.025	0.041	131.02	0.000
11	0.166	0.160	150.89	0.000
12	0.074	-0.058	154.87	0.000
13	-0.082	-0.104	159.68	0.000
14	-0.040	-0.004	160.86	0.000
15	-0.012	-0.004	160.96	0.000
16	-0.002	-0.046	160.96	0.000
17	0.021	0.053	161.29	0.000
18	-0.039	-0.037	162.37	0.000
19	-0.066	0.001	165.51	0.000
20	-0.007	0.026	165.54	0.000
21	0.078	0.041	169.93	0.000
22	0.078	-0.015	174.42	0.000
23	0.045	0.022	175.94	0.000
24	-0.049	-0.058	177.73	0.000
25	-0.054	-0.004	179.85	0.000
26	-0.076	-0.092	184.05	0.000
27	-0.073	-0.024	187.94	0.000
28	-0.075	-0.057	192.07	0.000
29	-0.071	0.007	195.75	0.000
30	-0.026	0.021	196.25	0.000
31	-0.085	-0.104	201.62	0.000
32	-0.018	-0.027	201.87	0.000
33	0.004	-0.014	201.88	0.000
34	0.000	-0.040	201.88	0.000
35	0.051	0.061	203.82	0.000
36	0.064	0.042	206.93	0.000

Null Hypothesis: D(COPPER) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=19)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-18.75198	0.0000
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,2)
Method: Least Squares
Date: 02/13/19 Time: 20:17
Sample (adjusted): 1960M03 2018M12
Included observations: 706 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(COPPER(-1))	-0.665749	0.035503	-18.75198	0.0000

R-squared	0.332788	Mean dependent var	-0.188938
Adjusted R-squared	0.332788	S.D. dependent var	281.6753
S.E. of regression	230.0808	Akaike info criterion	13.71615
Sum squared resid	37320724	Schwarz criterion	13.72261
Log likelihood	-4840.802	Hannan-Quinn criter.	13.71865
Durbin-Watson stat	1.963378		

Results suggest that the D(copper) series is stationary.

- The graph of D(copper) shows no patterns.
- The correlogram shows that auto correlation of residuals tend to 0
- The augmented dickey-fuller test shows that the T-Stat is significant and that the null hypothesis can be rejected which suggest that the series is stationary.

1b)

MA(1) – based on result below, model seems reasonable

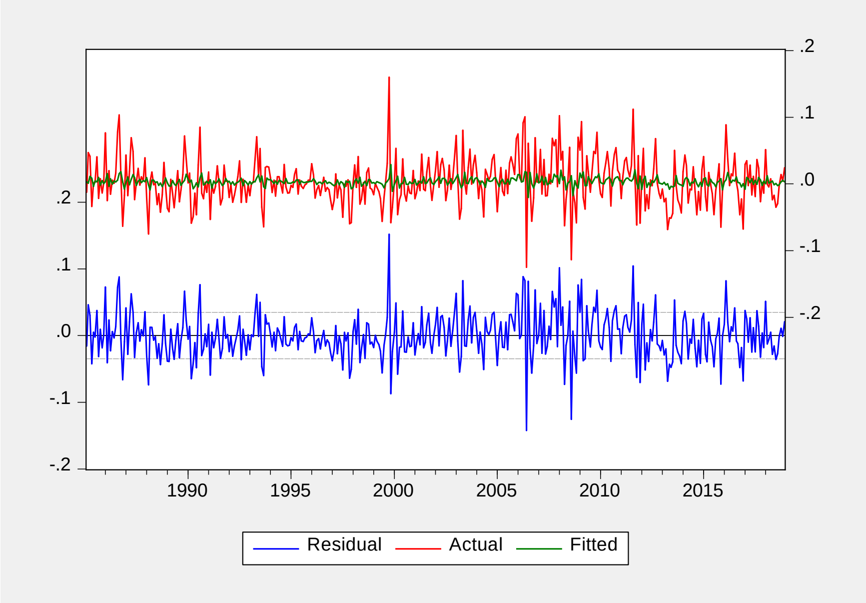
Dependent Variable: DLOG(GOLD)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 02/13/19 Time: 19:56
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 16 iterations
Coefficient covariance computed using outer product of gradients

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

Both the coefficient is significant



Residuals don’t seem to have any pattern

Date: 02/13/19 Time: 19:58
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

Correlogram also suggest random residuals

None of the Q stat is significant (>0.05)

ARMA(2, 0): based on result below, model seems reasonable

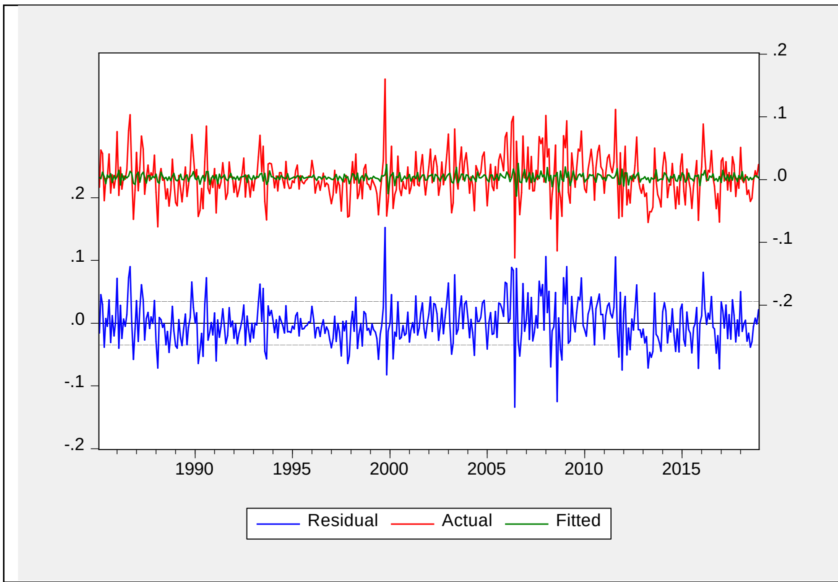
Dependent Variable: DLOG(GOLD)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 02/13/19 Time: 20:05
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 15 iterations
Coefficient covariance computed using outer product of gradients

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

All coefficients are significant



Residuals don't seem to have any pattern

Date: 02/13/19 Time: 20:09
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

Correlogram also suggest random residuals

None of the Q stat is significant (>0.05)

ARMA(0, 2): based on result below, model MA(2) is not significant which suggest that it can be dropped from the model, and hence this model should not be used

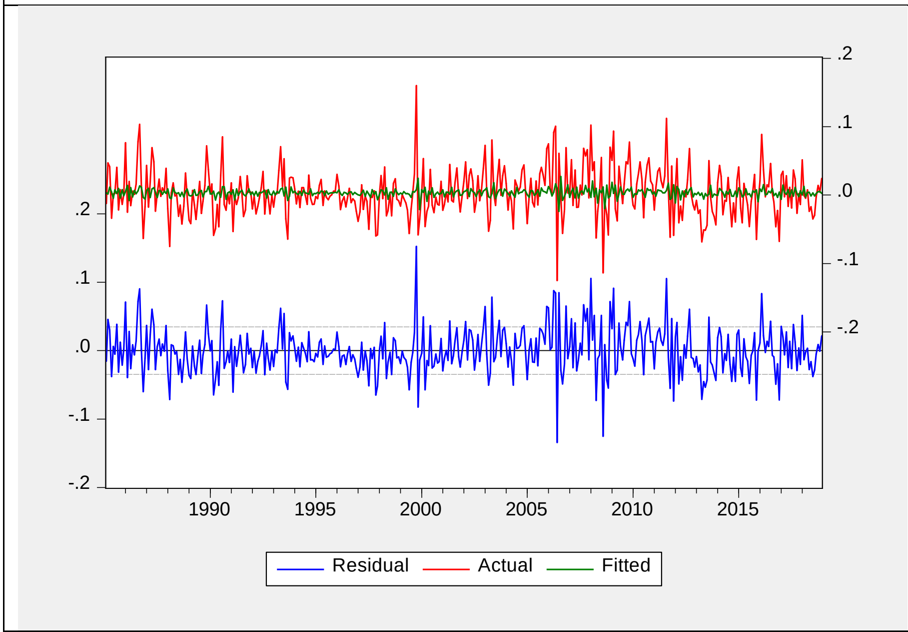
Dependent Variable: DLOG(GOLD)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 02/13/19 Time: 20:10
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 16 iterations
Coefficient covariance computed using outer product of gradients

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

All coefficients are significant except MA(2) which has p-value more than 0.05



Residuals don't seem to have any pattern

Date: 02/13/19 Time: 20:12
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

Correlogram also suggest random residuals

None of the Q stat is significant (>0.05)

ARMA(1, 0): based on result below, residuals may not be stationary, hence not a good model

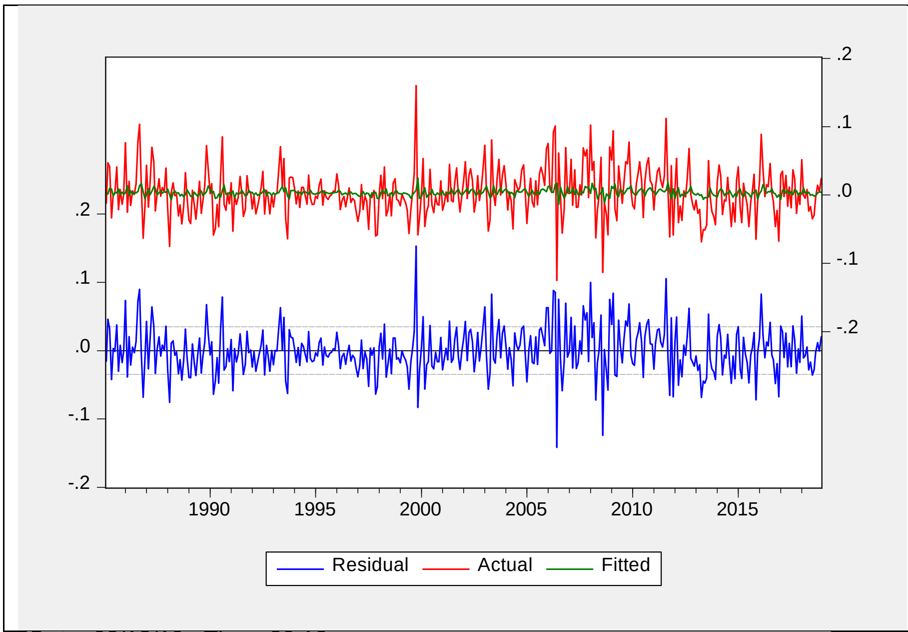
Dependent Variable: DLOG(GOLD)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 02/13/19 Time: 20:12
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 11 iterations
Coefficient covariance computed using outer product of gradients

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

All coefficients are significant



Residuals don't seem to have any pattern

Date: 02/13/19 Time: 20:13
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

Correlogram also suggest random residuals

One of the Q stat is significant

ARMA(1, 1): based on result below, AR(1) is not significant, which suggest that it can be dropped from the model, and hence this model should not be used

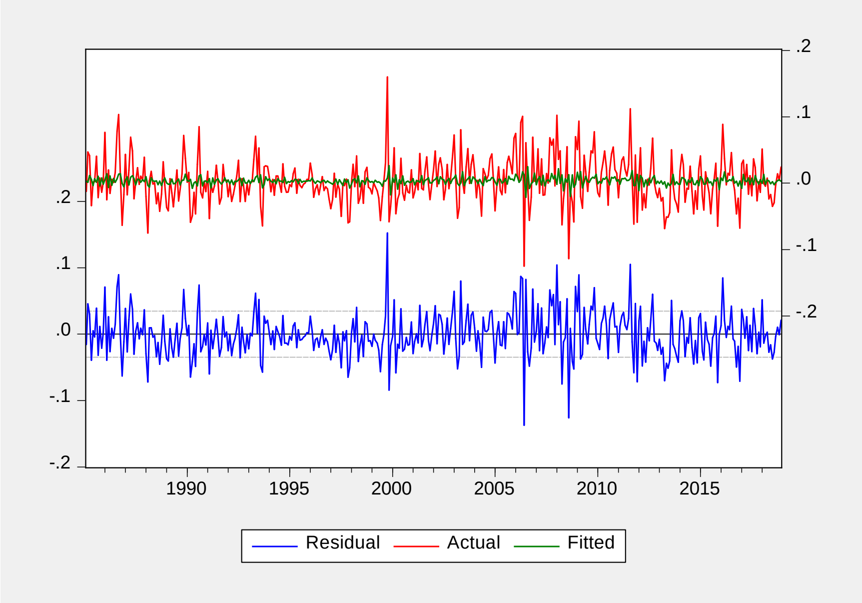
Dependent Variable: DLOG(GOLD)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 02/13/19 Time: 20:13
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 14 iterations
Coefficient covariance computed using outer product of gradients

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

Not all coefficients are significant,
AR(1) is not significant



Residuals don't seem to have any pattern

te: 02/13/19   Time: 20:14
mple: 1985M01 2018M12
luded observations: 407
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

Correlogram also suggest random residuals

None of the Q stat is significant

Based on above, only the first 2 out of these 5 models are compared

- ARMA(0,1)
- ARMA(2,0)

The RSS, SBC, AIC and HQ of this 2 models are very close. Hence propse to use the model with less parameters, i.e. ARMA(0,1) because it is more parsimonous.

1bv) Forecasting

Dependent Variable: DLOG(GOLD)
Method: ARMA Generalized Least Squares (Gauss-Newton)
Date: 02/13/19 Time: 20:29
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 7 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & covariance

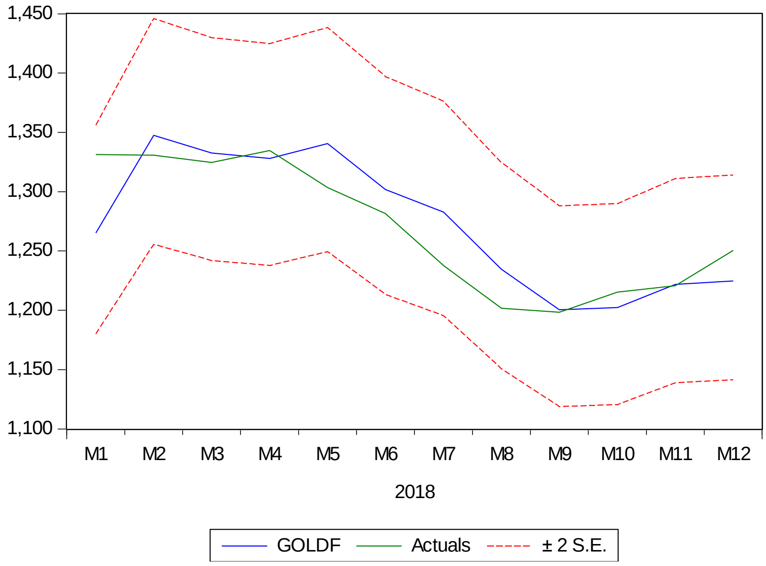
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003484	0.002007	1.736294	0.0833
MA(1)	0.168141	0.049007	3.430960	0.0007

R-squared	0.022957	Mean dependent var	0.003484
Adjusted R-squared	0.020545	S.D. dependent var	0.035029
S.E. of regression	0.034667	Akaike info criterion	-3.881092
Sum squared resid	0.486726	Schwarz criterion	-3.861393
Log likelihood	791.8023	Hannan-Quinn criter.	-3.873297
F-statistic	9.516057	Durbin-Watson stat	2.027007
Prob(F-statistic)	0.002176		

Inverted MA Roots	-.17

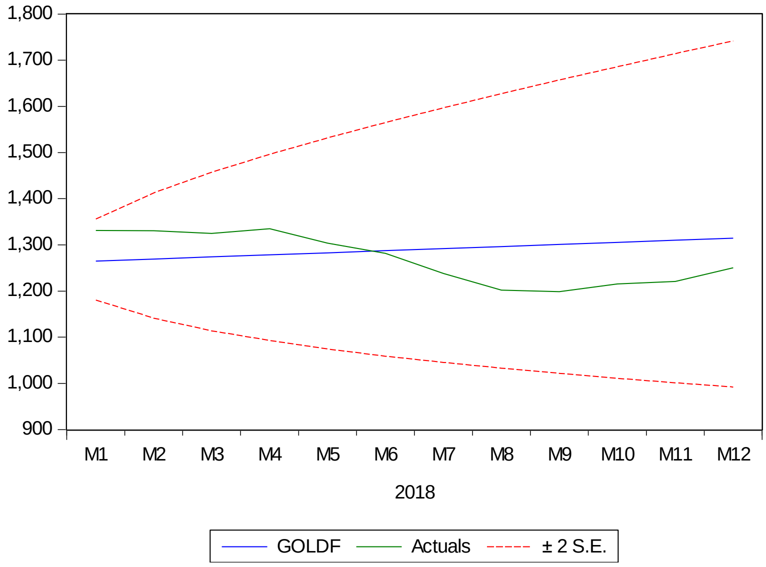
Diagnostic looks reasonable

Static forecast:



Forecast: GOLDF	
Actual: GOLD	
Forecast sample: 2018M01 2018M12	
Included observations: 12	
Root Mean Squared Error	29.58882
Mean Absolute Error	22.91981
Mean Abs. Percent Error	1.795537
Theil Inequality Coef.	0.011627
Bias Proportion	0.020820
Variance Proportion	0.002435
Covariance Proportion	0.976745
Theil U2 Coefficient	0.998494
Symmetric MAPE	1.794831

Dynamic Forecast:

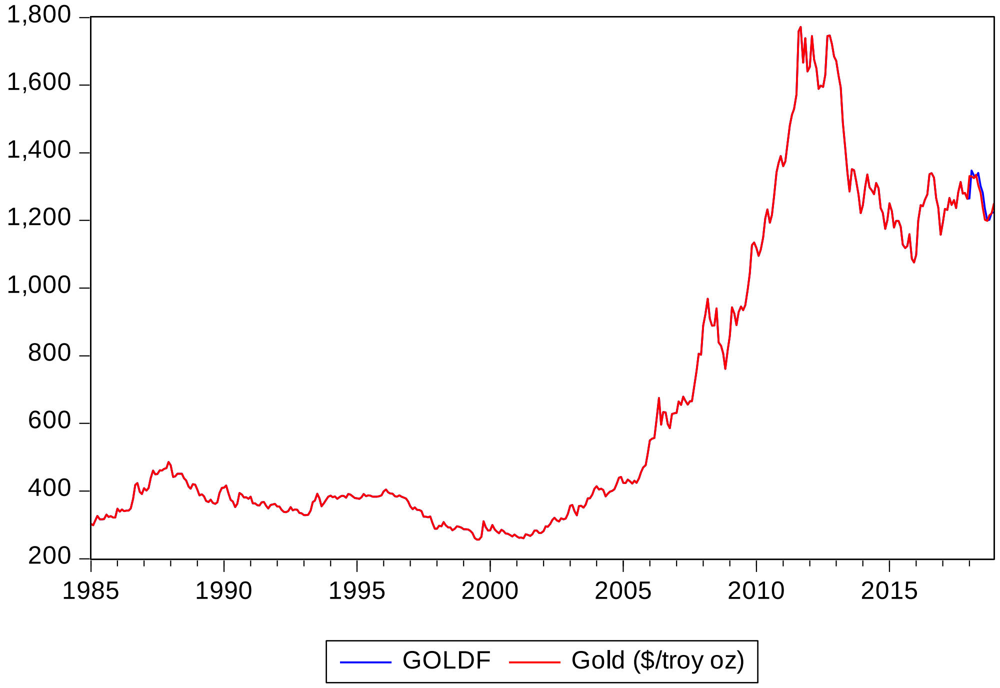


Forecast: GOLDF
Actual: GOLD
Forecast sample: 2018M01 2018M12
Included observations: 12

Root Mean Squared Error	68.85195
Mean Absolute Error	62.95120
Mean Abs. Percent Error	5.024407
Theil Inequality Coef.	0.026895
Bias Proportion	0.087829
Variance Proportion	0.281625
Covariance Proportion	0.630546
Theil U2 Coefficient	3.025021
Symmetric MAPE	4.942829

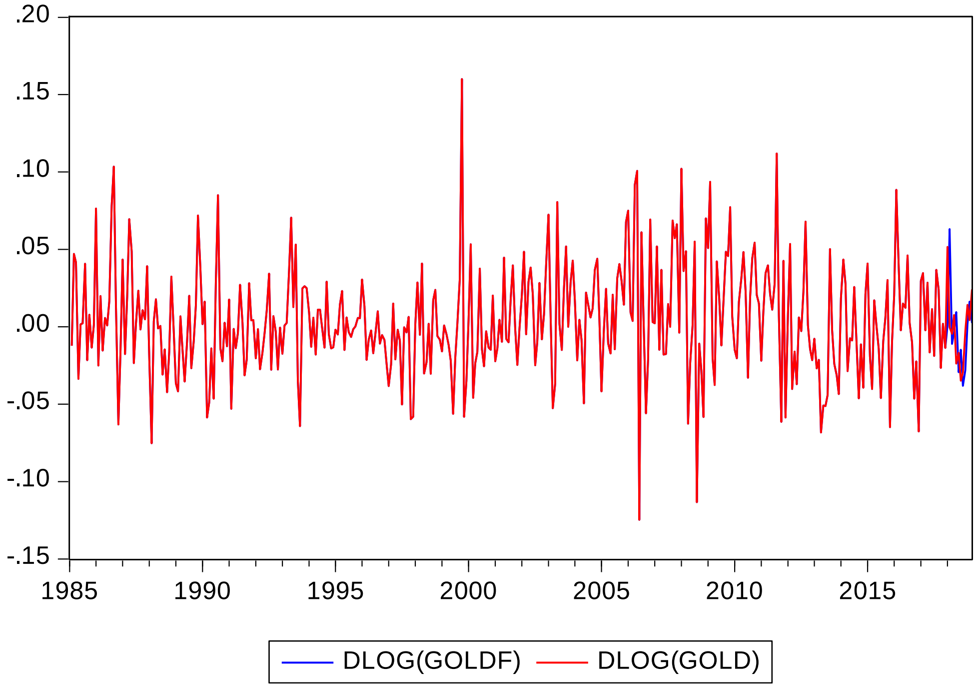
Static forecasts are better.

Plot of goldf and gold



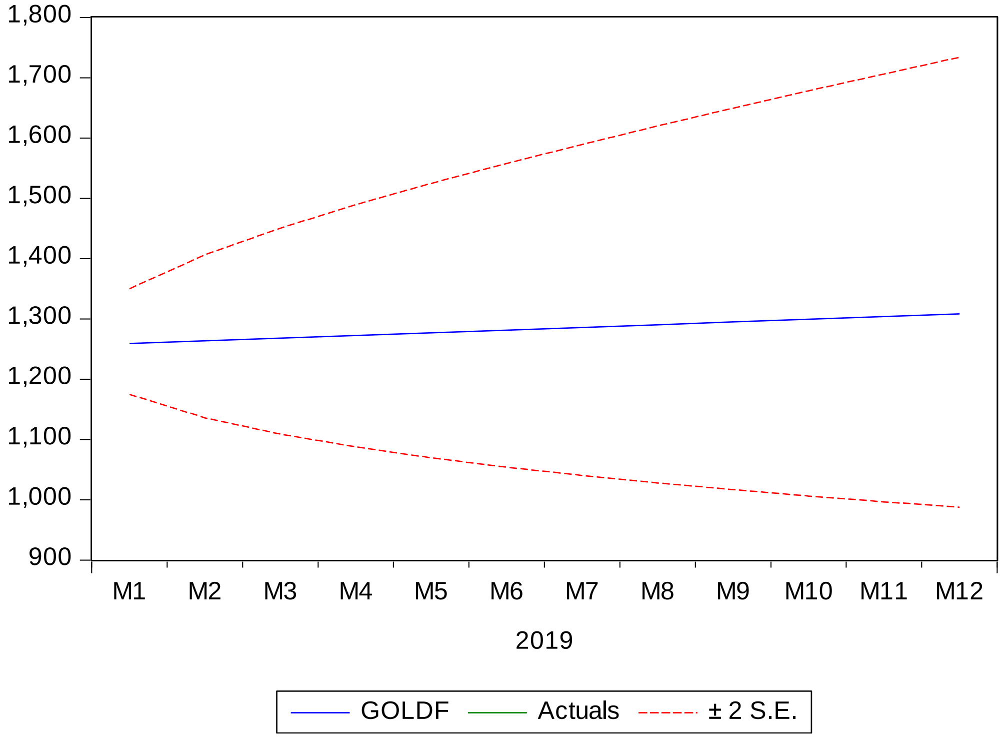
The fit of the forecast is good.

Plot of dlog(goldf) and dlog(gold)



The fit of the forecast is good also.

The gold price is expected to go up as the e(t-1) is positive and the coefficient is positive, the price is expected to be positive.



We cannot use static as there is no actual data. Dynamic forecast will take previously forecasted values while static forecast will take actual values to make next step forecast.