Workshop 4

Student: James Laybourn A0176654U

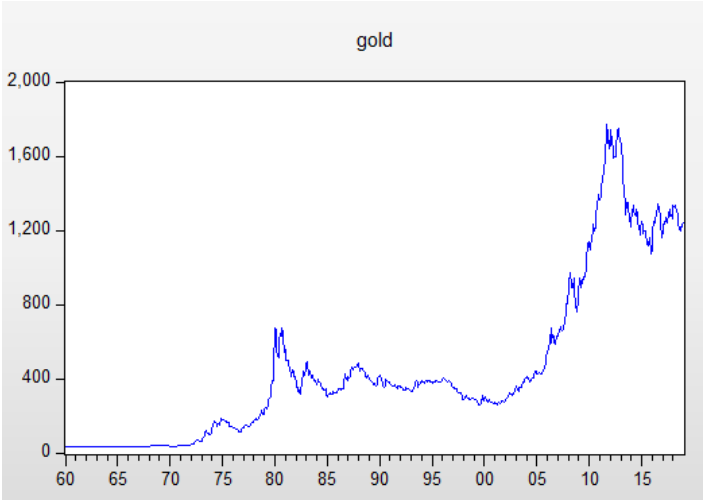
Yeo Wei Ling A0186070H

Pham Huong Giang A0032685A

b. Arima modelling

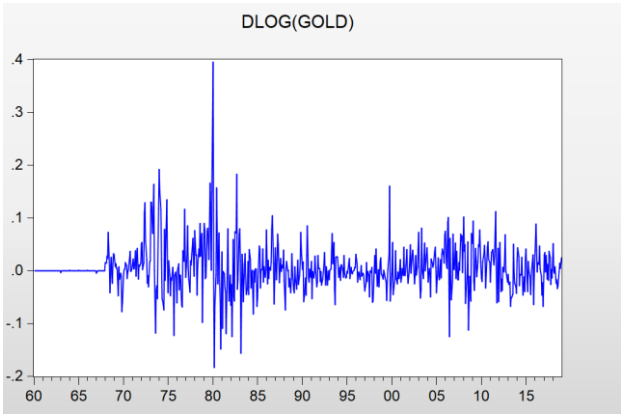
I. Establishing stationarity

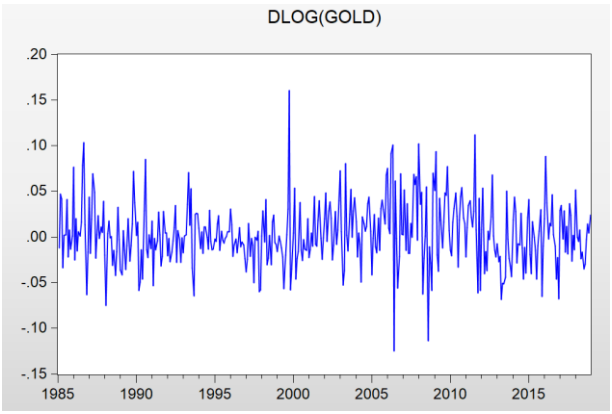
Gold price from 1960 to 2018



Date: 02/13/19 Time: 19:42
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





II. Identification

Date: 02/13/19 Time: 19:48
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

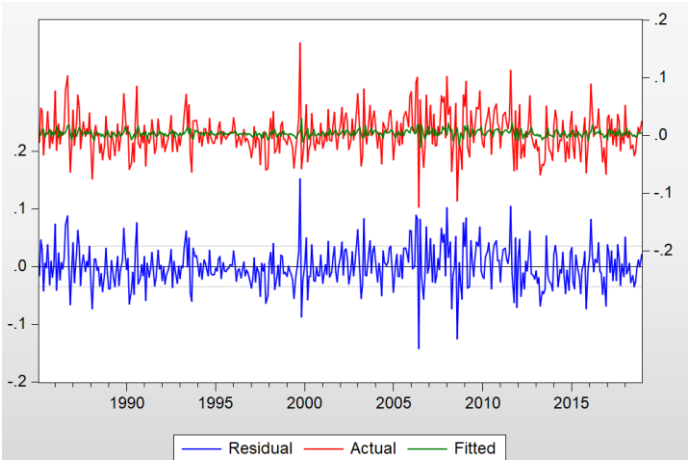
III. Estimation

Dependent Variable: DLOG(GOLD)
Method: ARMA Generalized Least Squares (Gauss-Newton)
Date: 02/13/19 Time: 21:15
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



Date: 02/13/19 Time: 21:15
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	0.0826	
		2	-0.083	-0.084	2.9407	0.086
		3	0.006	0.004	2.9562	0.228
		4	0.044	0.037	3.7572	0.289
		5	0.012	0.015	3.8212	0.431
		6	-0.009	-0.002	3.8545	0.571
		7	0.071	0.073	5.9501	0.429
		8	0.014	0.013	6.0286	0.536
		9	-0.013	-0.002	6.0963	0.636
		10	-0.014	-0.013	6.1841	0.721
		11	0.155	0.150	16.261	0.092
		12	0.006	0.005	16.276	0.131
		13	-0.007	0.020	16.295	0.178
		14	0.030	0.028	16.687	0.214
		15	0.034	0.025	17.179	0.247
		16	0.035	0.037	17.712	0.278
		17	0.004	0.014	17.720	0.341
		18	0.056	0.042	19.067	0.325
		19	-0.002	-0.006	19.068	0.388
		20	0.079	0.087	21.738	0.297
		21	0.009	0.011	21.775	0.353
		22	0.030	0.016	22.172	0.390
		23	0.025	0.021	22.442	0.434
		24	0.044	0.045	23.291	0.444
		25	-0.009	-0.021	23.329	0.500
		26	0.067	0.069	25.265	0.448
		27	-0.022	-0.047	25.476	0.492
		28	0.003	0.007	25.481	0.548
		29	0.004	-0.022	25.489	0.601
		30	-0.034	-0.040	25.988	0.626
		31	0.059	0.024	27.526	0.596
		32	-0.009	-0.021	27.565	0.643
		33	-0.032	-0.046	28.029	0.668
		34	-0.052	-0.071	29.253	0.654
		35	0.065	0.038	31.146	0.608
		36	-0.033	-0.054	31.641	0.631

IV. TESTING

Model ARMA(2,0) is the best since the AIC, RSS, SBC and HQ are smallest and all the coefficients are significant.

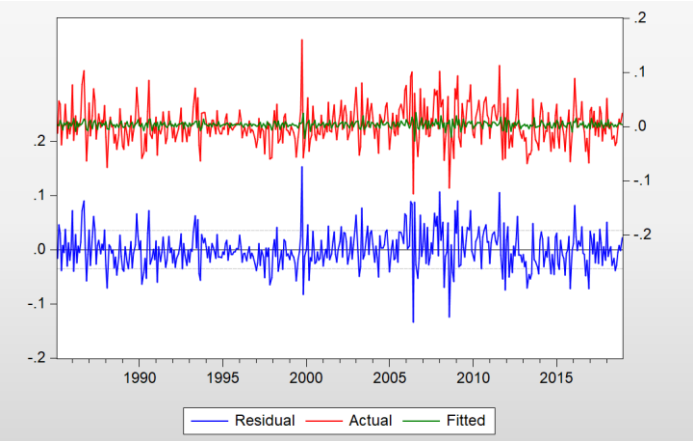
ARMA(2,0)

Dependent Variable: DLOG(GOLD)
Method: ARMA Generalized Least Squares (Gauss-Newton)
Date: 02/13/19 Time: 20:05
Sample: 1985M02 2018M12
Included observations: 407
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	0.003473	0.001795	1.934889	0.0537
AR(1)	0.151000	0.049495	3.050839	0.0024
AR(2)	-0.106442	0.049492	-2.150690	0.0321

R-squared	0.029622	Mean dependent var	0.003484
Adjusted R-squared	0.024818	S.D. dependent var	0.035029
S.E. of regression	0.034591	Akaike info criterion	-3.882991
Sum squared resid	0.483406	Schwarz criterion	-3.853442
Log likelihood	793.1887	Hannan-Quinn criter.	-3.871297
F-statistic	6.166225	Durbin-Watson stat	1.993252
Prob(F-statistic)	0.002302		

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



Date: 02/13/19 Time: 20:06
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	0.0029	
		2	0.001	0.001	0.0031	
		3	0.023	0.023	0.2232	0.637
		4	0.038	0.038	0.8345	0.659
		5	0.018	0.018	0.9745	0.807
		6	-0.003	-0.003	0.9773	0.913
		7	0.073	0.071	3.1785	0.672
		8	0.016	0.014	3.2896	0.772
		9	0.006	0.004	3.3028	0.856
		10	-0.009	-0.012	3.3375	0.911
		11	0.156	0.151	13.581	0.138
		12	0.011	0.007	13.629	0.191
		13	0.010	0.010	13.669	0.252
		14	0.038	0.028	14.272	0.284
		15	0.037	0.026	14.846	0.317
		16	0.044	0.038	15.658	0.335
		17	0.011	0.012	15.707	0.402
		18	0.067	0.045	17.622	0.346
		19	0.004	-0.005	17.628	0.413
		20	0.088	0.085	20.937	0.283
		21	0.015	0.012	21.038	0.335
		22	0.041	0.013	21.772	0.353
		23	0.029	0.019	22.148	0.391
		24	0.053	0.048	23.356	0.382
		25	-0.006	-0.027	23.373	0.439
		26	0.072	0.065	25.608	0.373
		27	-0.021	-0.049	25.800	0.418
		28	0.007	0.000	25.820	0.473
		29	0.008	-0.018	25.847	0.527
		30	-0.034	-0.041	26.366	0.553
		31	0.056	0.020	27.734	0.532
		32	-0.015	-0.023	27.832	0.579
		33	-0.025	-0.046	28.113	0.615
		34	-0.056	-0.073	29.509	0.593
		35	0.056	0.036	30.937	0.570
		36	-0.038	-0.051	31.586	0.587

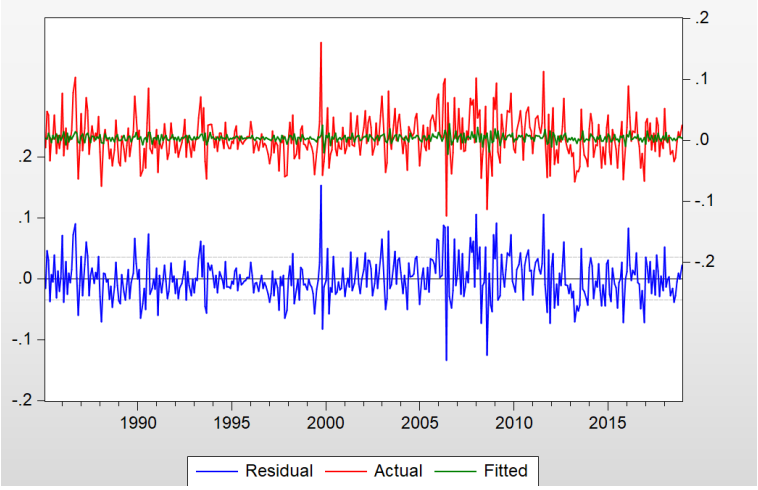
ARMA(0,2)

Dependent Variable: DLOG(GOLD)
Method: ARMA Generalized Least Squares (Gauss-Newton)
Date: 02/13/19 Time: 20:06
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 6 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003479	0.001840	1.890931	0.0593
MA(1)	0.152267	0.049625	3.068330	0.0023
MA(2)	-0.079426	0.049625	-1.600517	0.1103

R-squared	0.029432	Mean dependent var	0.003484
Adjusted R-squared	0.024628	S.D. dependent var	0.035029
S.E. of regression	0.034595	Akaike info criterion	-3.882799
Sum squared resid	0.483500	Schwarz criterion	-3.853250
Log likelihood	793.1496	Hannan-Quinn criter.	-3.871105
F-statistic	6.125643	Durbin-Watson stat	1.997577
Prob(F-statistic)	0.002394		

Inverted MA Roots	.22	-.37



Date: 02/13/19 Time: 20:07
Sample: 1985M01 2018M12
Included observations: 407
Q-statistic probabilities adjusted for 2 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.000	0.000	0.0001	
		2	-0.004	-0.004	0.0069	
		3	-0.004	-0.004	0.0151	0.902
		4	0.045	0.045	0.8489	0.654
		5	0.018	0.018	0.9808	0.806
		6	-0.003	-0.003	0.9848	0.912
		7	0.073	0.074	3.1922	0.670
		8	0.012	0.010	3.2501	0.777
		9	0.005	0.004	3.2596	0.860
		10	-0.011	-0.011	3.3143	0.913
		11	0.156	0.150	13.485	0.142
		12	0.010	0.006	13.526	0.196
		13	0.008	0.009	13.553	0.259
		14	0.033	0.032	14.025	0.299
		15	0.036	0.024	14.566	0.335
		16	0.044	0.039	15.382	0.353
		17	0.007	0.011	15.404	0.423
		18	0.066	0.045	17.246	0.370
		19	0.001	-0.005	17.247	0.438
		20	0.087	0.085	20.504	0.305
		21	0.012	0.012	20.563	0.361
		22	0.042	0.014	21.320	0.379
		23	0.025	0.019	21.585	0.424
		24	0.053	0.049	22.818	0.412
		25	-0.008	-0.026	22.844	0.470
		26	0.070	0.066	25.013	0.405
		27	-0.021	-0.046	25.206	0.451
		28	0.006	-0.002	25.220	0.507
		29	0.006	-0.016	25.235	0.561
		30	-0.033	-0.042	25.712	0.589
		31	0.057	0.023	27.169	0.563
		32	-0.017	-0.025	27.291	0.608
		33	-0.024	-0.046	27.544	0.645
		34	-0.056	-0.070	28.952	0.622
		35	0.058	0.036	30.476	0.593
		36	-0.038	-0.052	31.125	0.609

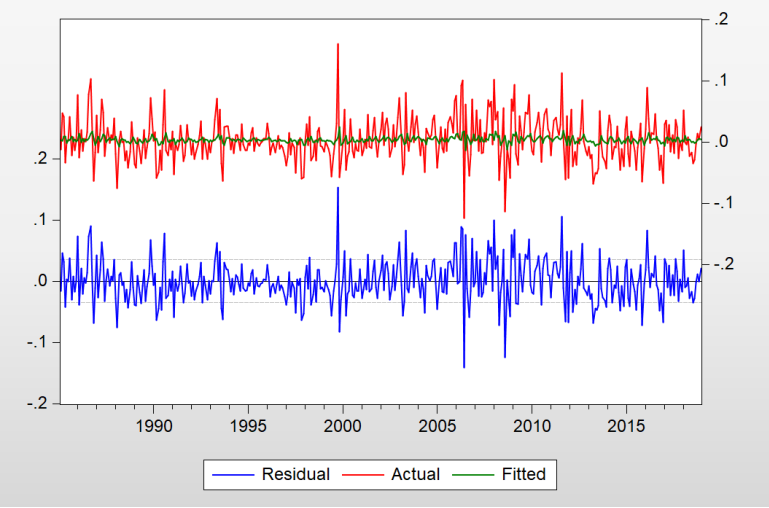
ARMA(1,0)

Dependent Variable: DLOG(GOLD)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 02/13/19 Time: 20:08
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



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

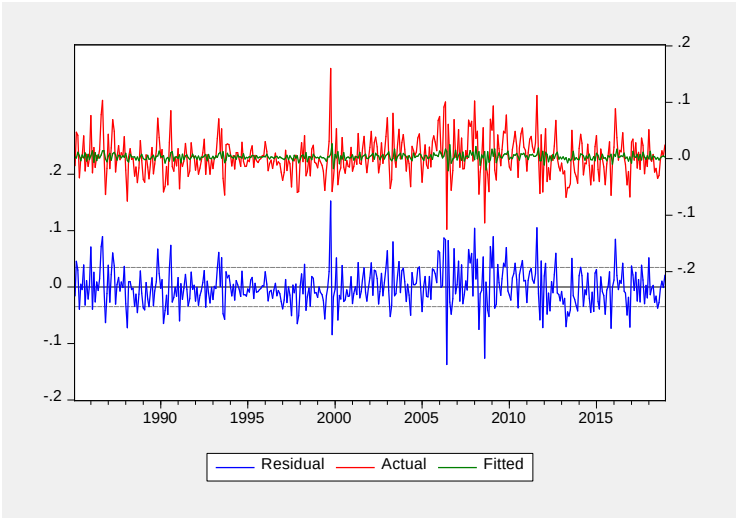
ARMA(1,1)

Dependent Variable: DLOG(GOLD)
Method: ARMA Generalized Least Squares (Gauss-Newton)
Date: 02/13/19 Time: 19:55
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 8 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	0.001922	1.813133	0.0706
AR(1)	-0.331592	0.246073	-1.347533	0.1786
MA(1)	0.491350	0.227199	2.162646	0.0312

R-squared	0.027818	Mean dependent var	0.003484
Adjusted R-squared	0.023006	S.D. dependent var	0.035029
S.E. of regression	0.034623	Akaike info criterion	-3.881146
Sum squared resid	0.484304	Schwarz criterion	-3.851597
Log likelihood	792.8132	Hannan-Quinn criter.	-3.869452
F-statistic	5.780121	Durbin-Watson stat	2.012300
Prob(F-statistic)	0.003349		

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



Date: 02/13/19 Time: 19:56
Sample: 1985M01 2018M12
Included observations: 407
Q-statistic probabilities adjusted for 2 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.007	-0.007	0.0193	
		2	-0.031	-0.031	0.4112	
		3	-0.019	-0.019	0.5526	0.457
		4	0.051	0.050	1.6156	0.446
		5	0.013	0.012	1.6820	0.641
		6	-0.004	-0.001	1.6894	0.793
		7	0.072	0.075	3.8358	0.573
		8	0.010	0.009	3.8768	0.693
		9	-0.001	0.002	3.8776	0.794
		10	-0.014	-0.010	3.9589	0.861
		11	0.155	0.149	14.056	0.120
		12	0.008	0.007	14.082	0.169
		13	0.002	0.012	14.084	0.228
		14	0.030	0.034	14.463	0.272
		15	0.034	0.022	14.968	0.309
		16	0.041	0.040	15.682	0.333
		17	0.004	0.010	15.689	0.403
		18	0.062	0.044	17.336	0.364
		19	-0.001	-0.005	17.336	0.432
		20	0.084	0.086	20.398	0.311
		21	0.008	0.011	20.427	0.369
		22	0.039	0.015	21.088	0.392
		23	0.021	0.020	21.288	0.441
		24	0.051	0.048	22.420	0.435
		25	-0.009	-0.024	22.458	0.493
		26	0.069	0.067	24.514	0.433
		27	-0.021	-0.045	24.715	0.478
		28	0.004	-0.000	24.723	0.535
		29	0.004	-0.016	24.731	0.590
		30	-0.032	-0.043	25.193	0.617
		31	0.059	0.026	26.728	0.586
		32	-0.015	-0.025	26.831	0.632
		33	-0.026	-0.046	27.124	0.666
		34	-0.055	-0.069	28.490	0.645
		35	0.062	0.037	30.193	0.608
		36	-0.037	-0.054	30.797	0.625

V. FORECASTING

2018 forecasting

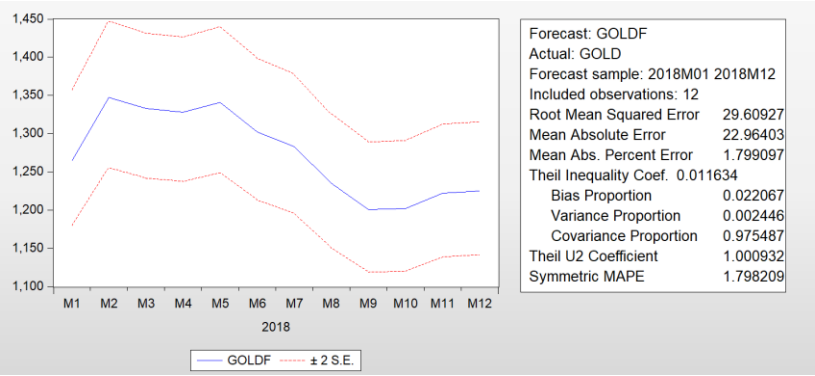
Dependent Variable: DLOG(GOLD)
Method: ARMA Generalized Least Squares (Gauss-Newton)
Date: 02/13/19 Time: 20:18
Sample: 1985M02 2017M12
Included observations: 395
Convergence achieved after 8 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & 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

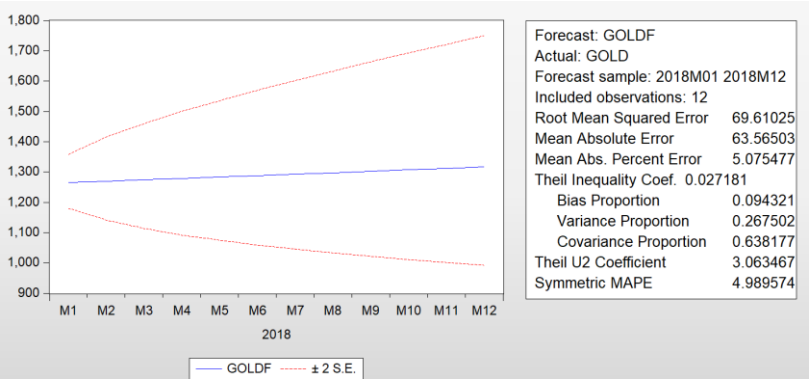
R-squared	0.022688	Mean dependent var	0.003619
Adjusted R-squared	0.020201	S.D. dependent var	0.035318
S.E. of regression	0.034959	Akaike info criterion	-3.864134
Sum squared resid	0.480310	Schwarz criterion	-3.843988
Log likelihood	765.1665	Hannan-Quinn criter.	-3.856152
F-statistic	9.123316	Durbin-Watson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

Inverted MA Roots	-.17

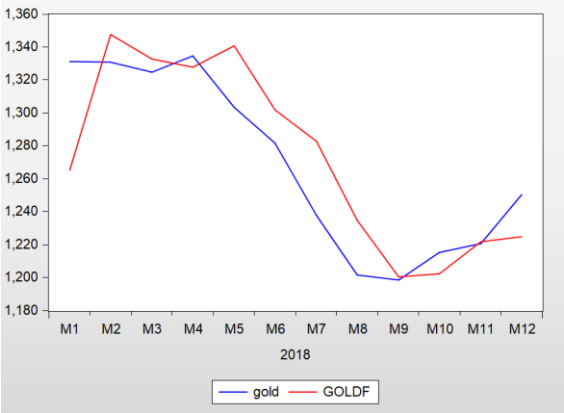
STATIC



DYNAMIC



The static model prediction fit well with the actual data.



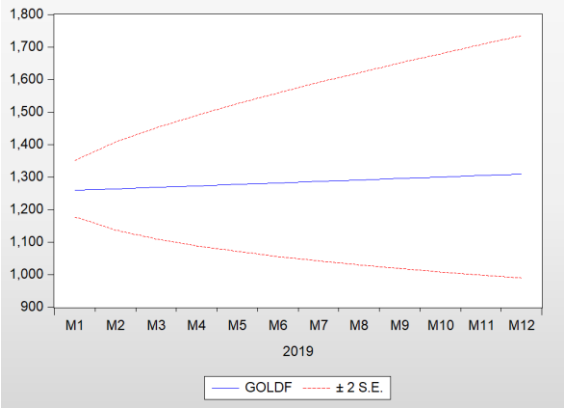
Predict for 2019

Dependent Variable: DLOG(GOLD)
Method: ARMA Generalized Least Squares (Gauss-Newton)
Date: 02/13/19 Time: 20:31
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



The gold price for the next 12 months (Jan to Dec 2019) will marginally increase.

The risk is high for the next 12 months since the 95% prediction interval is wide, 50% of the current price. If you need to sell physical gold within 12 months, it is risky. However, if you can choose when to sell the gold, due to the generic trend in the long term, you would be able to choose when to sell at the optimal price. The prediction interval is (1000, 1700)

If it is one-step forecast then both forecasts are the same. The difference arises when forecasting further: "dynamic forecast" will take previously forecasted values while "static forecast" will take actual values to make next step forecast. So, for 2019, the data is not available therefore the "static forecast" cannot be used.