Session 4 - Workshop

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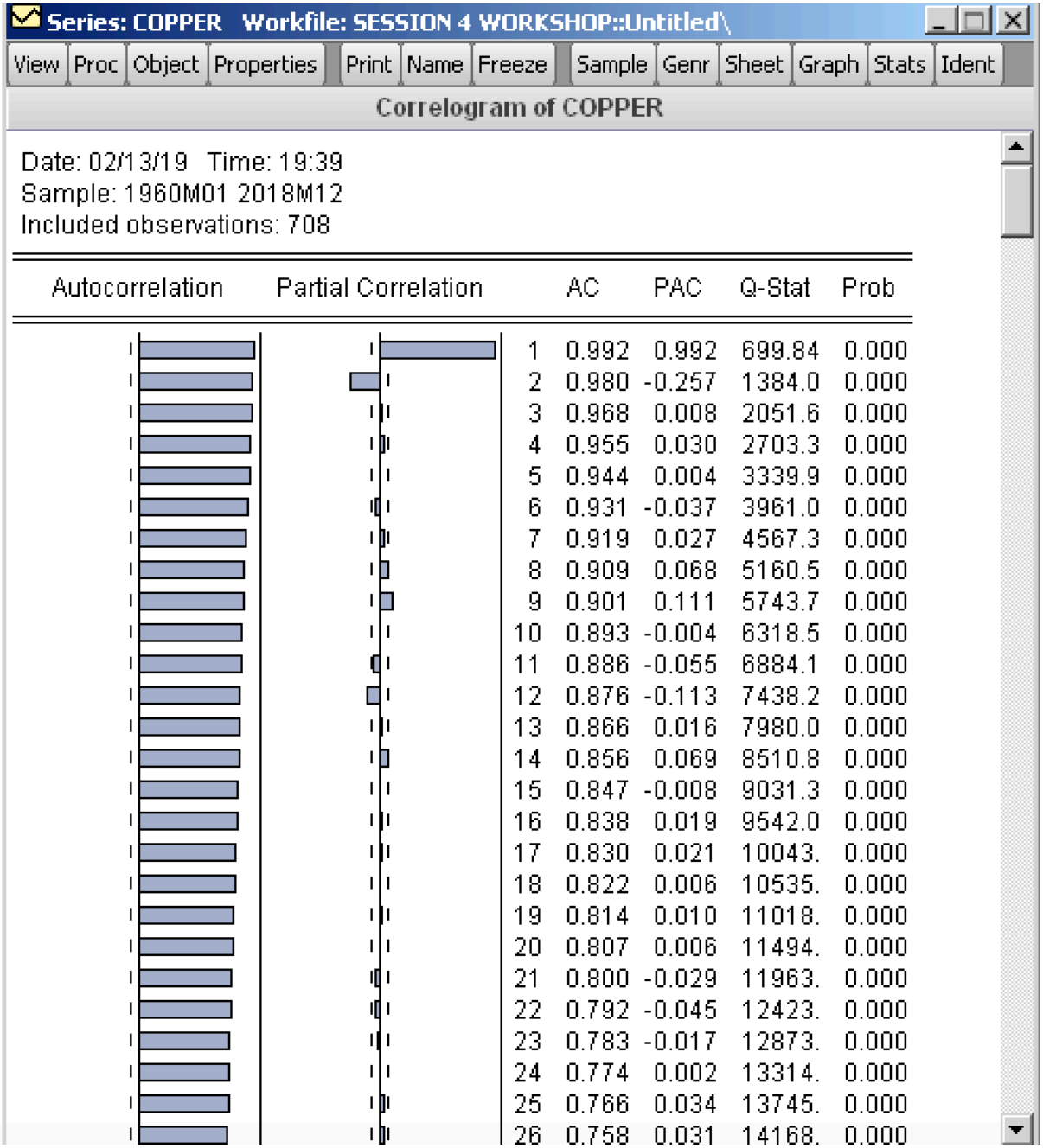
(a)

(i)



It looks non-stationary because both Autocorrelation and AC value still very large when the order is growing large and Autocorrelation decrease very slow from from lag 1-36.

(ii)

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: 19:44
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		

Null Hypothesis: Copper has a unit root , means the coefficient of the copper(-1) is 1. Because the statistic fall outside the confident level , which shows significant autocorrelation. so we can't reject the null hypothesis.
So the series is non-stationary.

(iii)

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

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.

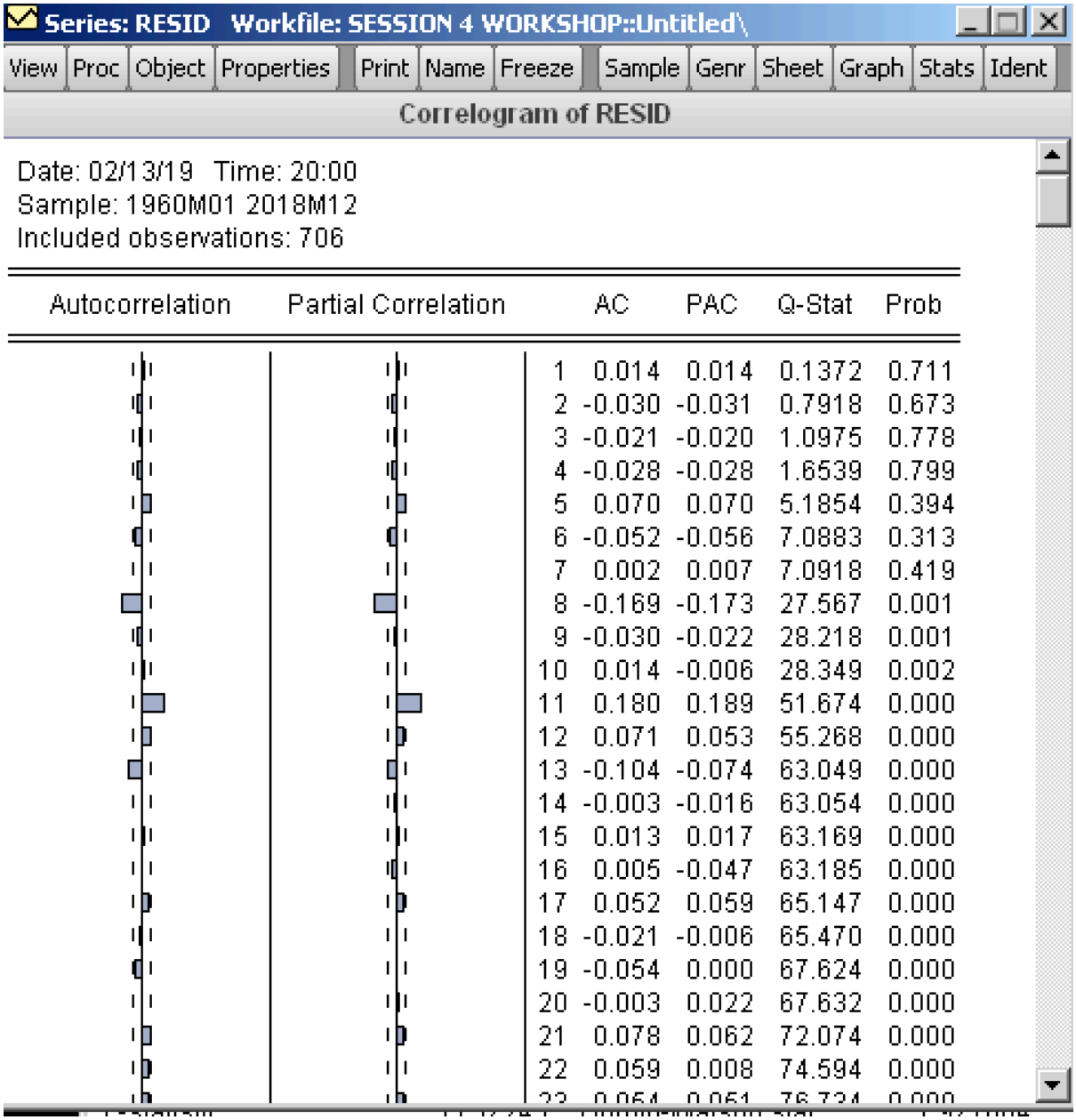
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(COPPER)
Method: Least Squares
Date: 02/13/19 Time: 19:54
Sample (adjusted): 1960M03 2018M12
Included observations: 706 after adjustments

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		

Null Hypothesis: Copper has a unit root , means the coefficient of the copper(-1) is 1.
After adding the trend and intercept, the test is in 90% confident level, but not in 95%.
So the series is non-stationary in 95% confident level .

(iv)



The series is stationary because Prob. is >0.5 for the first few order and the AC and PAC value are very small and no spikes observed.

(v)

Series: D(COPPER) Workfile: SESSION 4 WORKSHOP::Untitled\

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

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

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=17)

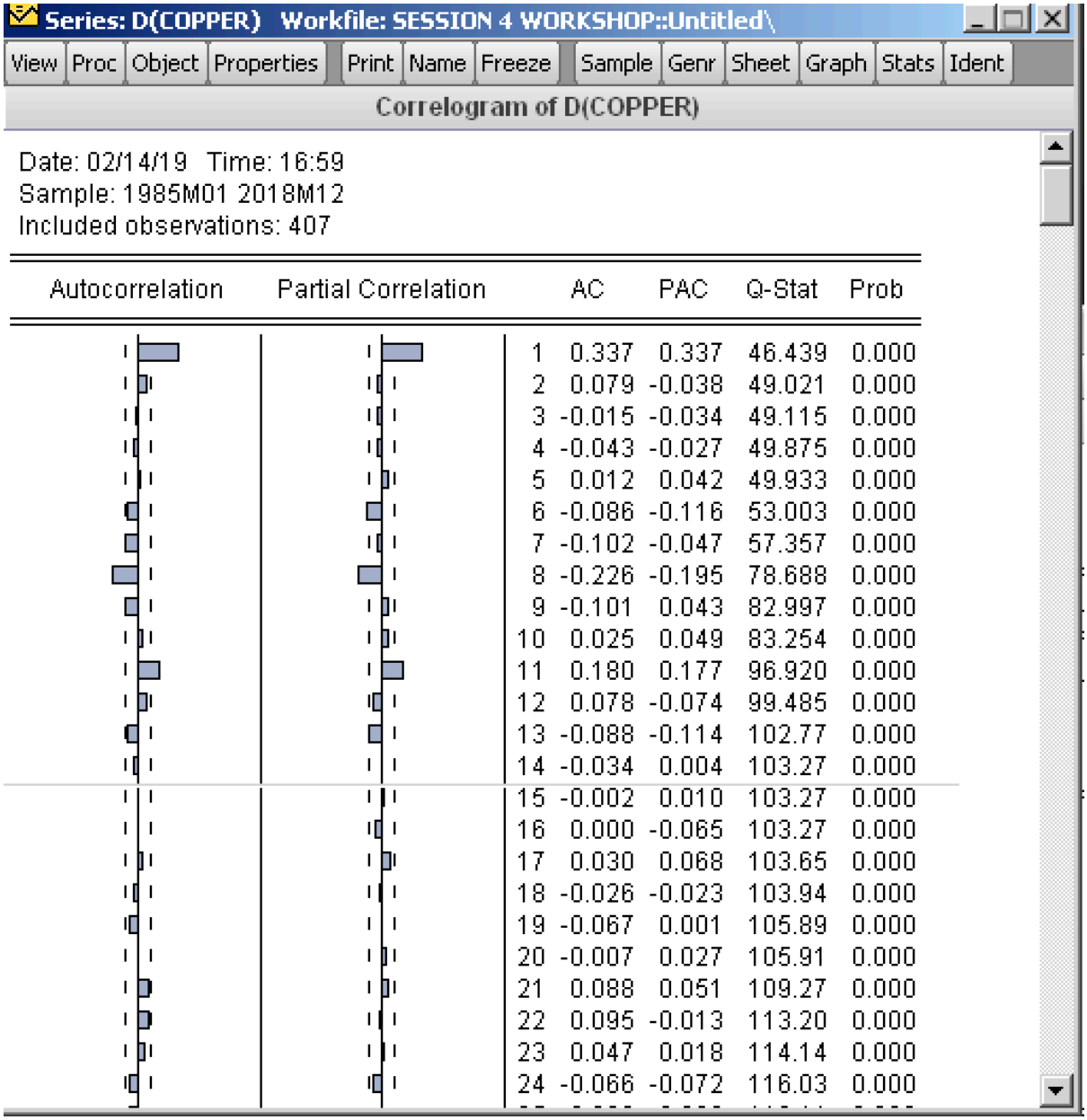
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-14.13802	0.0000
Test critical values:	1% level	-3.980823	
	5% level	-3.420930	
	10% level	-3.133194	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(COPPER,2)
Method: Least Squares
Date: 02/14/19 Time: 17:00
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



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

After adding both trend and intercept and the lag. The test fall in side the 95% confident level, which shows that the model is non-stationary in 95% confident level. The stationarity is better than just include the trend and intercept

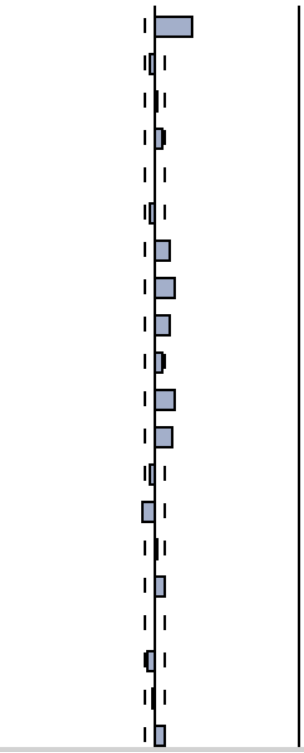
(b)
(i)
Gold:

Series: DLOG(GOLD) Workfile: SESSION 4 WORKSHOP::Untitled\

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

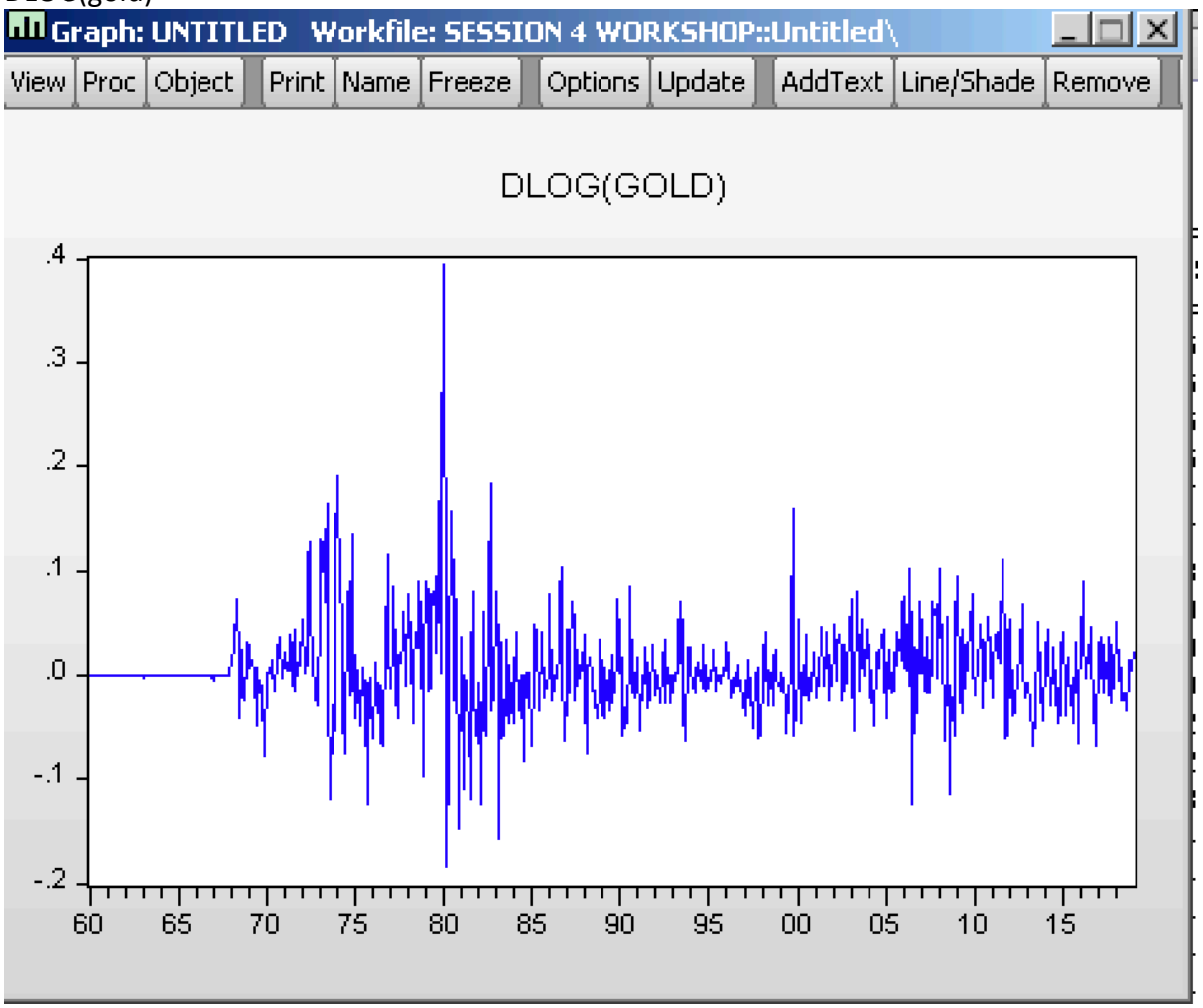
Correlogram of DLOG(GOLD)

Date: 02/13/19 Time: 20:14
Sample: 1960M01 2018M12
Included observations: 707



Autocorrelation	Partial Correlation		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

DLOG(gold)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Series: GOLD Workfile: SESSION 4 WORKSHOP::Untitled\

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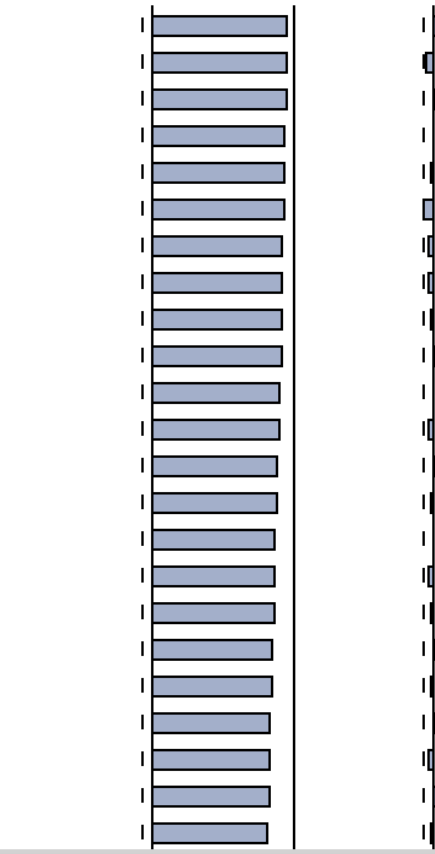
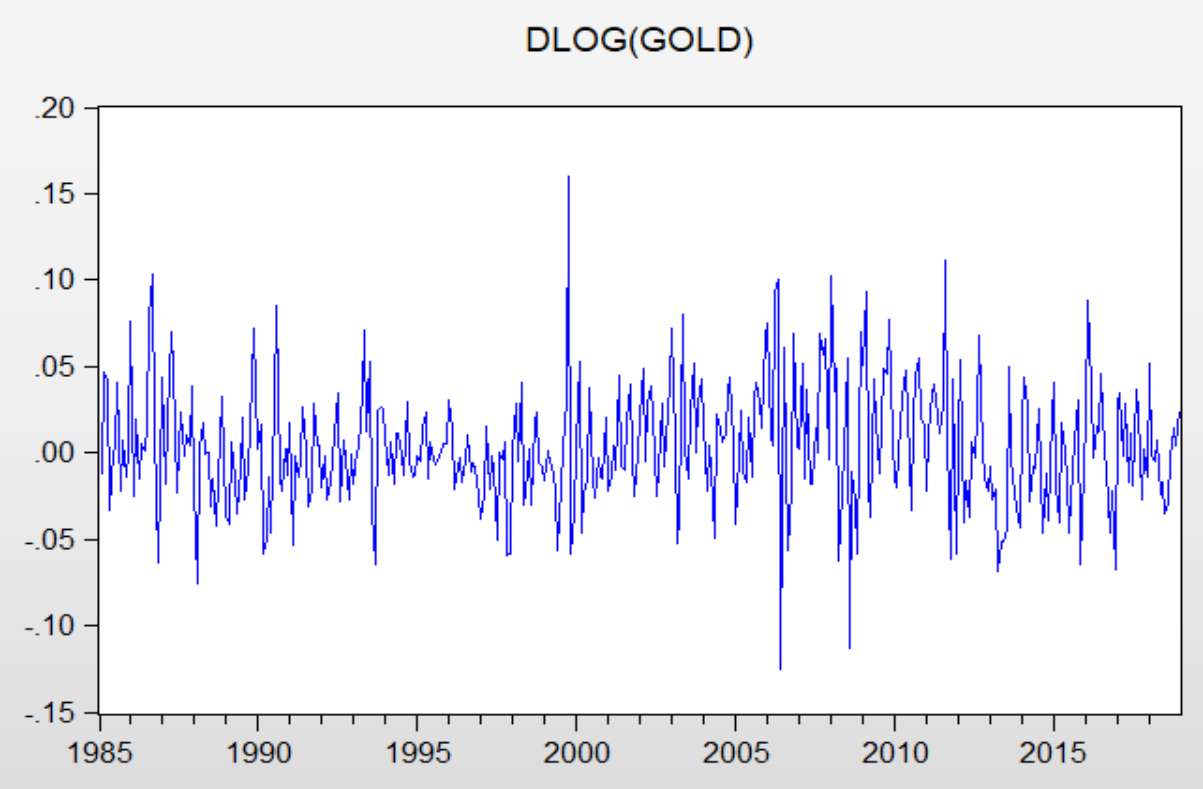
Correlogram of GOLD

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


DLOG(GOLD)
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2015

Series: DLOG(GOLD) Workfile: SESSION 4 WORKSHOP::Untitled\

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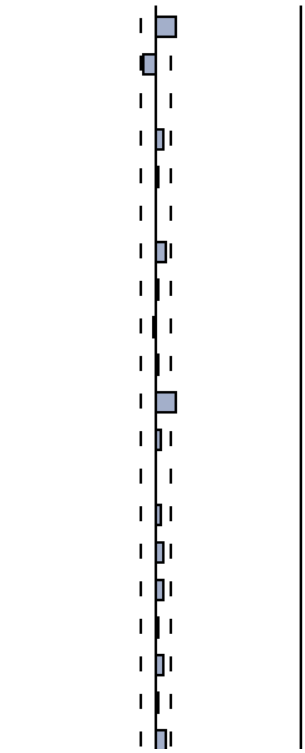
Correlogram of DLOG(GOLD)

Date: 02/13/19 Time: 20:21
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

(ii) + (iii)

ARMA(2,0)

Dependent Variable: DLOG(GOLD)
Method: ARMA Generalized Least Squares (BFGS)
Date: 02/13/19 Time: 20:47
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 4 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

ARMA(1,1)

Dependent Variable: DLOG(GOLD)
Method: ARMA Generalized Least Squares (BFGS)
Date: 02/13/19 Time: 20:48
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 11 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	-1.347534	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

ARMA(1,0)

Dependent Variable: DLOG(GOLD)
Method: ARMA Generalized Least Squares (BFGS)
Date: 02/13/19 Time: 20:47
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 2 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003486	0.001993	1.748993	0.0810
AR(1)	0.136344	0.049248	2.768527	0.0059

R-squared	0.018565	Mean dependent var	0.003484
Adjusted R-squared	0.016141	S.D. dependent var	0.035029
S.E. of regression	0.034745	Akaike info criterion	-3.876631
Sum squared resid	0.488914	Schwarz criterion	-3.856932
Log likelihood	790.8945	Hannan-Quinn criter.	-3.868836
F-statistic	7.660941	Durbin-Watson stat	1.969945
Prob(F-statistic)	0.005902		

Inverted AR Roots	.14

ARMA(0,2)

Dependent Variable: DLOG(GOLD)
Method: ARMA Generalized Least Squares (BFGS)
Date: 02/13/19 Time: 20:47
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 4 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

ARMA(0,1)

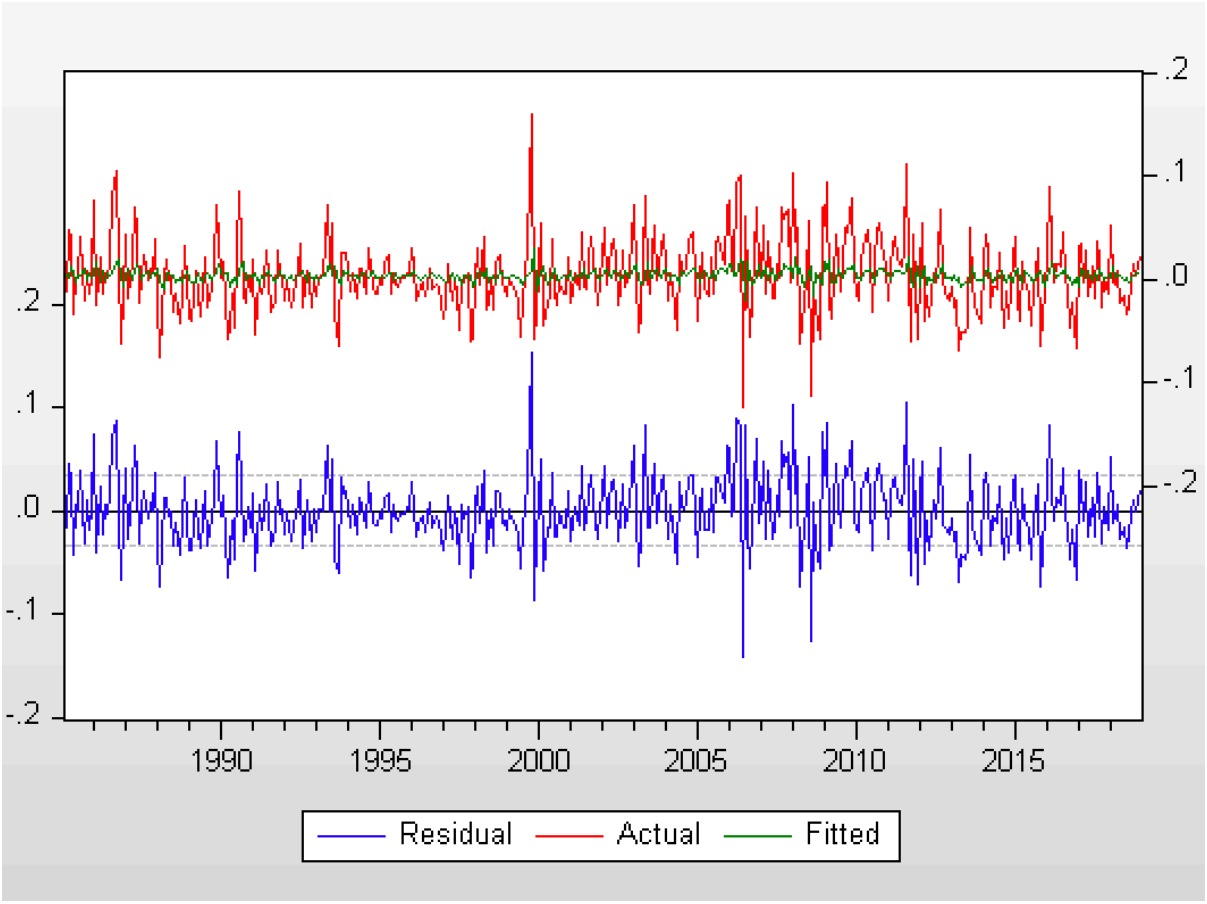
Dependent Variable: DLOG(GOLD)
Method: ARMA Generalized Least Squares (BFGS)
Date: 02/13/19 Time: 20:47
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 4 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & covariance

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

(iv)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Date: 02/13/19 Time: 20:36
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

The residuals not random

The correlogram doesn't suggest random residuals, because the p value sometime large sometimes small

P-value suggest that the Q-statistic not significant because are all larger than 5%

(v)

ARMA(0,1)

Equation: UNTITLED Workfile: SESSION 4 WORKSHOP::Untitled\

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

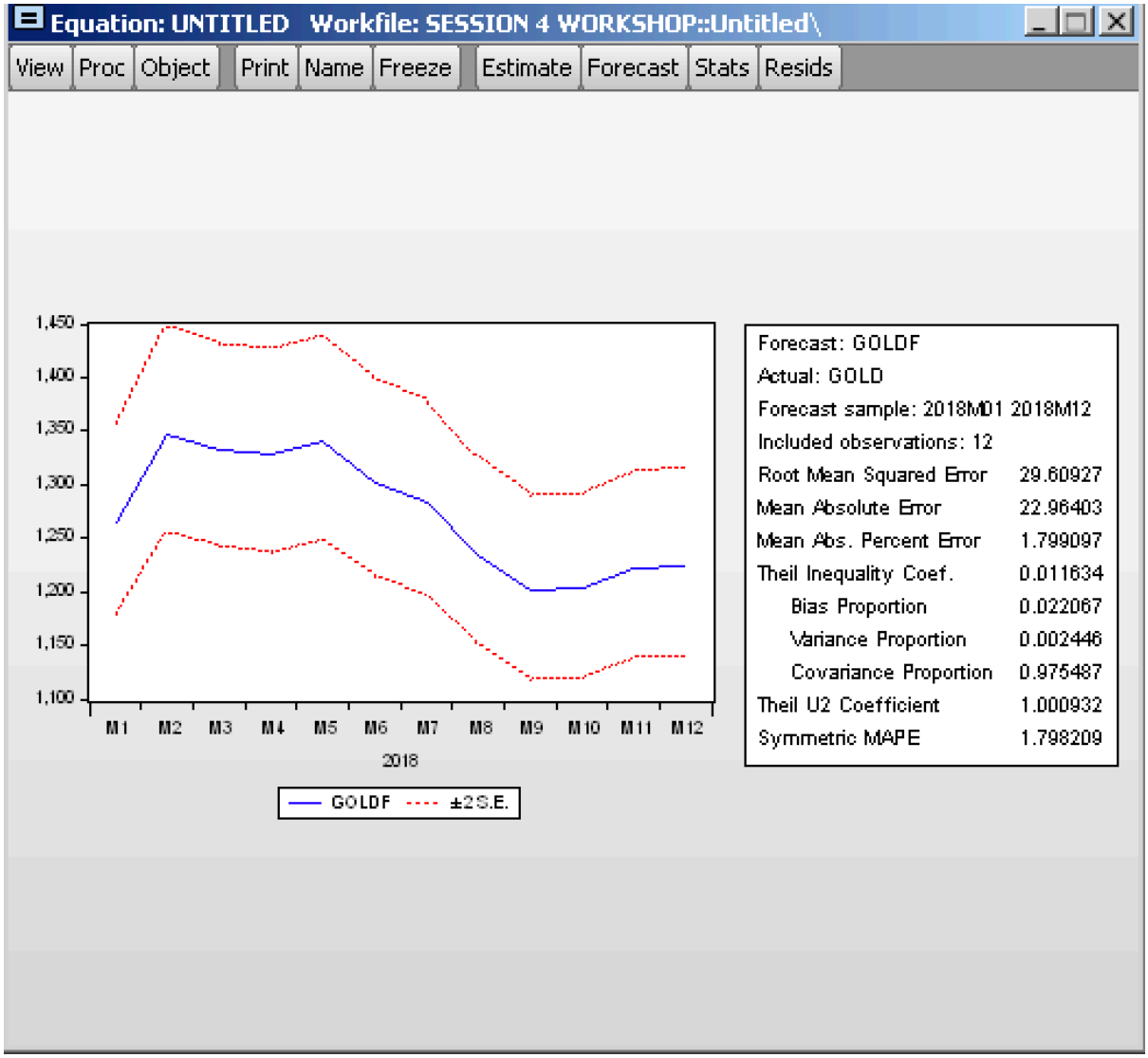
Dependent Variable: DLOG(GOLD)
Method: ARMA Generalized Least Squares (Gauss-Newton)
Date: 02/13/19 Time: 20:47
Sample: 1985M02 2017M12
Included observations: 395
Convergence achieved after 8 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & 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

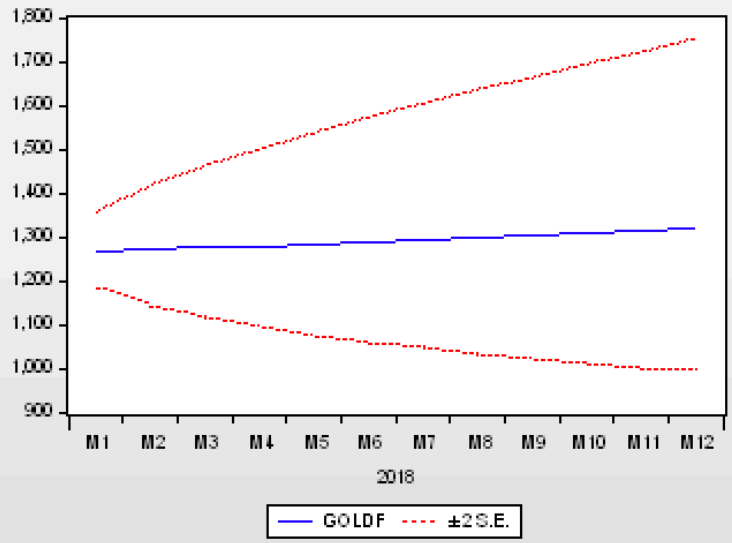
Statistic:


Equation: UNTITLED Workfile: SESSION 4 WORKSHOP::Untitled\
View
Proc
Object
Print
Name
Freeze
Estimate
Forecast
Stats
Resids
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
M1
M2
M3
M4
M5
M6
M7
M8
M9
M10
M11
M12
2018
GOLDF
±2S.E.
Forecast: GOLDF
Actual: GOLD
Forecast sample: 2018M01 2018M12
Included observations: 12
Root Mean Squared Error 29.60927
Mean Absolute Error 22.96403
Mean Abs. Percent Error 1.799097
Theil Inequality Coef. 0.011634
Bias Proportion 0.022067
Variance Proportion 0.002446
Covariance Proportion 0.975487
Theil U2 Coefficient 1.000932
Symmetric MAPE 1.798209

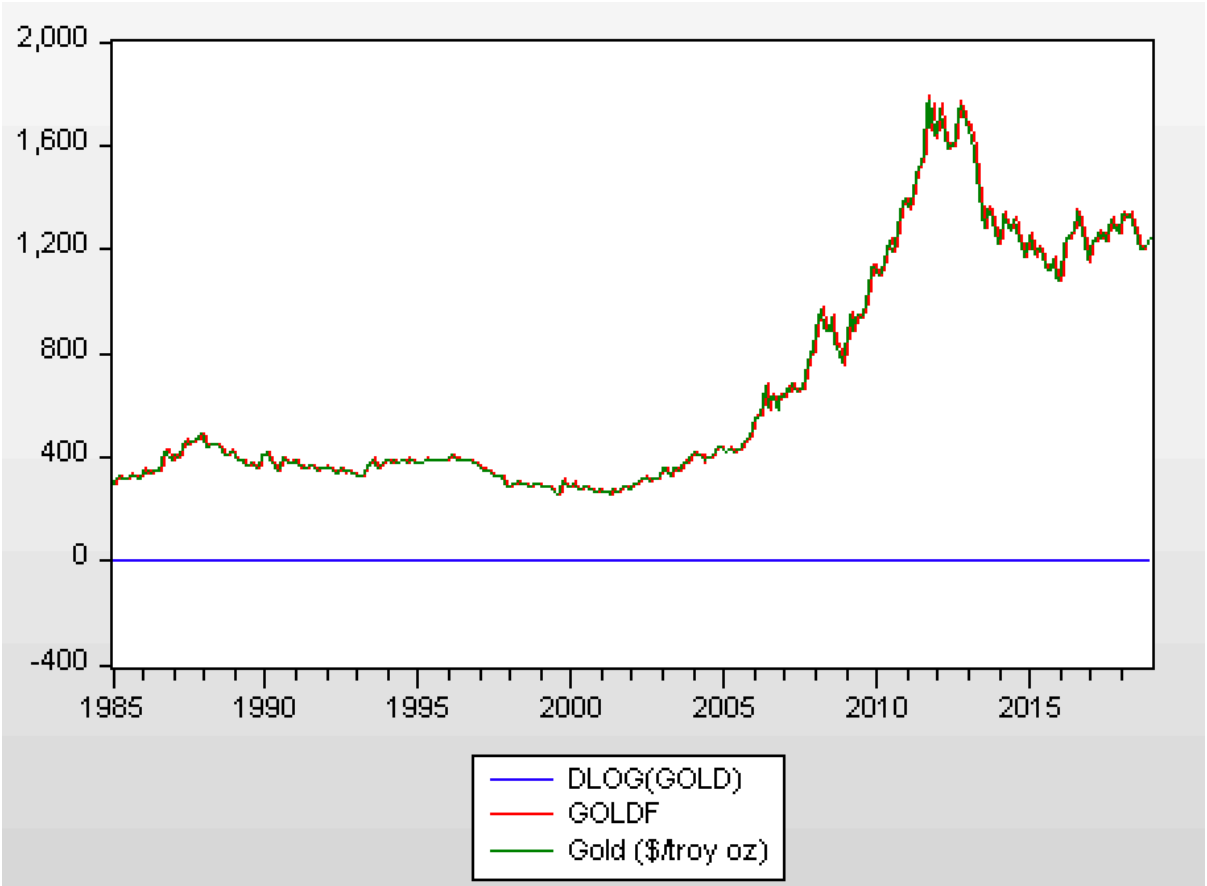
Dynamic:

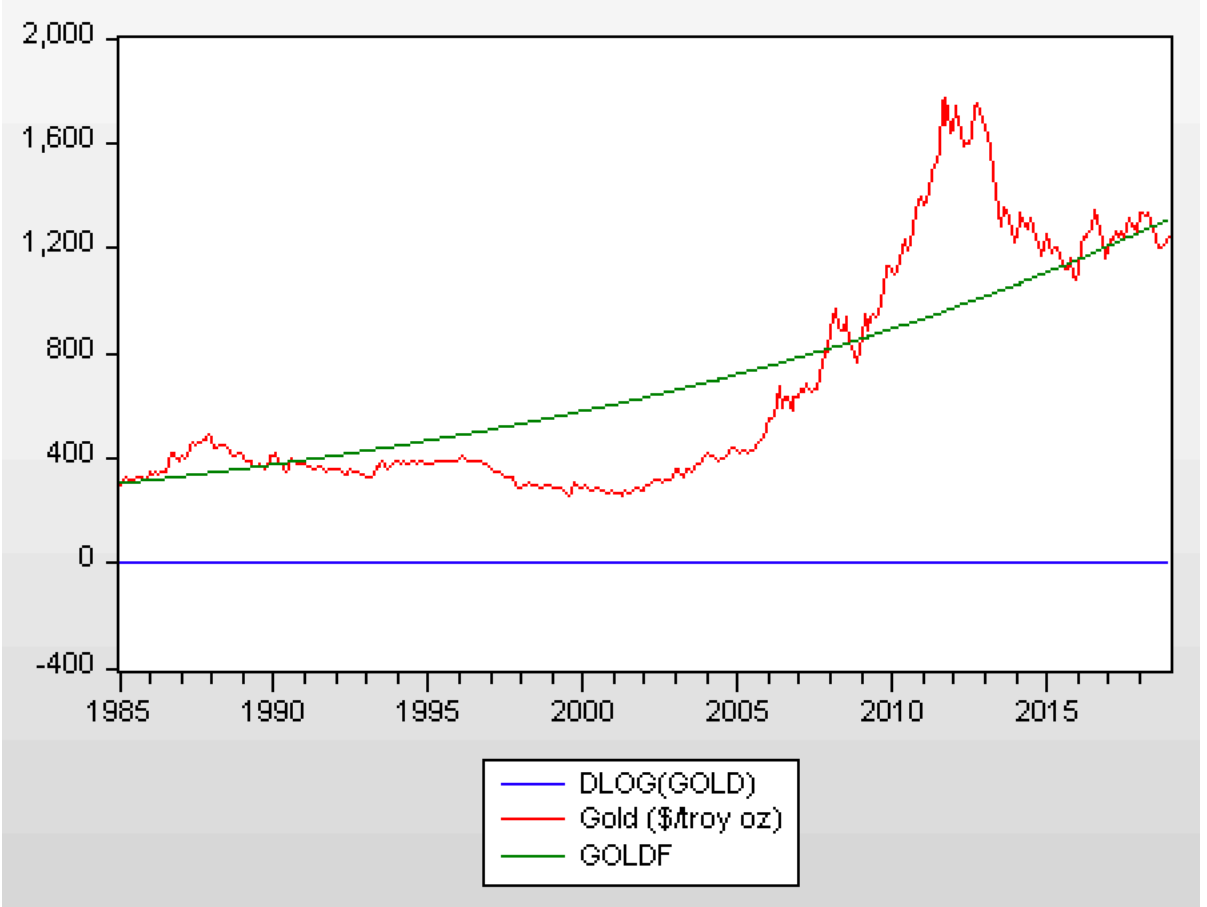
Equation: UNTITLED Workfile: SESSION 4 WORKSHOP::Untitled\

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

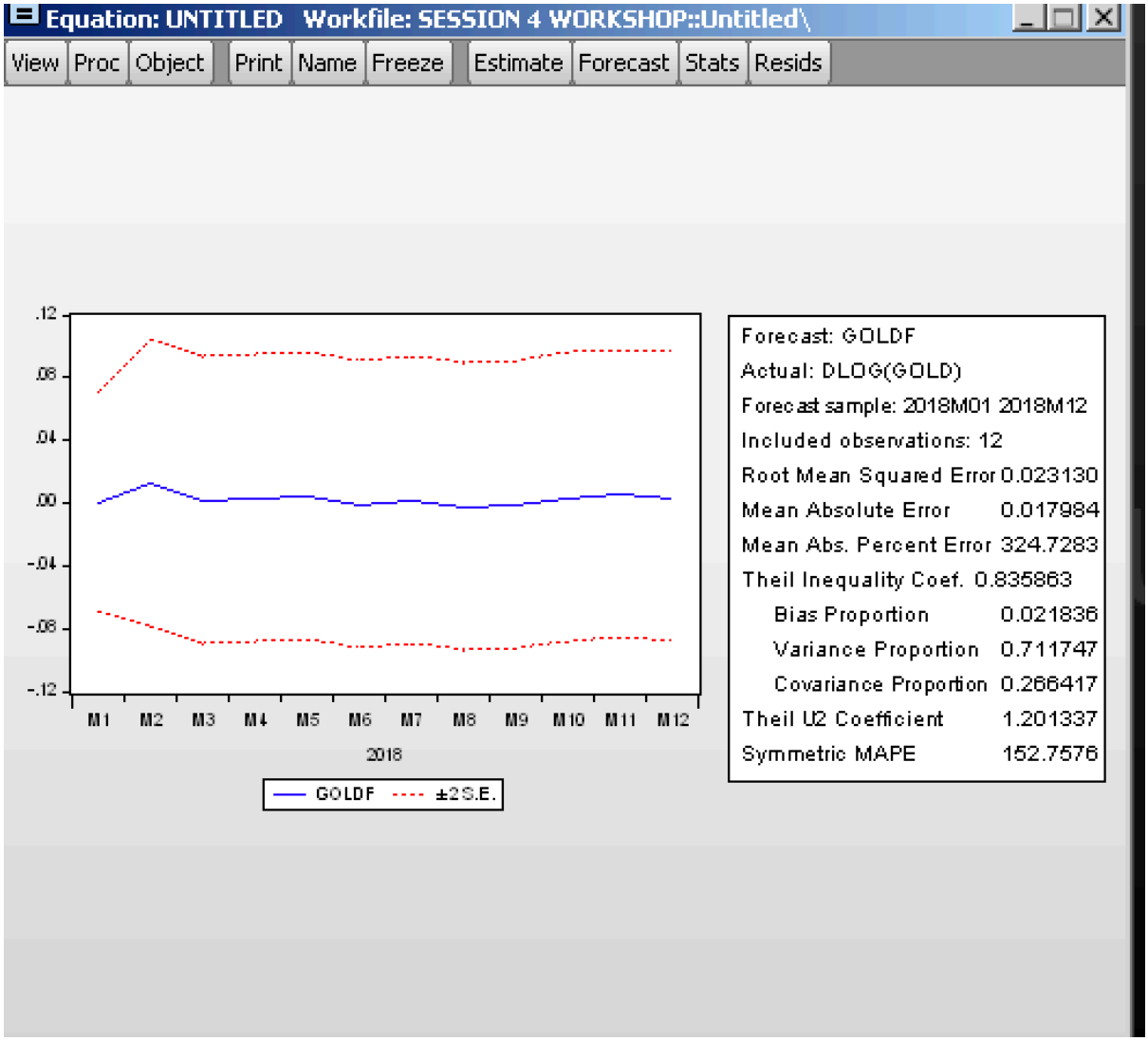


Forecast: GOLDF	
Actual: GOLD	
Forecast sample: 2018M01 2018M12	
Included observations: 12	
Root Mean Squared Error	69.61025
Mean Absolute Error	63.56503
Mean Abs. Percent Error	5.075477
Theil Inequality Coef.	0.027181
Bias Proportion	0.094321
Variance Proportion	0.267502
Covariance Proportion	0.638177
Theil U2 Coefficient	3.063467
Symmetric MAPE	4.989574

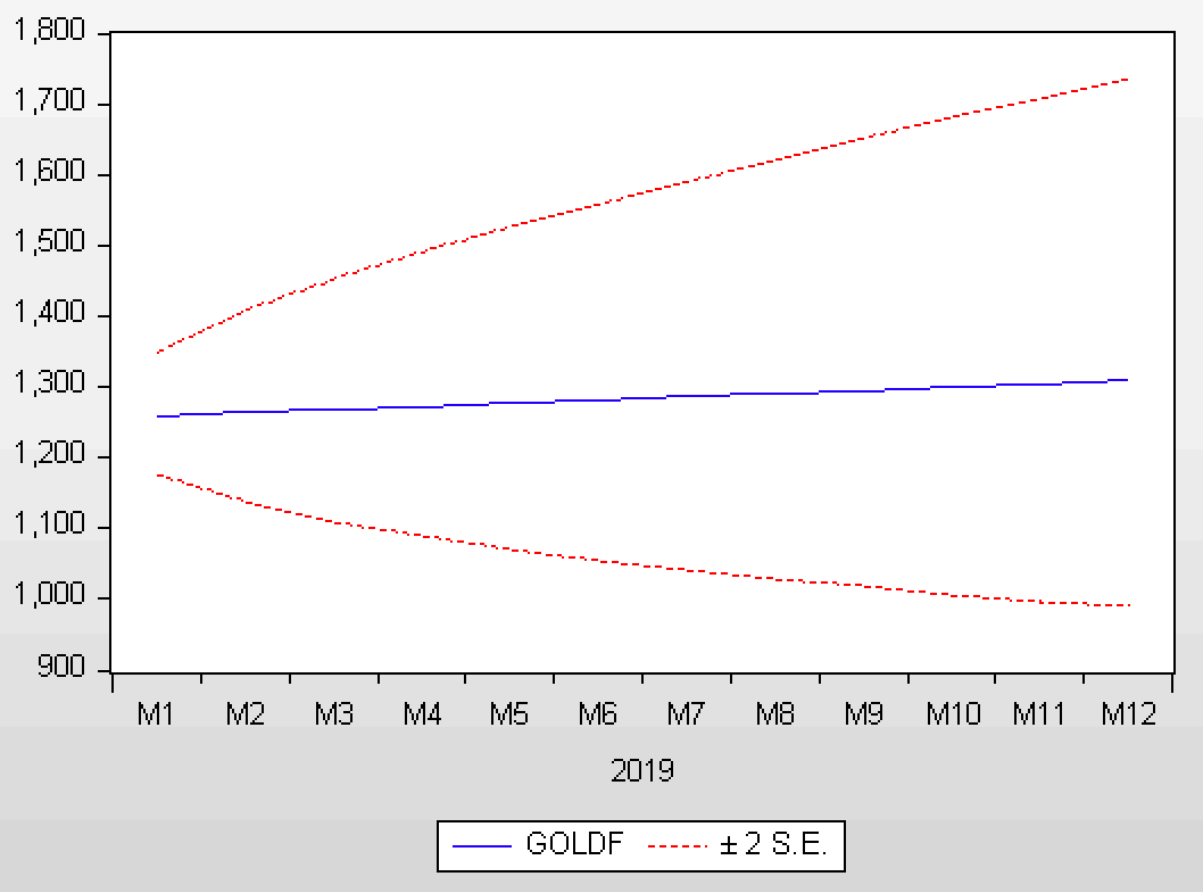

2,000
1,600
1,200
800
400
0
-400
1985
1990
1995
2000
2005
2010
2015
DLOG(GOLD)
GOLDF
Gold ($/troy oz)


2,000
1,600
1,200
800
400
0
-400
1985
1990
1995
2000
2005
2010
2015
DLOG(GOLD)
Gold ($/troy oz)
GOLDF

DLOG(gold)



2019 forecast


1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
M1
M2
M3
M4
M5
M6
M7
M8
M9
M10
M11
M12
2019
GOLDF
± 2 S.E.

Dependent Variable: DLOG(GOLD)
Method: ARMA Generalized Least Squares (BFGS)
Date: 02/13/19 Time: 21:04
Sample: 1985M02 2018M12
Included observations: 407
Convergence achieved after 4 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