QRM Workshop 4

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a)

(i) Does the series look stationary?

No, from the graph the series does not look stationary as the mean price has increased over time and the fluctuation has not remained constant.

(ii) What is the test's null hypothesis? Can it be rejected for the exchange rate series? Is the series stationary?

The test's null hypothesis is that Copper has a unit root/not stationary. It cannot be rejected as the p-value > 0.05 and indicates that the series is not stationary.

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: 02/15/19 Time: 10:30
Sample (adjusted): 1960M03 2018M12
Included observations: 706 after adjustments

(iii) Include a constant and a trend in the basic Dickey-Fuller test. Does the test indicate stationarity?

Even after accounting for the presence of a trend and intercept, the p-value for the test is still above 0.05. This indicates that the series is not stationary.

(iv)

Null Hypothesis: D(COPPER) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=19)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-18.75189	0.0000
Test critical values:	1% level	-3.439384	
	5% level	-2.865417	
	10% level	-2.568891	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(COPPER,2)
Method: Least Squares
Date: 02/15/19 Time: 12:01
Sample (adjusted): 1960M03 2018M12
Included observations: 706 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(COPPER(-1))	-0.666399	0.035538	-18.75189	0.0000
C	4.984169	8.667712	0.575027	0.5655

R-squared	0.333102	Mean dependent var	-0.188938
Adjusted R-squared	0.332154	S.D. dependent var	281.6753
S.E. of regression	230.1901	Akaike info criterion	13.71852
Sum squared resid	37303203	Schwarz criterion	13.73143
Log likelihood	-4840.637	Hannan-Quinn criter.	13.72351
F-statistic	351.6332	Durbin-Watson stat	1.963070
Prob(F-statistic)	0.000000		

Including a lagged value of dependent variable yields DF test to be highly statistically significant.

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: 02/15/19 Time: 12:14
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		

Omitting previously non-significant constant results similarly.

Date: 02/15/19 Time: 12:05
Sample: 1960M01 2018M12
Included observations: 706

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.018	0.018	0.2359	0.627
		2	-0.039	-0.040	1.3359	0.513
		3	-0.035	-0.033	2.1837	0.535
		4	-0.042	-0.042	3.4410	0.487
		5	0.055	0.054	5.6044	0.347
		6	-0.066	-0.073	8.7588	0.188
		7	-0.016	-0.011	8.9335	0.257
		8	-0.185	-0.191	33.554	0.000
		9	-0.046	-0.041	35.045	0.000
		10	0.003	-0.025	35.051	0.000
		11	0.171	0.171	55.993	0.000
		12	0.061	0.033	58.663	0.000
		13	-0.115	-0.092	68.168	0.000
		14	-0.015	-0.032	68.341	0.000
		15	0.001	0.000	68.342	0.000

Correlogram of residuals suggest no autocorrelation between residuals.

(v) Examine whether the first differences are stationary

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

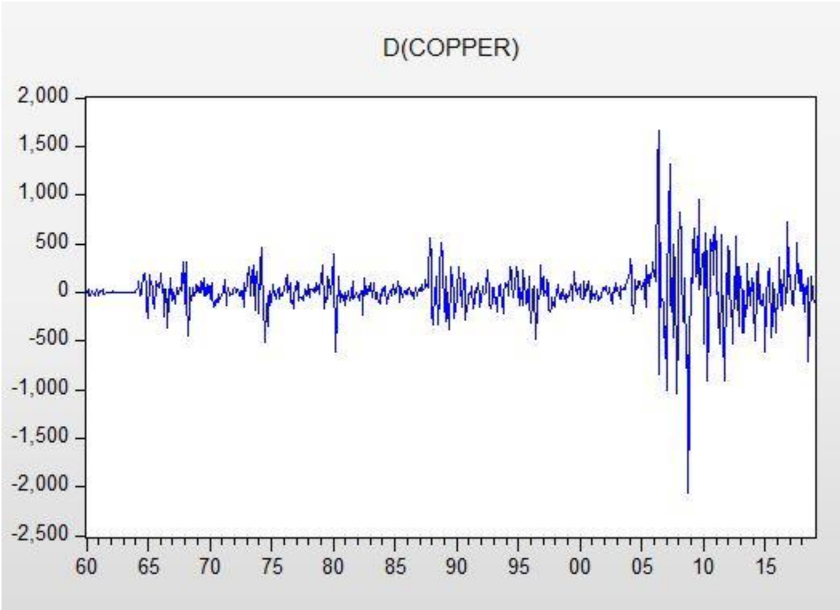
Null Hypothesis: D(COPPER) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=19)

		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: 02/15/19 Time: 10:41
Sample (adjusted): 1960M03 2018M12
Included observations: 706 after adjustments

The first difference of copper is stationary as evidenced by the p-value < 0.05.



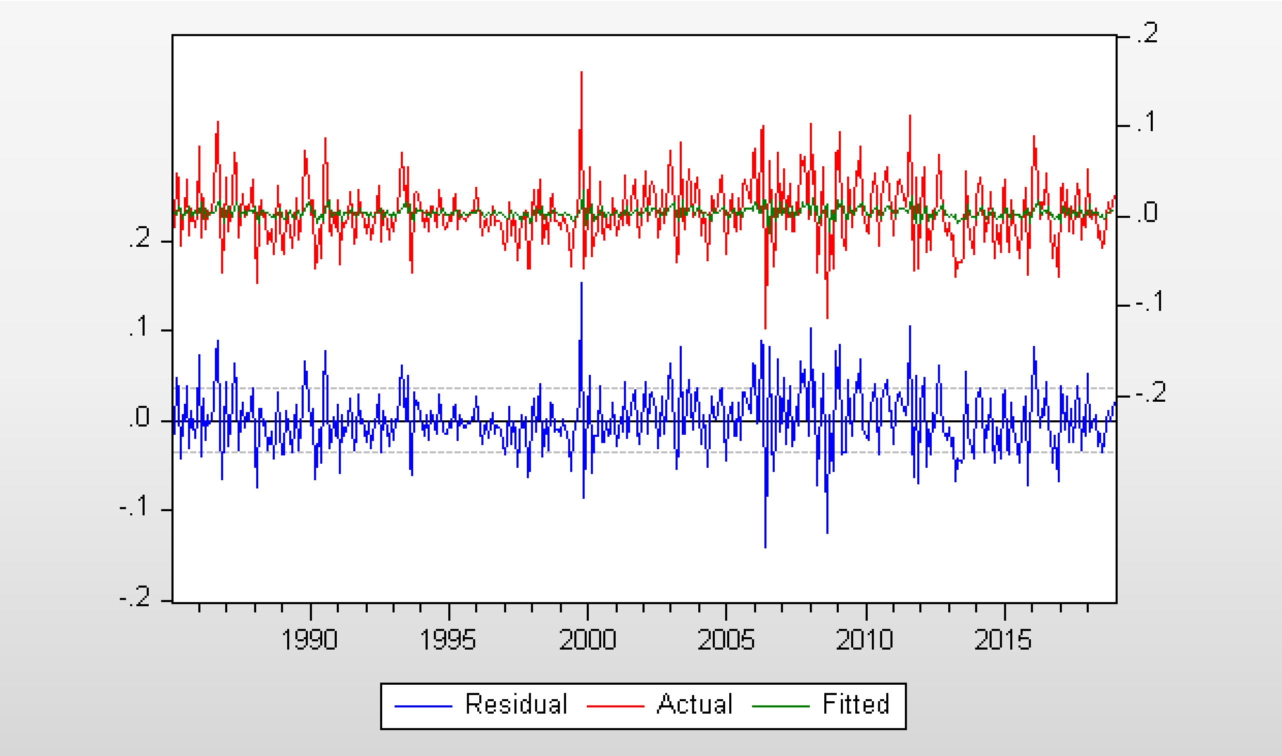
Graph of differenced series.

Autocorrelation	Partial Correlation		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

Correlogram of differenced series

b) (iv) Do residuals look random?

- Yes. They fluctuate both sides over zero, some trends can be identified but overall they are random.



Does the correlogram suggest random residuals?

- Yes. The residuals do not have low p-values.

Are any of the Q-statistics significant?

- No. Everything is above 0.05.

Try to find an alternative model which has better or comparable fit, and which also has no residual autocorrelation.

- The best overall performing model is AR(1) AR(2). MA(1) MA(2) has slightly lower AIC and SCI, however only one of the variables is statistically significant.

Dependent Variable: DLOG(GOLD)
Method: ARMA Generalized Least Squares (Gauss-Newton)
Date: 02/13/19 Time: 20:40
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

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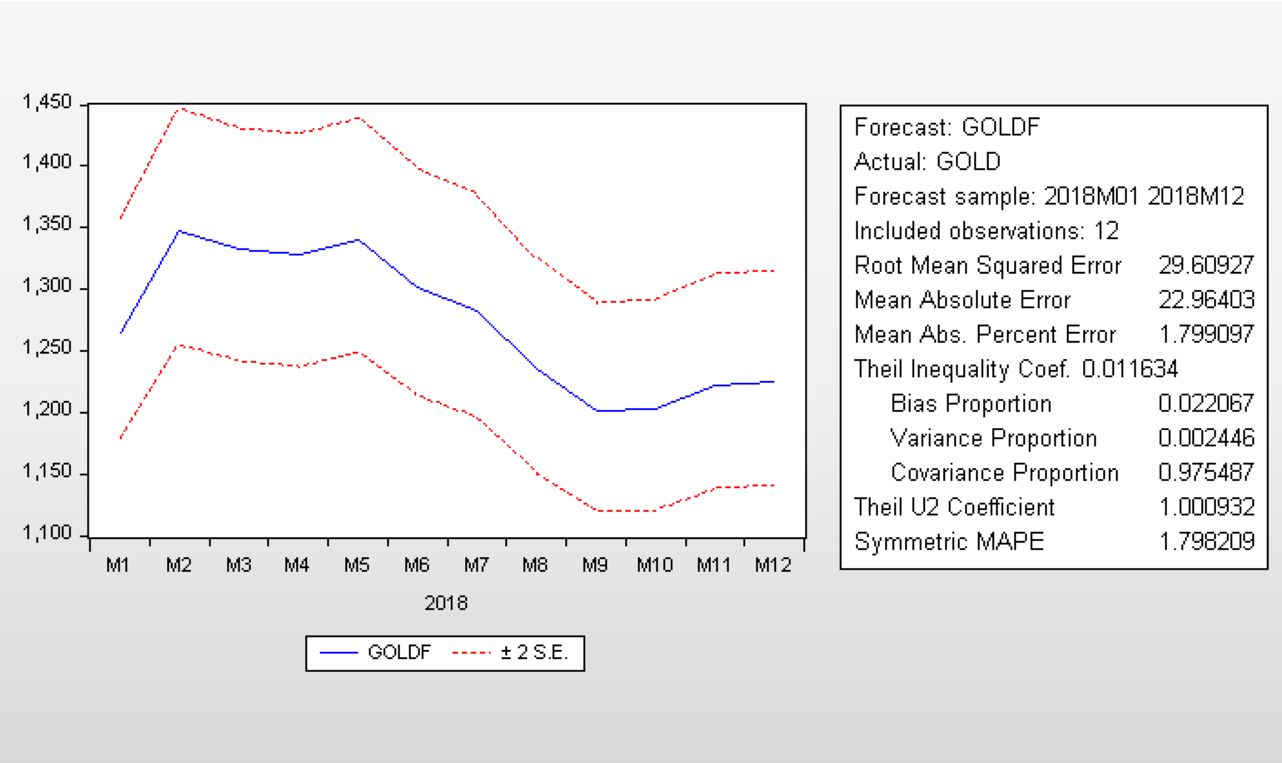
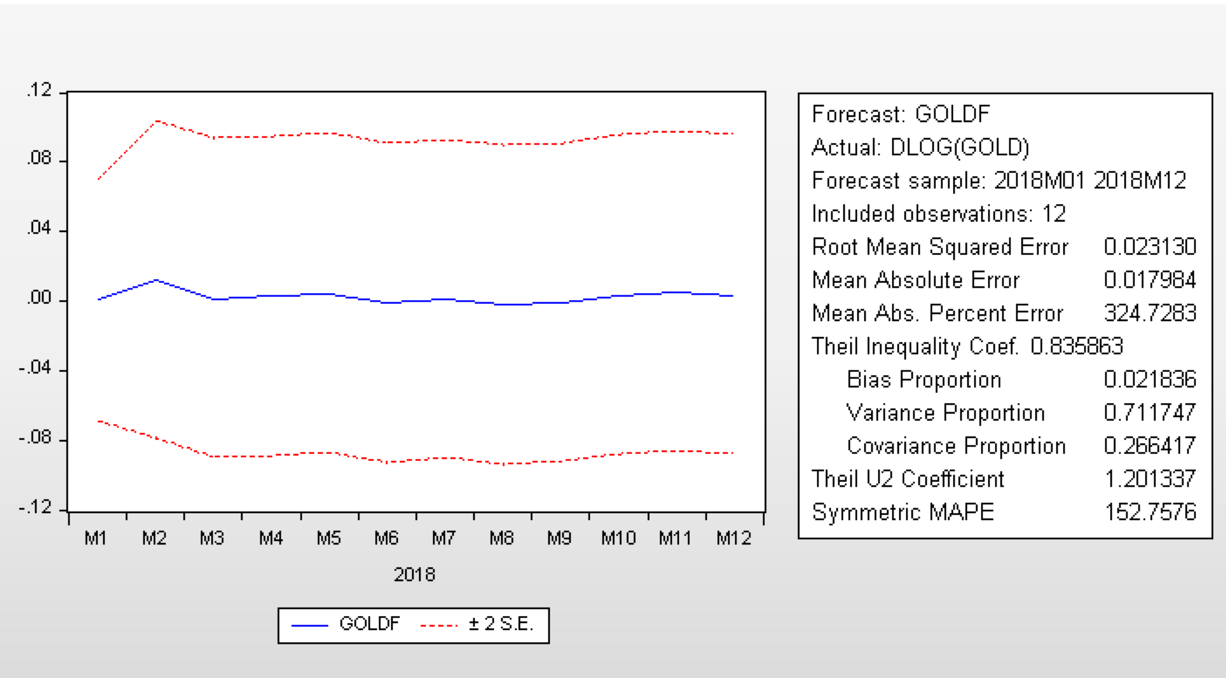
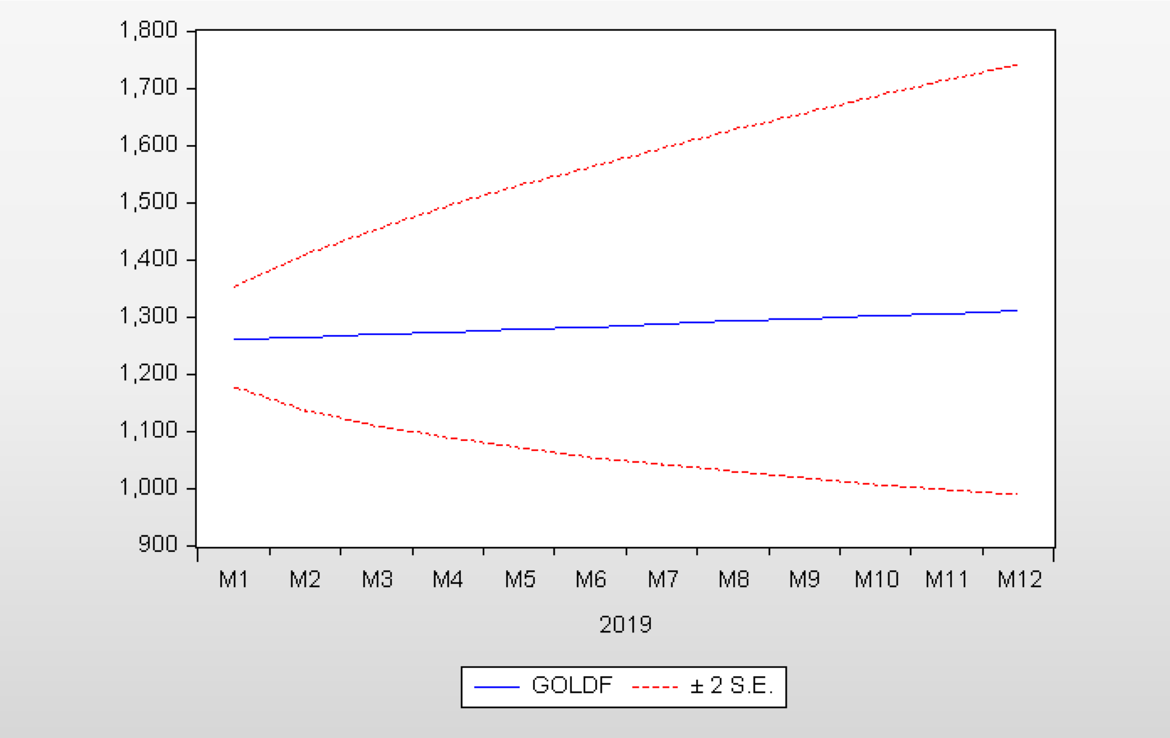
(iv) Forecasting





Based on static forecasting graphs predicting 2019 gold price performance is difficult. The predictions are within an interval of $100/troy oz.



Dynamic forecasting graphs instead would indicate gold price increase for 2019.

Why can't you use the Static Forecasting method?

-Since static is only forecasting one step forward, so able to forecast only for January.