Name: George Loo and Daniel Yuan

In-Class Workshop 5

Edit Expectations for Values Using Simple 12 Month Average

obs	sales	prom	adv	index
1	504.72	15.6	30	100
2	406.59	22.2	36	102
3	398.55	0	45	104
4	587.76	0	57	104
5	598.92	0	39	104
6	703.62	31.8	21	100
7	387.24	21.3	12	98
8	365.67	3.9	6	96
9	388.71	0	6	98
10	372.96	8.4	30	103
11	603.3	45.3	30	105
12	614.73	50.1	33	107
13	484.38	39.6	6	107
14	227.76	4.2	33	107
15	329.13	0	6	108
16	308.25	0	3	105
17	433.86	0	45	103
18	514.98	13.8	48	108
19	404.7	17.7	0	110
20	245.43	0	15	112
21	433.2	17.4	9	113
22	627.24	37.8	54	112
23	647.61	42.3	36	113
24	342.81	11.4	39	114
25		15	25	109
26		13	26	110
27		14	26	110
28		15	27	110
29		16	29	110
30		18	28	111

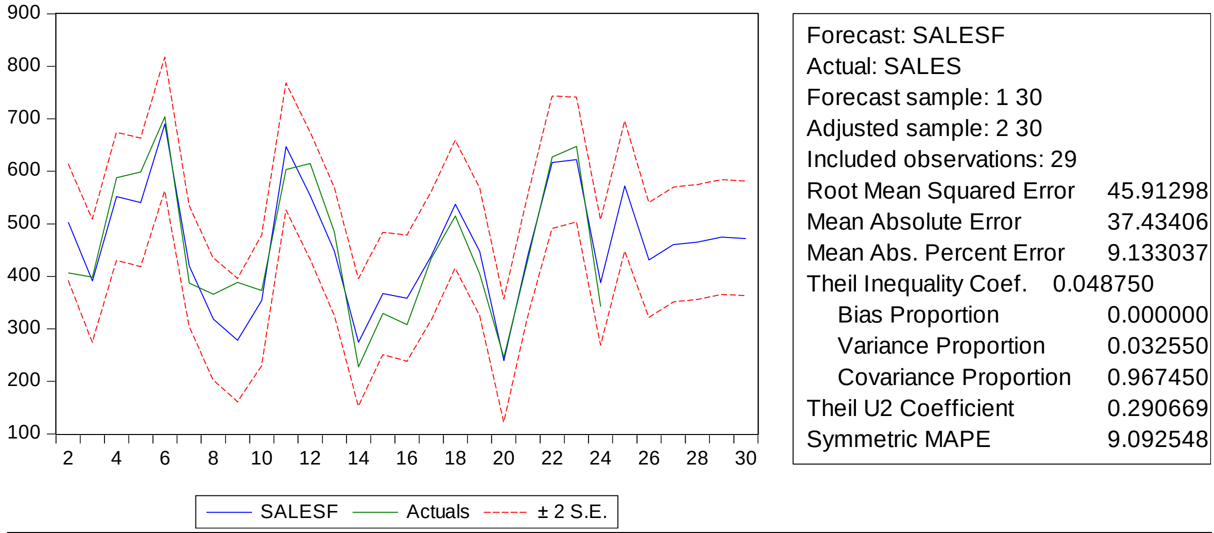
A colleague's model

Dependent Variable: SALES
Method: Least Squares
Date: 02/16/19 Time: 11:50
Sample (adjusted): 2 24
Included observations: 23 after adjustments

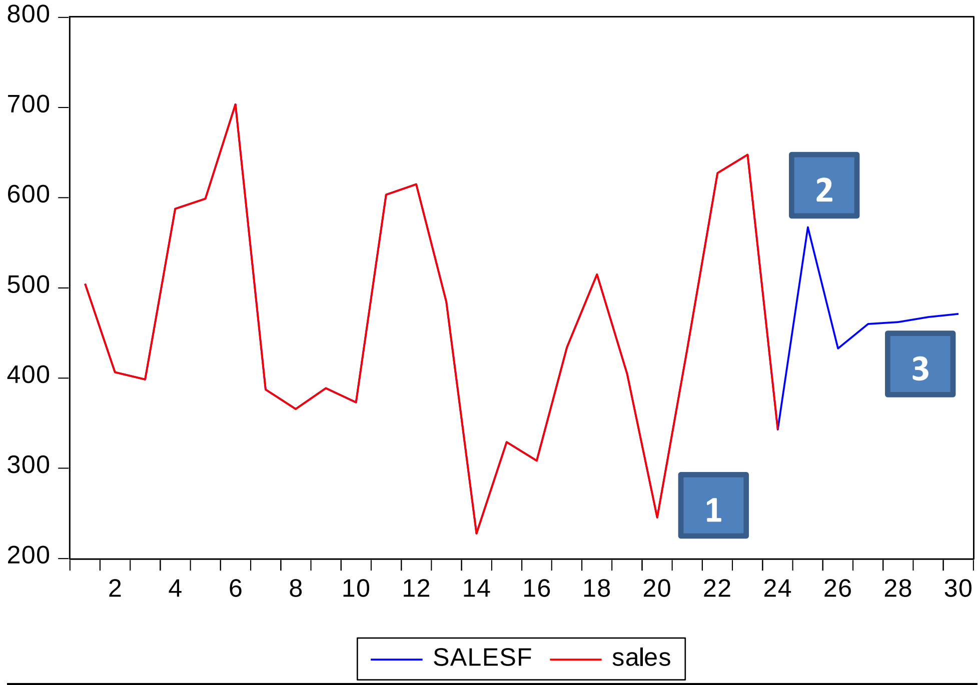
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	341.2918	28.95320	11.78770	0.0000
ADV(-1)	3.238252	0.875865	3.697203	0.0016
PROM	5.818424	1.002906	5.801565	0.0000
PROM(-1)	-3.621209	0.969695	-3.734381	0.0015
DLOG(INDEX)	-1197.232	682.6878	-1.753704	0.0965

R-squared	0.782850	Mean dependent var	453.3652
Adjusted R-squared	0.734594	S.D. dependent var	134.3372
S.E. of regression	69.20722	Akaike info criterion	11.50175
Sum squared resid	86213.50	Schwarz criterion	11.74859
Log likelihood	-127.2701	Hannan-Quinn criter.	11.56383
F-statistic	16.22300	Durbin-Watson stat	1.717798
Prob(F-statistic)	0.000009		

Plot salesf and actuals

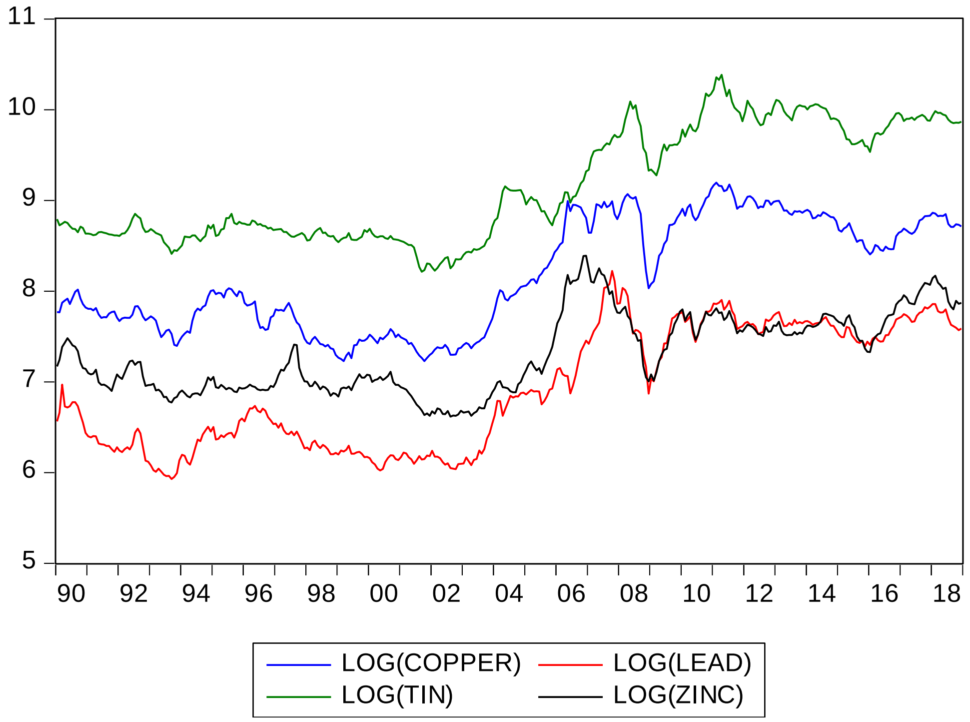


Salesf against sales



Forecasts (2) seem to mirror the same pattern observed 12 months ago (month 14 onwards) (1) before tapering off in month 27-31 (3). This is possibly because I used a L12M average for the variables for prom adv and index.

Metal Prices (Monthly Log(Prices) from 1990-2018)



<u>To check for stationarity we used the correlogram</u>

<u>Correlogram of LOG Copper</u>

Date: 02/16/19 Time: 15:29
Sample: 1990M01 2018M12
Included observations: 348

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.993	0.993	346.16	0.000
		2	0.982	-0.300	685.64	0.000
		3	0.970	0.020	1017.9	0.000
		4	0.958	0.023	1343.1	0.000
		5	0.947	-0.020	1661.4	0.000
		6	0.934	-0.065	1972.4	0.000
		7	0.922	0.038	2276.0	0.000
		8	0.911	0.074	2573.2	0.000
		9	0.901	0.068	2865.0	0.000
		10	0.893	-0.001	3152.1	0.000
		11	0.884	-0.038	3434.4	0.000
		12	0.874	-0.084	3711.1	0.000
		13	0.863	-0.001	3981.9	0.000
		14	0.853	0.031	4247.1	0.000
		15	0.843	-0.011	4506.9	0.000
		16	0.833	0.038	4761.5	0.000
		17	0.823	-0.034	5010.8	0.000
		18	0.813	-0.021	5254.5	0.000
		19	0.802	-0.006	5492.7	0.000
		20	0.793	0.070	5726.1	0.000
		21	0.784	0.002	5955.2	0.000
		22	0.776	-0.048	6179.9	0.000
		23	0.765	-0.068	6399.5	0.000
		24	0.754	-0.023	6613.4	0.000
		25	0.744	0.022	6821.9	0.000
		26	0.734	0.043	7025.5	0.000
		27	0.725	0.057	7224.9	0.000
		28	0.716	-0.010	7420.2	0.000
		29	0.707	-0.020	7611.2	0.000
		30	0.698	-0.014	7798.0	0.000
		31	0.690	0.003	7980.9	0.000
		32	0.683	0.042	8160.5	0.000
		33	0.675	-0.054	8336.6	0.000
		34	0.667	0.022	8509.1	0.000
		35	0.659	0.064	8678.2	0.000
		36	0.651	-0.056	8843.8	0.000

<u>Correlogram of LOG Lead</u>

Date: 02/16/19 Time: 15:30
Sample: 1990M01 2018M12
Included observations: 348

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.992	0.992	345.75	0.000
		2	0.983	-0.147	685.80	0.000
		3	0.973	0.027	1020.3	0.000
		4	0.963	-0.055	1348.8	0.000
		5	0.953	-0.032	1671.0	0.000
		6	0.941	-0.066	1986.2	0.000
		7	0.928	-0.039	2294.0	0.000
		8	0.915	-0.022	2594.3	0.000
		9	0.903	0.036	2887.3	0.000
		10	0.891	0.022	3173.6	0.000
		11	0.879	-0.017	3452.9	0.000
		12	0.867	-0.017	3725.4	0.000
		13	0.855	0.009	3991.0	0.000
		14	0.844	0.070	4250.7	0.000
		15	0.834	0.076	4505.4	0.000
		16	0.826	0.063	4756.0	0.000
		17	0.819	0.013	5002.8	0.000
		18	0.811	-0.024	5245.8	0.000
		19	0.803	-0.068	5484.5	0.000
		20	0.795	-0.025	5719.1	0.000
		21	0.787	0.037	5949.9	0.000
		22	0.780	0.006	6177.3	0.000
		23	0.773	0.001	6401.2	0.000
		24	0.765	-0.025	6621.4	0.000
		25	0.758	-0.006	6837.8	0.000
		26	0.750	-0.017	7050.5	0.000
		27	0.742	0.002	7259.4	0.000
		28	0.735	0.044	7465.0	0.000
		29	0.728	0.033	7667.4	0.000
		30	0.721	-0.017	7866.3	0.000
		31	0.713	-0.033	8061.6	0.000
		32	0.706	0.066	8253.7	0.000
		33	0.700	-0.021	8443.0	0.000
		34	0.693	-0.032	8629.2	0.000
		35	0.685	-0.046	8811.9	0.000
		36	0.678	0.026	8991.3	0.000

Correlogram of LOG Tin

Date: 02/16/19 Time: 15:32
Sample: 1990M01 2018M12
Included observations: 348

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.994	0.994	346.59	0.000
		2	0.985	-0.180	688.24	0.000
		3	0.975	-0.095	1023.9	0.000
		4	0.965	0.017	1353.6	0.000
		5	0.954	-0.017	1677.1	0.000
		6	0.944	0.007	1994.5	0.000
		7	0.934	-0.025	2305.8	0.000
		8	0.923	-0.033	2610.7	0.000
		9	0.912	0.051	2909.6	0.000
		10	0.902	0.005	3202.8	0.000
		11	0.892	-0.021	3490.2	0.000
		12	0.881	-0.044	3771.7	0.000
		13	0.871	0.041	4047.4	0.000
		14	0.861	-0.011	4317.5	0.000
		15	0.850	-0.003	4582.1	0.000
		16	0.841	0.013	4841.3	0.000
		17	0.832	0.059	5095.8	0.000
		18	0.823	0.005	5345.7	0.000
		19	0.814	-0.036	5591.1	0.000
		20	0.806	0.023	5832.3	0.000
		21	0.798	0.068	6069.7	0.000
		22	0.792	0.052	6304.0	0.000
		23	0.786	-0.002	6535.5	0.000
		24	0.780	-0.034	6764.1	0.000
		25	0.775	0.056	6990.4	0.000
		26	0.770	0.023	7214.4	0.000
		27	0.765	0.044	7436.7	0.000
		28	0.762	0.009	7657.6	0.000
		29	0.759	0.035	7877.6	0.000
		30	0.756	-0.017	8096.5	0.000
		31	0.753	0.015	8314.5	0.000
		32	0.751	0.018	8531.8	0.000
		33	0.748	-0.010	8748.3	0.000
		34	0.745	-0.066	8963.8	0.000
		35	0.742	0.001	9177.9	0.000
		36	0.738	-0.023	9390.5	0.000

Correlogram of Log Zinc

Date: 02/16/19 Time: 15:33
Sample: 1990M01 2018M12
Included observations: 348

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.987	0.987	342.04	0.000
		2	0.968	-0.248	671.97	0.000
		3	0.947	-0.032	988.62	0.000
		4	0.926	0.010	1292.2	0.000
		5	0.902	-0.126	1581.1	0.000
		6	0.876	-0.034	1854.7	0.000
		7	0.849	-0.045	2112.3	0.000
		8	0.822	-0.004	2354.4	0.000
		9	0.794	-0.024	2581.0	0.000
		10	0.767	0.029	2793.1	0.000
		11	0.739	-0.044	2990.7	0.000
		12	0.712	-0.016	3174.3	0.000
		13	0.685	0.038	3344.8	0.000
		14	0.660	0.020	3503.4	0.000
		15	0.636	0.018	3651.2	0.000
		16	0.611	-0.056	3788.3	0.000
		17	0.587	0.016	3915.3	0.000
		18	0.565	0.034	4033.2	0.000
		19	0.545	0.005	4142.9	0.000
		20	0.525	-0.001	4245.2	0.000
		21	0.506	0.001	4340.4	0.000
		22	0.487	0.001	4429.1	0.000
		23	0.469	-0.017	4511.6	0.000
		24	0.454	0.100	4589.2	0.000
		25	0.442	0.021	4662.7	0.000
		26	0.430	-0.006	4732.7	0.000
		27	0.421	0.080	4799.8	0.000
		28	0.413	-0.010	4864.6	0.000
		29	0.404	-0.052	4927.0	0.000
		30	0.397	0.009	4987.4	0.000
		31	0.390	0.024	5045.9	0.000
		32	0.386	0.076	5103.4	0.000
		33	0.383	-0.037	5160.0	0.000
		34	0.380	0.028	5216.0	0.000
		35	0.377	-0.016	5271.4	0.000
		36	0.375	0.028	5326.4	0.000

A check against the above correlograms indicates that they are non stationary.

<u>Johansen-Cointegration Test</u>

Date: 02/16/19 Time: 15:35
Sample (adjusted): 1990M03 2018M12
Included observations: 346 after adjustments
Trend assumption: No deterministic trend (restricted constant)
Series: LOG(COPPER) LOG(LEAD) LOG(TIN) LOG(ZINC)
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.078118	54.58767	54.07904	$\boxed{0.0450}$
At most 1	0.044796	26.44455	35.19275	0.3177
At most 2	0.026528	10.58727	20.26184	0.5822
At most 3	0.003706	1.284661	9.164546	0.9101

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.078118	28.14312	28.58808	$\boxed{0.0569}$
At most 1	0.044796	15.85728	22.29962	0.3085
At most 2	0.026528	9.302613	15.89210	0.4020
At most 3	0.003706	1.284661	9.164546	0.9101

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LOG(COPPER)	LOG(LEAD)	LOG(TIN)	LOG(ZINC)	C
-2.664133	6.755345	-4.381520	-0.442444	18.44987
4.599743	-1.138564	-3.601509	0.888597	-3.114668
3.798540	1.556980	-2.014232	-5.279514	15.14970
-0.254843	0.728597	0.615509	0.310015	-11.42763

Unrestricted Adjustment Coefficients (alpha):

D(LOG(COP...	0.006838	-0.004264	-0.001509	-0.002849
D(LOG(LEAD))	-0.004979	0.004102	-0.001740	-0.003780
D(LOG(TIN))	0.009695	0.006532	0.000283	-0.001506
D(LOG(ZINC))	0.001629	-0.000571	0.005745	-0.002782

1 Cointegrating Equation(s): Log likelihood 2192.584

Normalized cointegrating coefficients (standard error in parentheses)

LOG(COPPER)	LOG(LEAD)	LOG(TIN)	LOG(ZINC)	C
1.000000	-2.535663	1.644632	0.166074	-6.925281
	(0.45645)	(0.40814)	(0.34076)	(1.93706)

Adjustment coefficients (standard error in parentheses)

D(LOG(COP...	-0.018218
	(0.00820)
D(LOG(LEAD))	0.013266
	(0.00982)
D(LOG(TIN))	-0.025830
	(0.00746)
D(LOG(ZINC))	-0.004341
	(0.00838)

2 Cointegrating Equation(s): Log likelihood 2200.512

Normalized cointegrating coefficients (standard error in parentheses)

LOG(COPPER)	LOG(LEAD)	LOG(TIN)	LOG(ZINC)	C
1.000000	0.000000	-1.045597	0.196117	-0.001223
		(0.17043)	(0.24422)	(1.03506)
0.000000	1.000000	-1.060957	0.011848	2.730669
		(0.10856)	(0.15556)	(0.65931)

Adjustment coefficients (standard error in parentheses)

D(LOG(COP...	-0.037830	0.051048
	(0.01632)	(0.02104)
D(LOG(LEAD))	0.032134	-0.038308
	(0.01957)	(0.02522)
D(LOG(TIN))	0.004214	0.058059
	(0.01477)	(0.01904)
D(LOG(ZINC))	-0.006969	0.011657
	(0.01671)	(0.02154)

3 Cointegrating Equation(s): Log likelihood 2205.164

Normalized cointegrating coefficients (standard error in parentheses)

LOG(COPPER)	LOG(LEAD)	LOG(TIN)	LOG(ZINC)	C
1.000000	0.000000	0.000000	-1.554440	3.157166
			(0.22633)	(1.65523)
0.000000	1.000000	0.000000	-1.764425	5.935456
			(0.25745)	(1.88281)
0.000000	0.000000	1.000000	-1.674218	3.020657
			(0.27570)	(2.01632)

Adjustment coefficients (standard error in parentheses)

D(LOG(COP...	-0.043561	0.048699	-0.011566
	(0.02006)	(0.02157)	(0.01848)
D(LOG(LEAD))	0.025526	-0.041016	0.010547
	(0.02404)	(0.02585)	(0.02215)
D(LOG(TIN))	0.005290	0.058500	-0.066575
	(0.01816)	(0.01953)	(0.01673)
D(LOG(ZINC))	0.014855	0.020603	-0.016654
	(0.02044)	(0.02198)	(0.01883)

From the above, we can see that we can reject the null hypothesis that there are no cointegrated variables at a 95% confidence interval under the trace test and 94% confidence interval under the maximum eigen value test.

Vector Error Correction Estimates

Vector Error Correction Estimates
Date: 02/16/19 Time: 15:47
Sample (adjusted): 1990M03 2018M12
Included observations: 346 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LOG(COPPER(-1))	1.000000
LOG(LEAD(-1))	-2.535663
	(0.45645)
	$\boxed{[-5.55520]}$
LOG(TIN(-1))	1.644632
	(0.40814)
	$\boxed{[\ 4.02953]}$
LOG(ZINC(-1))	0.166074
	(0.34076)
	[0.48736]
C	-6.925281
	(1.93706)
	[-3.57515]

The equation indicates that:

LOG(COPPER (-1)) = 5.5 LOG(LEAD (-1)) – 1.65 LOG(TIN (-1)) + 0.17 LOG(ZINC (-1)) – 6.93

There is a positive correlation between the price of copper and lead, while there is a negative correlation between the price of copper and the price of tin.

We note from the t statistics that LOG ZINC is not statistically significant, meaning it is not entering into the long term equation with copper, lead, and tin.

System of Equations

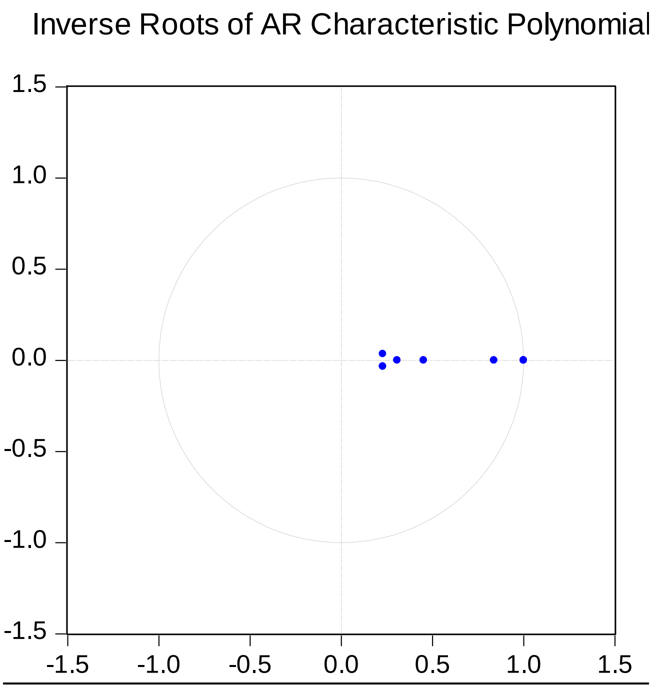
Error Correction:	D(LOG(CO...	D(LOG(LE...	D(LOG(TIN))	D(LOG(ZINC))
CointEq1	-0.018358	0.014190	-0.025730	-0.004139
	(0.00838)	(0.01002)	(0.00762)	(0.00855)
	[-2.19159]	[1.41546]	[-3.37608]	[-0.48402]
D(LOG(COPPER(-1)))	0.420359	0.088349	0.091142	0.190775
	(0.06853)	(0.08201)	(0.06235)	(0.06996)
	[6.13430]	[1.07727]	[1.46181]	[2.72676]
D(LOG(LEAD(-1)))	-0.090019	0.227931	0.017069	-0.051980
	(0.05867)	(0.07022)	(0.05338)	(0.05990)
	[-1.53429]	[3.24603]	[0.31975]	[-0.86775]
D(LOG(TIN(-1)))	-0.022938	-0.155624	0.199468	-0.222176
	(0.06518)	(0.07801)	(0.05931)	(0.06655)
	[-0.35192]	[-1.99493]	[3.36338]	[-3.33850]
D(LOG(ZINC(-1)))	0.032855	0.024887	-0.016007	0.303320
	(0.06805)	(0.08144)	(0.06192)	(0.06948)
	[0.48281]	[0.30558]	[-0.25854]	[4.36574]
C	0.001830	0.002201	0.002413	0.001508
	(0.00309)	(0.00370)	(0.00281)	(0.00315)
	[0.59238]	[0.59525]	[0.85857]	[0.47818]

From the VECR lead and tin have a statistically significant long term relationship with copper, while zinc does not.

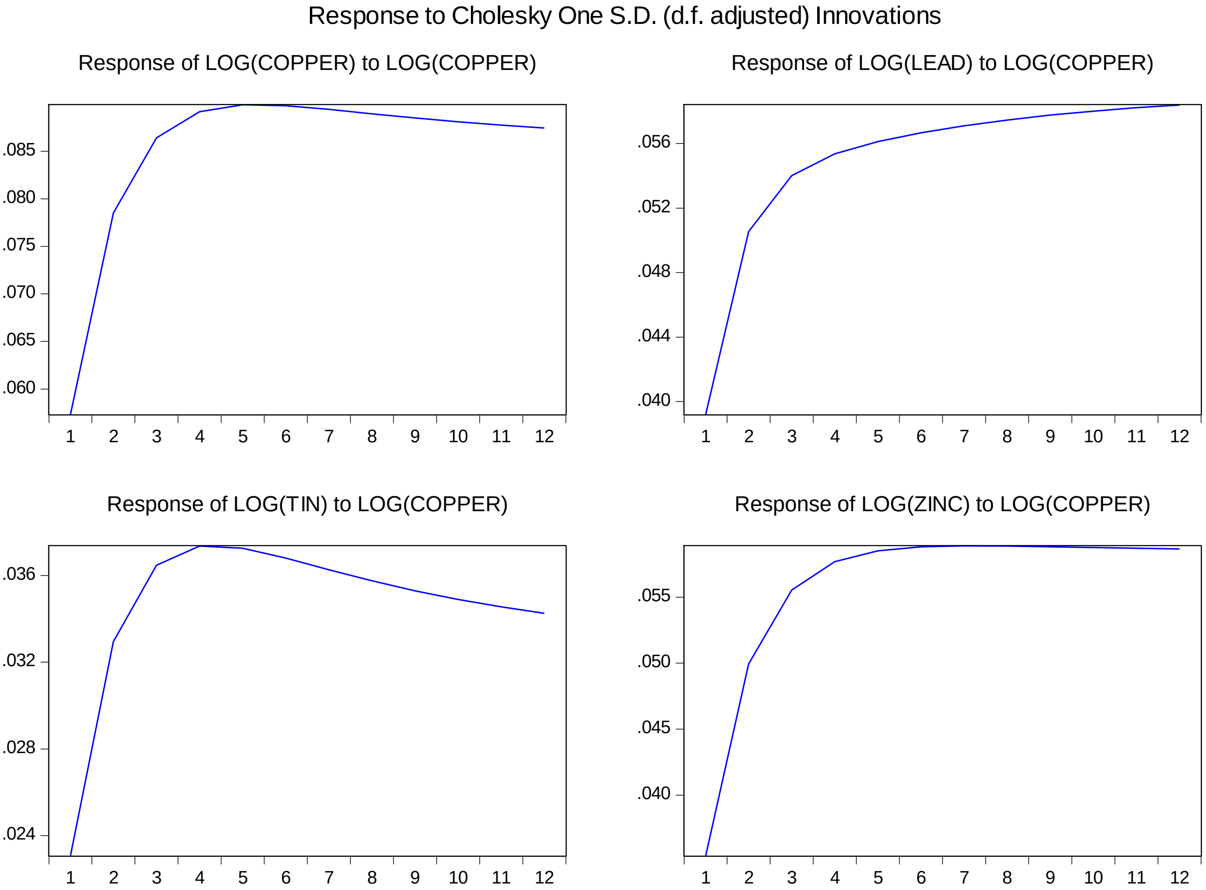
From the system of equations, tin(-1) is the most important variable in forecasting the prices of lead, tin, and zinc, but not copper.

I would improve the model by dropping the Zinc variable which is does not have a long term relationship with the other variables, and instead use past Zinc prices to forecast Zinc prices in the future.

Inverse roots of AR characteristic polynomial

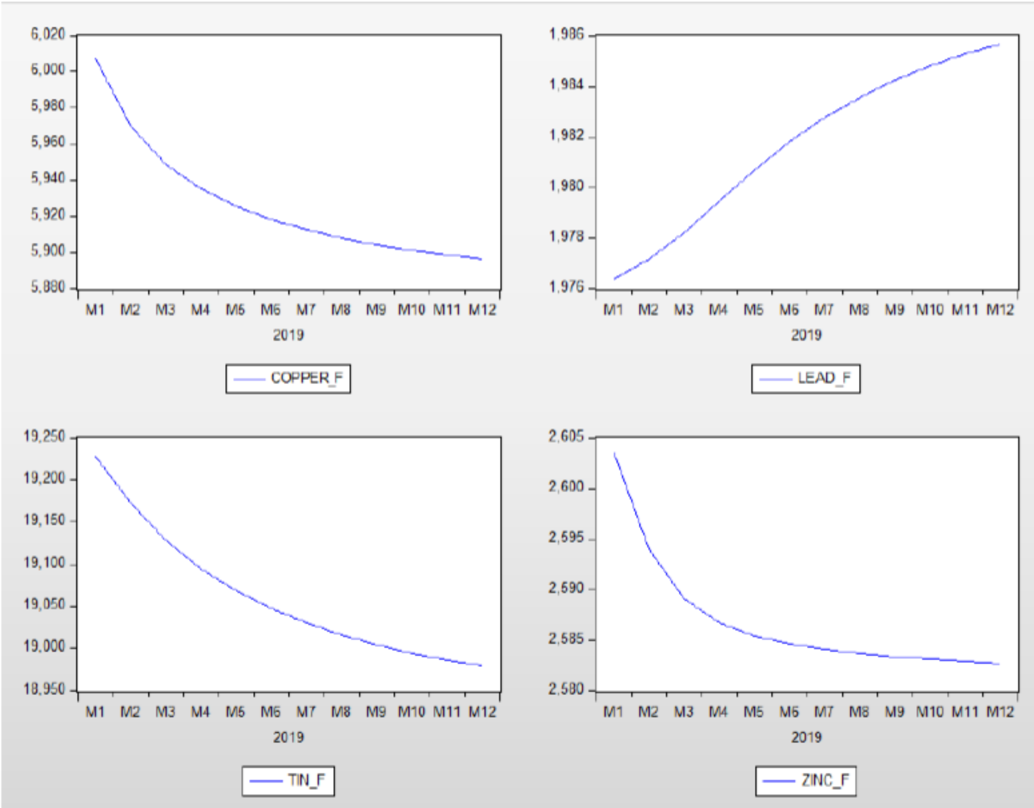


Impulse Response Graph



Finally we test the model's forecasts.

Out of Sample Forecasting



Error Correction:	D(LOG(CO...	D(LOG(LE...	D(LOG(TIN))	D(LOG(ZINC))
CointEq1	-0.018358 (0.00838) [-2.19159]	$\boxed{0.014190}$ (0.01002) [1.41546]	-0.025730 (0.00762) [-3.37608]	-0.004139 (0.00855) [-0.48402]

From the out of sample forecasting above, we can conclude:

In the next 12 months, prices of copper, tin, and zinc are expected to decrease, while prices of lead are expected to increase.

This is explained by the above circled long term change in price of lead which is expected to have a positive coefficient, while the other metals have a negative coefficient, forecasting a downward trend.