Workshop 5

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VAR & COINTEGRATION: precious metals

1. Log price

There is either none or at most 1 cointegration equation.

Date: 02/16/19 Time: 15:43
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	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	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(COPP...	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(CO...	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(COPP...	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(CO...	-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(COPP...	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(CO...	-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(COPP...	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(CO...	-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)

2. Estimate cointegration

Zinc is not important to the long-term relationship with other metals while the rest are.

Lead is important to the long-term relationship with others so we can not exclude lead but zinc.

Copper and Tin affect the long-term of themselves.

Vector Error Correction Estimates
Date: 02/16/19 Time: 15:48
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) [-5.55520]
LOG(TIN(-1))	1.644632 (0.40814) [4.02953]
LOG(ZINC(-1))	0.166074 (0.34076) [0.48736]
C	-6.925281 (1.93706) [-3.57515]

Error Correction:	D(LOG(C...	D(LOG(LE...	D(LOG(TIN))	D(LOG(ZINC))
CointEq1	-0.018218 (0.00820) [-2.22041]	0.013266 (0.00982) [1.35031]	-0.025830 (0.00746) [-3.46049]	-0.004341 (0.00838) [-0.51821]
D(LOG(COPPER(-1)))	0.420624 (0.06844) [6.14621]	0.089441 (0.08195) [1.09147]	0.091521 (0.06226) [1.46997]	0.191225 (0.06987) [2.73686]
D(LOG(LEAD(-1)))	-0.089978 (0.05860) [-1.53538]	0.227445 (0.07017) [3.24128]	0.016599 (0.05331) [0.31135]	-0.052085 (0.05983) [-0.87054]
D(LOG(TIN(-1)))	-0.021968 (0.06506) [-0.33765]	-0.153571 (0.07791) [-1.97125]	0.200727 (0.05919) [3.39117]	-0.221108 (0.06643) [-3.32867]
D(LOG(ZINC(-1)))	0.032673 (0.06797) [0.48070]	0.024900 (0.08139) [0.30595]	-0.016137 (0.06184) [-0.26096]	0.303236 (0.06939) [4.36983]
R-squared	0.163207	0.063175	0.112511	0.136039
Adj. R-squared	0.153391	0.052186	0.102100	0.125904
Sum sq. resids	1.119006	1.604394	0.926161	1.166389
S.E. equation	0.057285	0.068593	0.052115	0.058485
F-statistic	16.62706	5.748865	10.80750	13.42340
Log likelihood	501.0290	438.6961	533.7515	493.8543
Akaike AIC	-2.867220	-2.506914	-3.056367	-2.825747
Schwarz SC	-2.811635	-2.451330	-3.000782	-2.770163
Mean dependent	0.002733	0.002682	0.003296	0.001814
S.D. dependent	0.062258	0.070456	0.054999	0.062555

Determinant resid covariance (dof adj.)	3.90E-11
Determinant resid covariance	3.68E-11
Log likelihood	2192.584
Akaike information criterion	-12.52939
Schwarz criterion	-12.25146
Number of coefficients	25

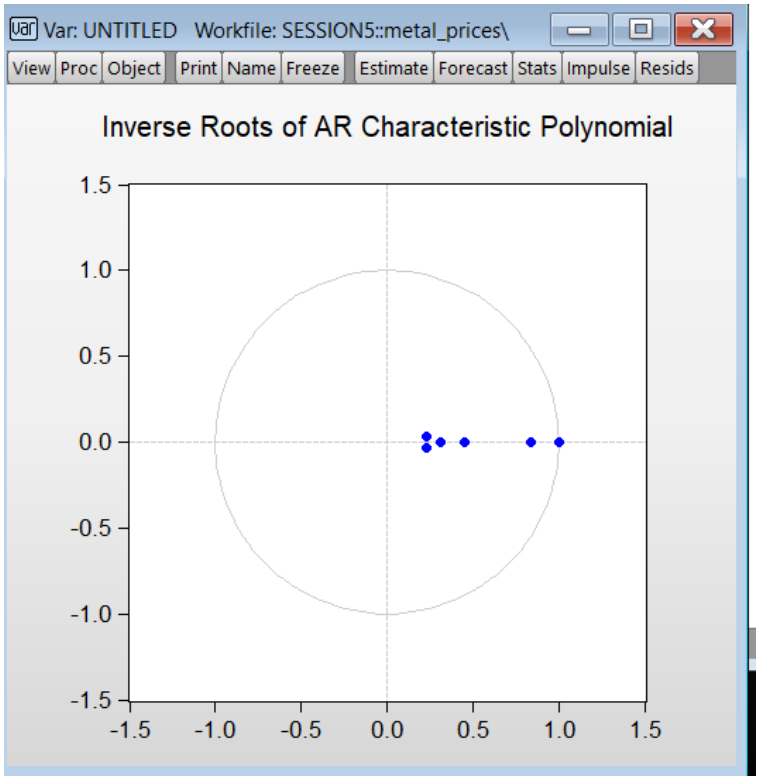
Improve the model by remove zinc. The Schwarz SC are smaller in the new model.

Vector Error Correction Estimates
Date: 02/16/19 Time: 16:33
Sample (adjusted): 1990M03 2018M12
Included observations: 346 after adjustments
Standard errors in ( ) & t-statistics in [ ]

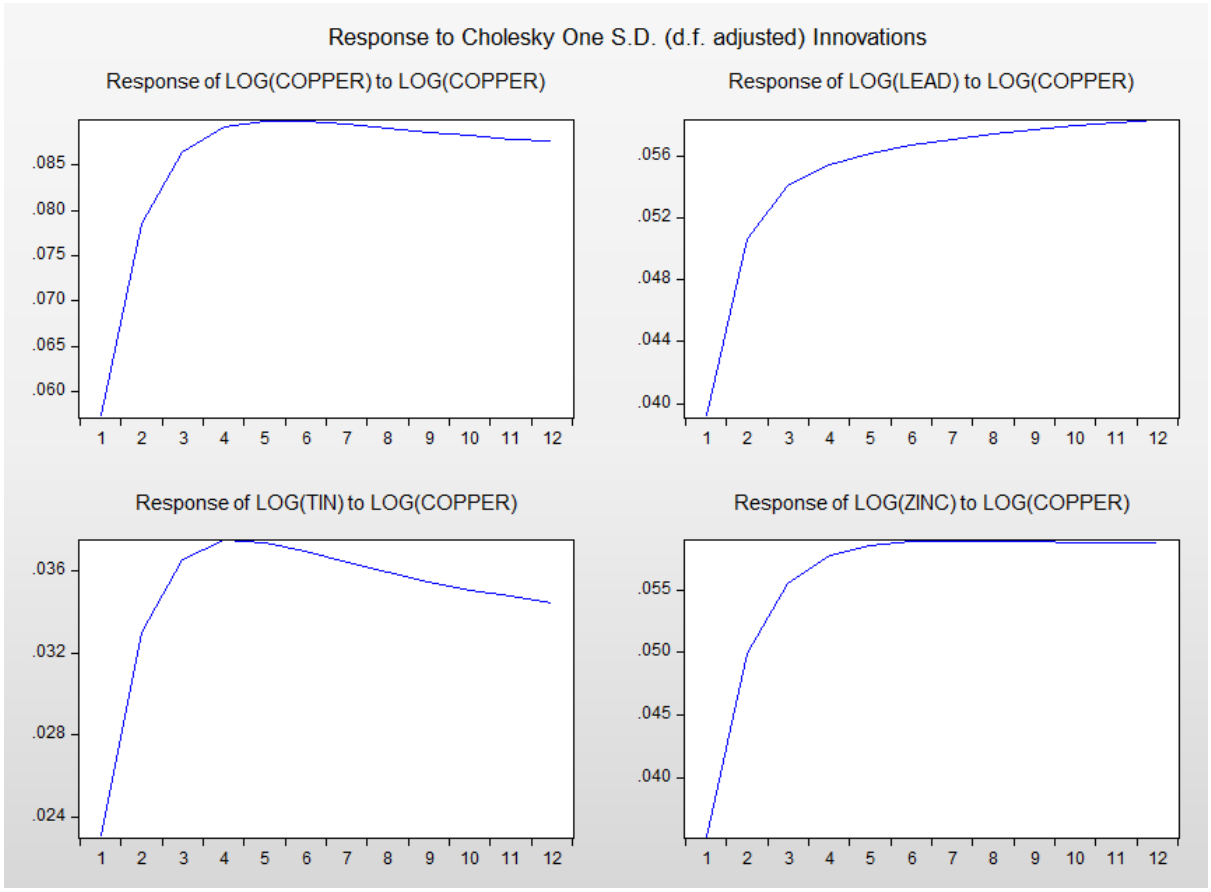
Cointegrating Eq:	CointEq1
LOG(COPPER(-1))	1.000000
LOG(LEAD(-1))	-2.317021 (0.35539) [-6.51974]
LOG(TIN(-1))	1.511694 (0.37974) [3.98085]
C	-6.007473 (1.31492) [-4.56871]

Error Correction:	D(LOG(C...	D(LOG(LE...	D(LOG(TIN))
CointEq1	-0.019226 (0.00873) [-2.20103]	0.013574 (0.01046) [1.29774]	-0.027917 (0.00794) [-3.51523]
D(LOG(COPPER(-1)))	0.434114 (0.06269) [6.92491]	0.099412 (0.07507) [1.32431]	0.085659 (0.05700) [1.50287]
D(LOG(LEAD(-1)))	-0.080055 (0.05474) [-1.46255]	0.234107 (0.06554) [3.57172]	0.011102 (0.04977) [0.22308]
D(LOG(TIN(-1)))	-0.020546 (0.06474) [-0.31736]	-0.150524 (0.07752) [-1.94166]	0.197517 (0.05886) [3.35557]
R-squared	0.162610	0.062416	0.112950
Adj. R-squared	0.155264	0.054191	0.105169
Sum sq. resids	1.119805	1.605695	0.925703
S.E. equation	0.057221	0.068520	0.052026
F-statistic	22.13722	7.589059	14.51583
Log likelihood	500.9055	438.5559	533.8371
Akaike AIC	-2.872286	-2.511884	-3.062642
Schwarz SC	-2.827819	-2.467416	-3.018174
Mean dependent	0.002733	0.002682	0.003296
S.D. dependent	0.062258	0.070456	0.054999

Determinant resid covariance (dof adj.)	2.11E-08
Determinant resid covariance	2.04E-08
Log likelihood	1590.489
Akaike information criterion	-9.101093
Schwarz criterion	-8.923223
Number of coefficients	16



There is no long-term impact of copper on zinc. While for copper, lead and tin, there is long-term relationship with copper.



There is relatively sharp fall in copper, tin and zinc in the next 3 months while an increase in lead. After falling, the price of zinc is forecast to stabilize in the longer term whereas the other three metals continue to vary due to the cointegration between them. The long term trends are aligned with Vector Error Correction coefficients.