Super Cycles in Metals Prices?

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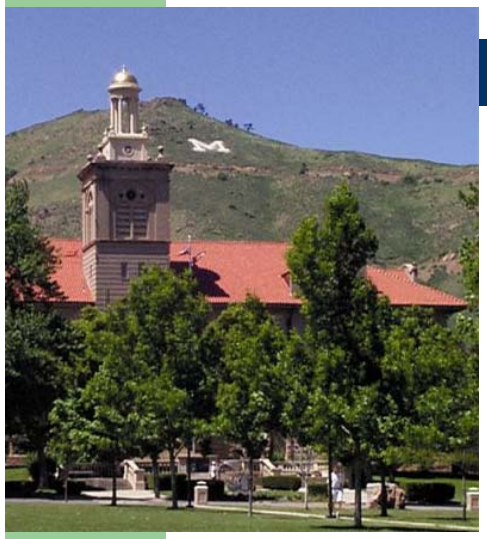


Economics (Policy)

Engineering Technology Mgt (ETM)

Quantitative Business Analysis (Finance-Operations Research)

Abstract

- "The study of super cycles necessarily begins with the measurement of super cycles"
- Are metal prices currently in the early phase of a 'super cycle'? Many market observers believe the answer is 'yes'
- This paper searches for evidence of super cycles in metal prices by using band-pass filters to extract particular cyclical components from time series data
- Evidence is consistent with the hypothesis that:
  - There have been two or three super cycles in the past 150 years or so
  - We are currently in the early phase of a new super cycle – presumably driven by Chinese urbanization and industrialization

Motivation/Background

- Economists and financial analysts have a longstanding interest in studying trends and cycles in various macroeconomic and financial variables
- Both very short cycles and very long cycles have been considered, as has everything in between:
  - Seasonal fluctuations
  - Business cycles: 6 - 32 quarters
  - Kitchin inventory cycles: 3 - 5 years
  - Juglar fixed investment cycles: 7 - 11 years
  - Kuznets (real estate, infrastructural investment) cycles: 15 - 25 years
  - Bronson asset allocation cycles: ~ 30 years
  - Kondratiev waves or ‘grand super cycles’: 45 - 60 years

Motivation/Background (cont.)

- **Skepticism about long cycles:**
  - **Academic economists have expressed skepticism about the existence of long cycles**
  - **Inappropriate de-trending techniques can produce cycles that are statistical artifacts (aka “spurious periodicity”)**

Motivation/Background (cont.)

- Ongoing interest in trends and cycles in the prices for nonrenewable resources
  - Hotelling hypothesis: real price of a nonrenewable resource should rise at a rate equal to the real interest rate
  - The Prebisch-Singer hypothesis -- there will be a secular decline in the price of primary commodities relative to manufacturing goods (due to both supply and demand factors)
  - Dutch Disease' or 'Malaise Hollandaise' -- commodity-dependent countries (and intra-national regions) are subject to booms and busts and macroeconomic mismanagement often leaves the economy worse off after the boom subsides
  - Longer cycles discussed by Marian Radetkzi (2006) -- three booms in post World War II period
  - Metal prices have a large business cycle component
- Current interest in super cycles

Super Cycles

- Alan Heap (Citigroup) argued in March 2005 that "a super cycle is underway, driven by material intensive economic growth in China" (Heap 2005 at 1)
- "A super cycle is a prolonged (decades) long trend rise in real commodity prices, driven by urbanization and industrialization of a major economy" (Heap 2005 at 1)
- "Super cycles are demand driven" (Heap 2005 at 2)
- "There have been two super cycles in the past 150 years: late 1800s - early 1900s, [driven by] economic growth in the USA; and from 1945 to 1975 as a result of post-war reconstruction in Europe, and subsequently by the Japanese economics renaissance" (Heap 2005 at 1 - 2)

Methods for Studying Trends and Cycles

- Informal inspection of the data combined with a good knowledge of economic history and particular markets being studied
- Formal statistical methods, which have begun to appear in the macroeconomic 'business cycle' literature.
  - Hodrick-Prescott (1997) filter for isolating long-term growth effects ('trends') and business cycles.
  - Band-pass filters of Baxter-King (1999) and Christiano-Fitzgerald (2003).

Band-Pass Filters

- Economic time series can be represented as a combination of cyclical components of various periodicities or frequencies
- Christiano and Fitgerald:
  - "The theory of the spectral analysis of time series provides a rigorous foundation for the notion that there are different frequency components of the data. An advantage of this theory, relative to other perspectives on decomposing time series, is that it does not require a commitment to any particular statistical model of the data. Instead it replies on the Spectral Representation Theorem, according to which *any* time series within a broad class can be decomposed into different frequency components. The theory also supplies a tool for extracting those components. That tool is the *ideal band pass filter.*" (1999 p. 1)

Methodology

- Use the Christiano-Fitzgerald asymmetric filter to decompose (the natural logs of) real and nominal metal prices into several components
  - LP_SC
    - Super cycles - periods between 20 and 70 years (based on Heap's discussion): LP_BP(20,70)
  - LP_T
    - Long-term trends - cyclical components with a period > 70 years: LP_BP(70,∞)
  - LP_NT
    - Total non-trend: LP_BP(2,70)

Methodology (cont.)

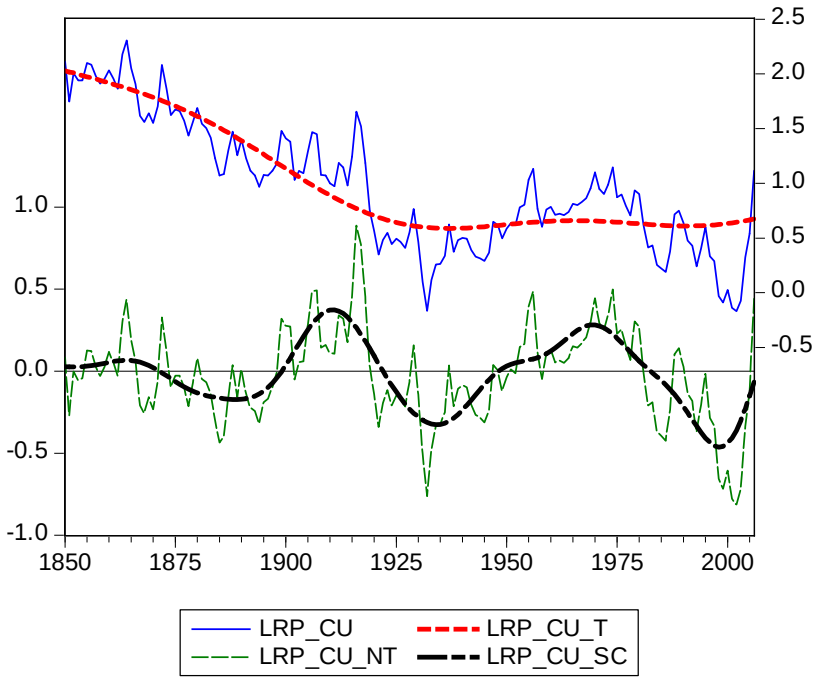
- Non-Trend Component (cycles with periods from 2 - 70 years) are comprised of:
  - Business cycles (2 - 8 years)
  - Intermediate cycles (8 - 20 years)
  - Super cycles (20 - 70 years)
- LP_BP(2,70) = LP_BP(2,8) + LP_BP(8,20) + LP_BP(20,70)

Real Prices: LME Metals

- Copper

- Aluminum
- Lead
- Nickel
- Tin
- Zinc

Copper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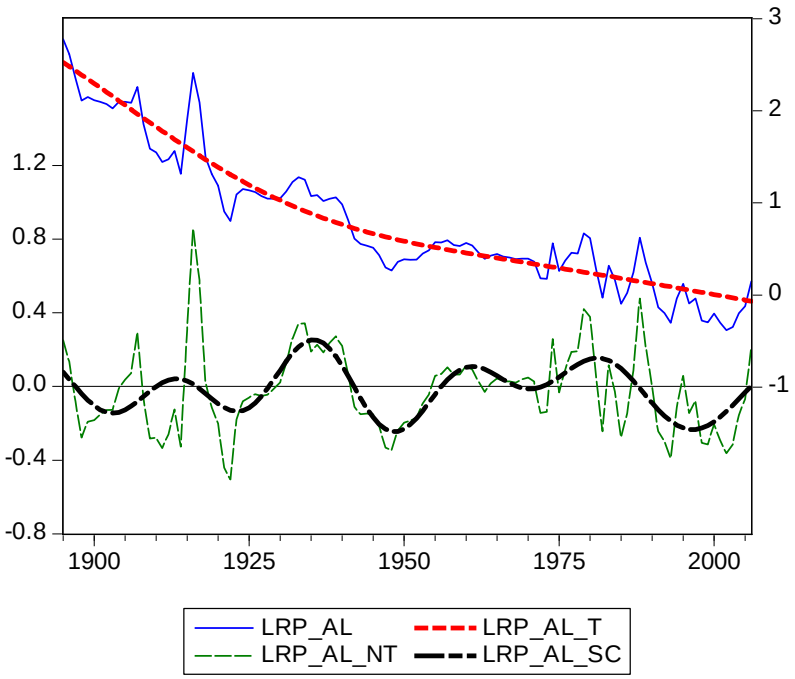
Aluminum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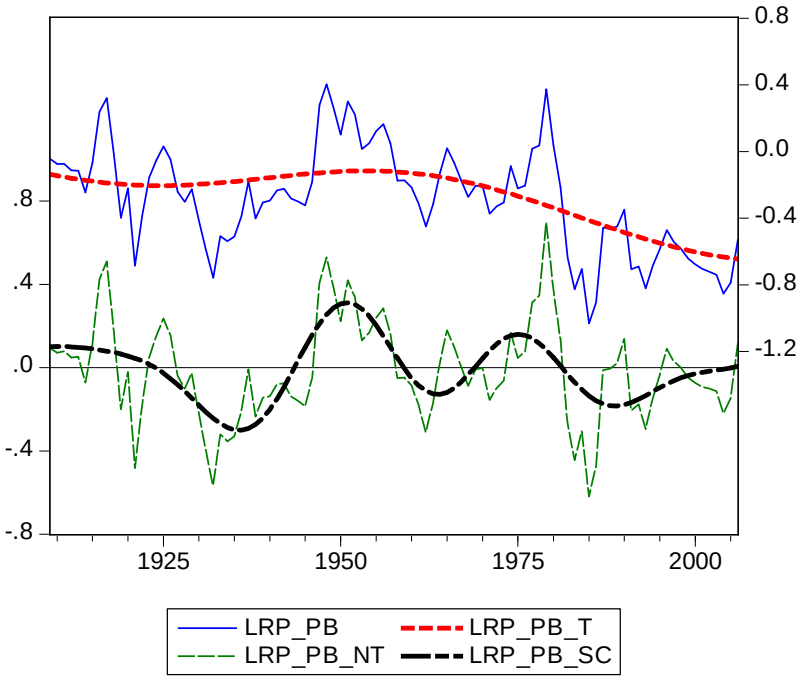
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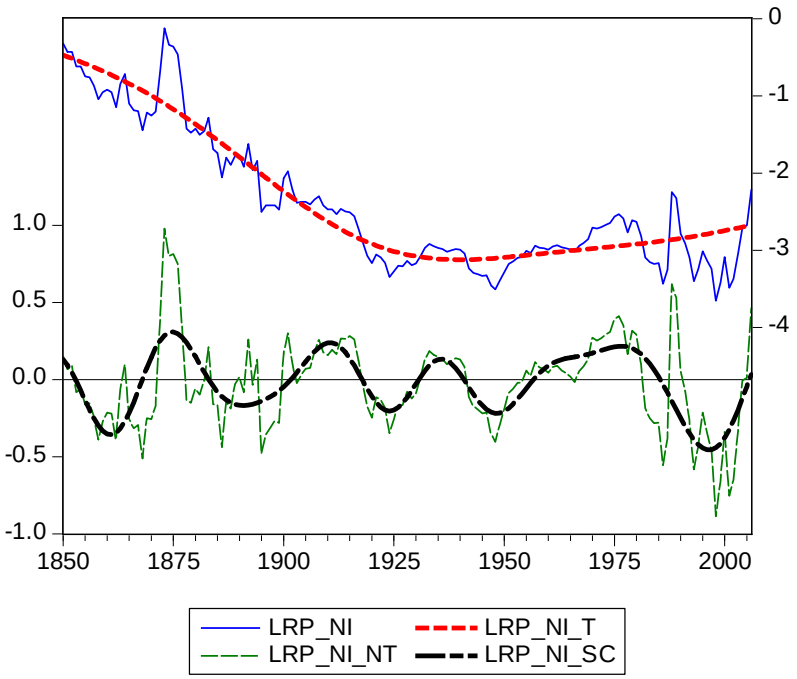
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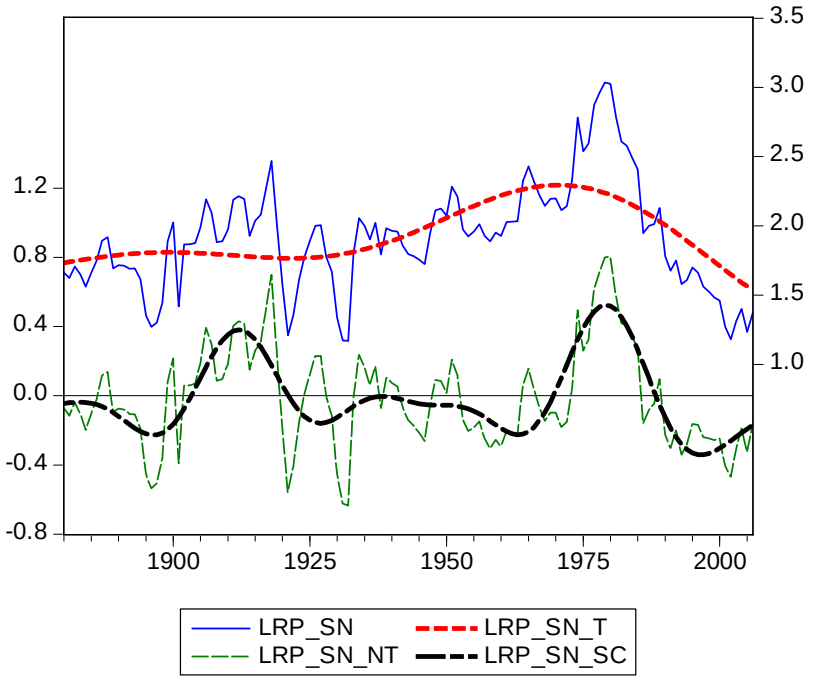
Tin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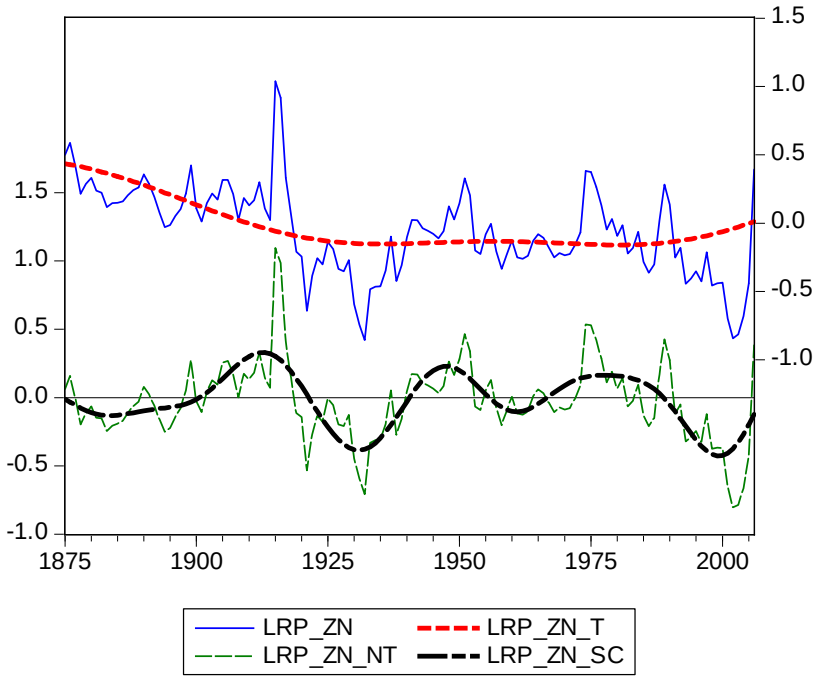
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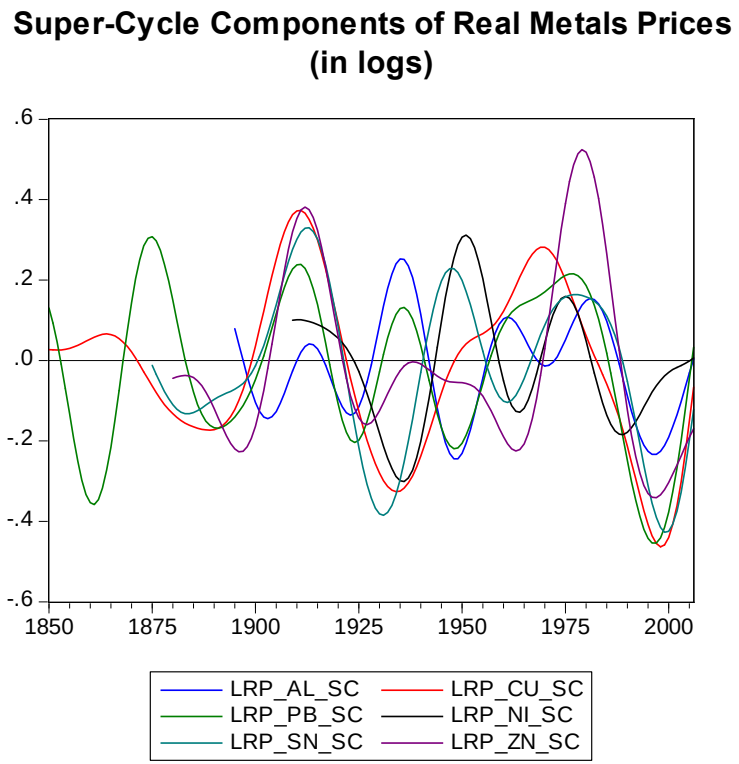
Super Cycles in Real Base Metal Prices?



More Formal Evidence

- **Correlations among the super cycle components are very high**
- **“Principal component” analysis supports view that there is a single component that explains a large portion of the super cycle component in each of the metal series**

Correlation Analysis: Base Metals

Covariance (p-value)	Aluminum	Copper	Lead	Nickel	Tin	Zinc
Aluminum	1.00					
Copper	0.33	1.00				
	(0.00)	--				
Lead	0.17	0.70	1.00			
	(0.10)	(0.00)	--			
Nickel	0.73	0.75	0.29	1.00		
	(0.00)	(0.00)	(0.00)	--		
Tin	0.62	0.67	0.56	0.79	1.00	
	(0.00)	(0.00)	(0.00)	(0.00)	--	
Zinc	0.33	0.83	0.77	0.58	0.81	1.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	--

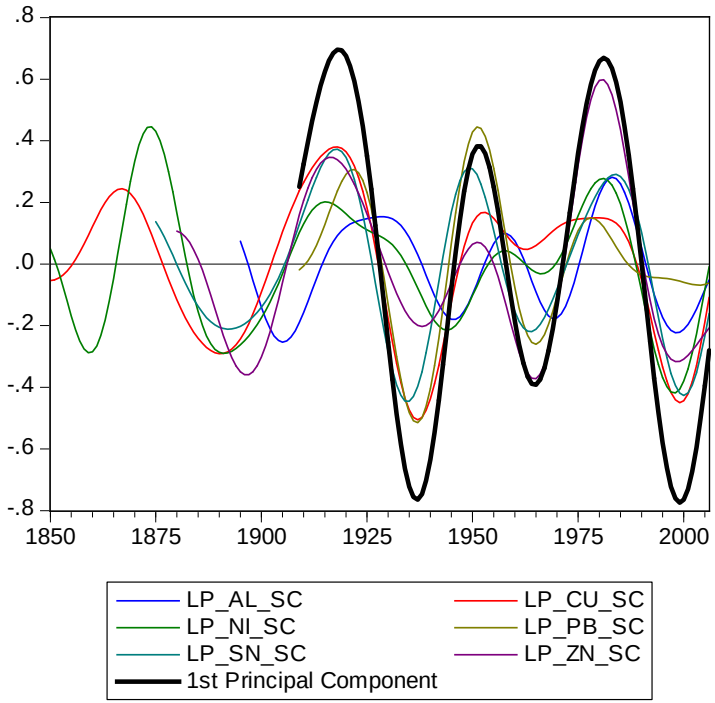
Principal Component Analysis: Eigen Values: Base Metals

Name	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	0.22	0.18	0.73	0.22	0.73
2	0.04	0.02	0.14	0.26	0.87
3	0.02	0.01	0.07	0.29	0.94
4	0.01	0.01	0.04	0.30	0.98
5	0.01	0.00	0.02	0.30	1.00
6	0.00	--	0.00	0.30	1.00

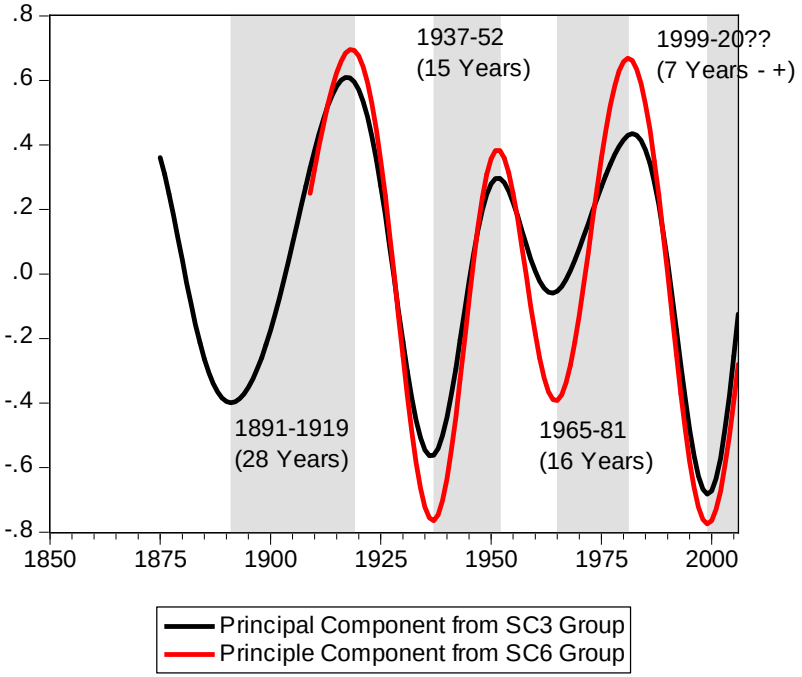
Principal Component Analysis: Eigen Vectors (Loadings): Base

Variable	PC 1	PC2
Aluminum	0.15	0.45
Copper	0.49	-0.16
Lead	0.29	0.46
Nickel	0.36	-0.58
Tin	0.51	0.40
Zinc	0.50	-0.23

1st Principal Component: Base Metals



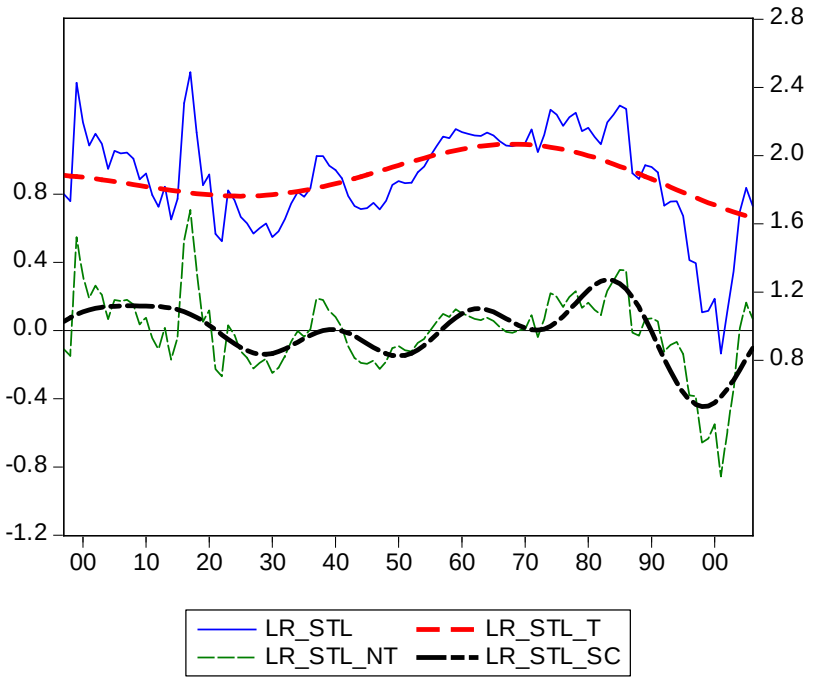
Principal Component Comparison



Real Prices: Steel-related metals

- Steel
- Pig Iron
- Molybdenum

Steel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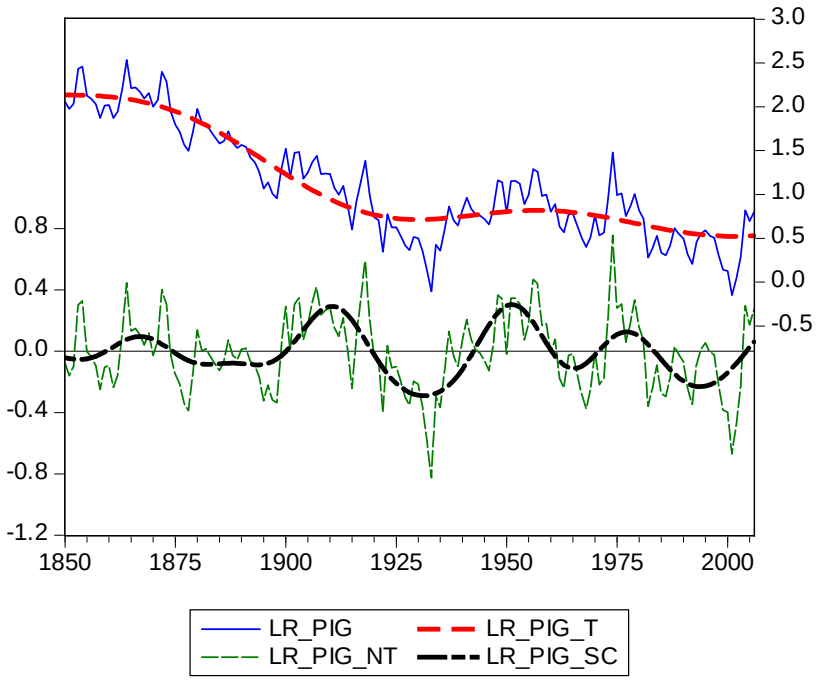
Pig Iron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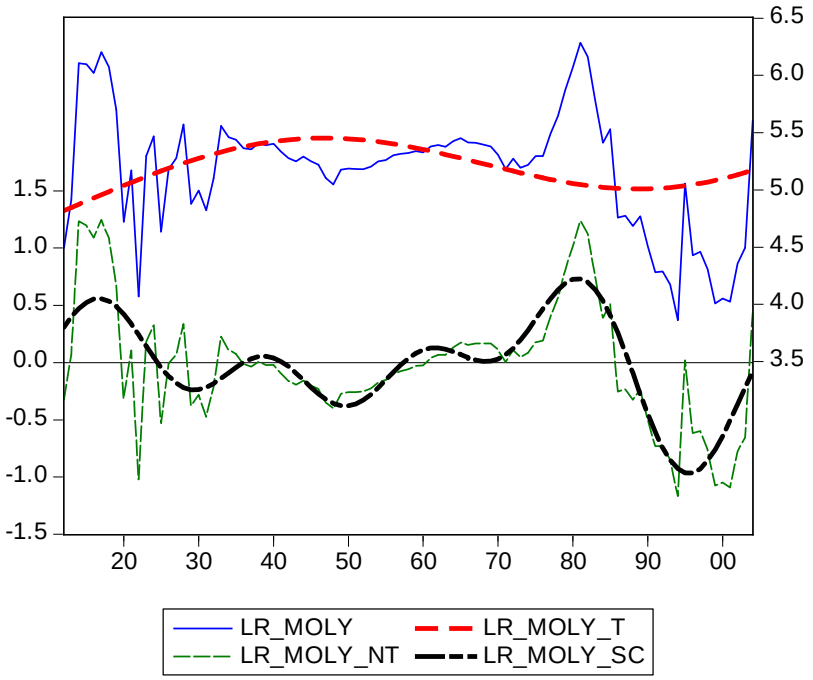
Molybdenum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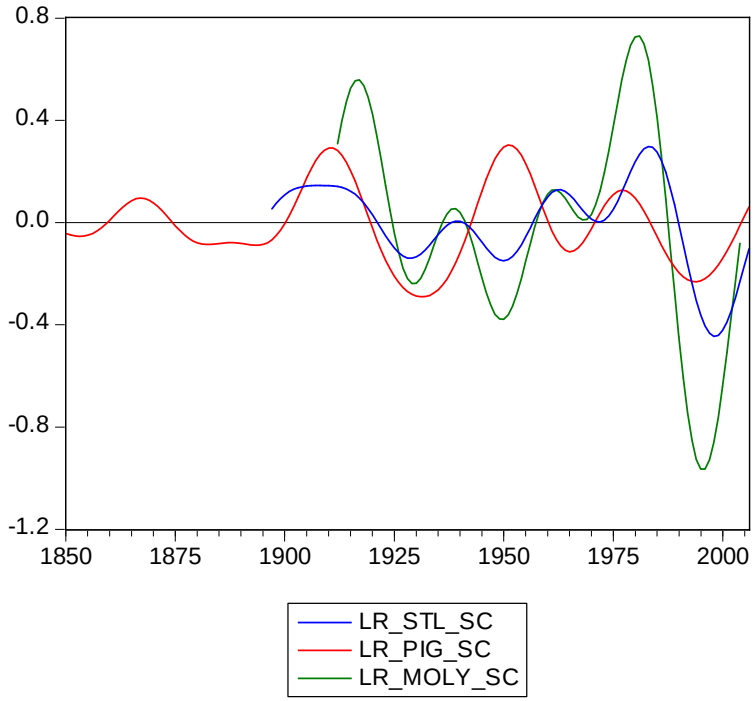
Super Cycles in Real Steel , Pig Iron, and Moly Prices?



Correlation Analysis: Steel Group

Covariance (p-value)	Steel	Pig Iron	Molybdenum
Steel	1.00		
Pig Iron	0.30	1.00	
	(0.00)	--	
Molybdenum	0.87	0.37	1.00
	(0.00)	(0.00)	--

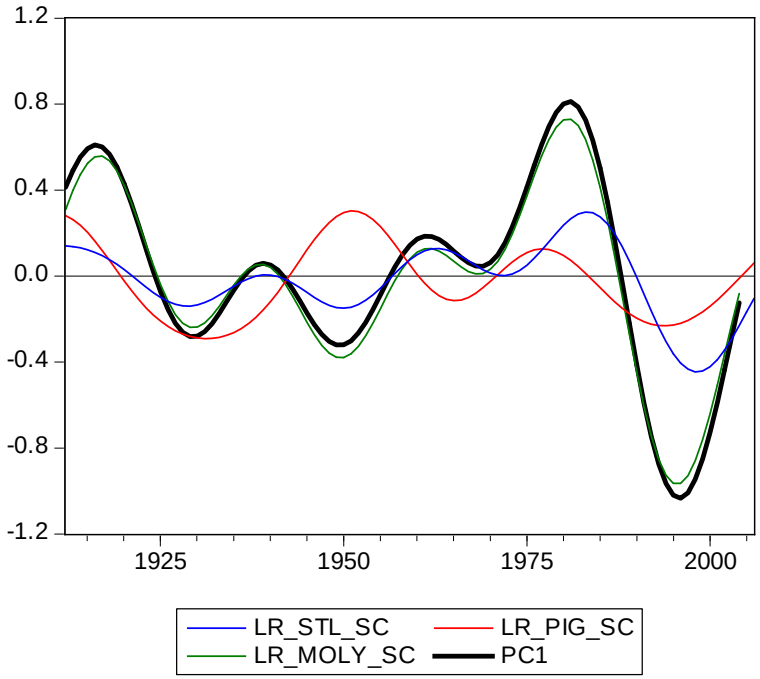
Principal Component Analysis: Eigen Values: Steel Group

Name	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	0.20	0.17	0.86	0.19	0.86
2	0.03	0.02	0.11	0.22	0.97
3	0.00	0.00	0.02	0.23	1.00

Principal Component Analysis: Eigen Vectors (Loadings): Steel

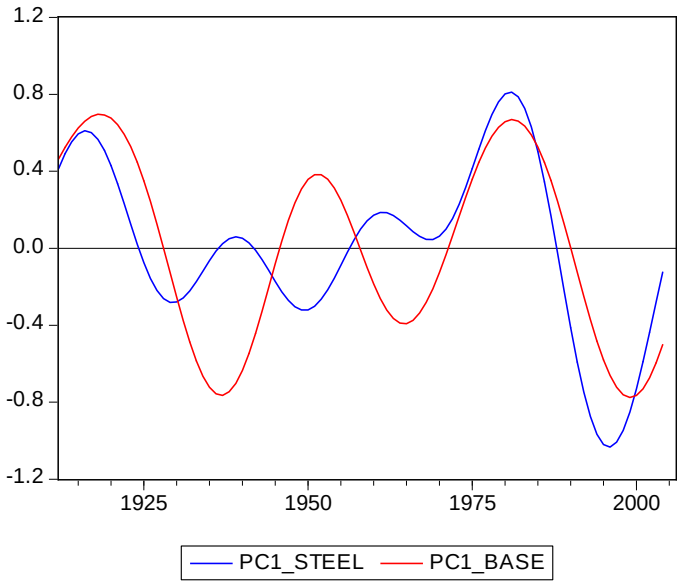
Variable	PC 1
Steel	0.35
Pig Iron	0.16
Molybdenum	0.92

1st Principal Component: Steel Group



Comparison of 1st PCs: Steel Group vs. Base Metals

--Steel Group Super Cycle appears to lead the LME6 Super Cycle



Conclusions

- **Considerable evidence of 'super cycles."** That is, cyclical components in metal prices with periodicity between 20 and 70 years. Timing of these cycles matches Heap (2005).
- **Dynamic interaction between nominal metal prices and the CPI is important.** The super cycle is more clearly defined when looking at nominal rather than real prices.
- **Super cycle components for the 6 LME metals studied have a high positive correlation.** This is consistent with the hypothesis that super cycles are demand-driven

Conclusions (cont.)

- **Industry claims are consistent with analysis:**
  - Statistical evidence from band pass filter analysis is consistent with claim that we are currently in the early phase of a new super cycle.
  - Primary source of the demand surge is presumably China, but our statistical analysis does not attempt to identify causes of the super cycles.
- **Amplitude of super cycles is large.** 20-40% above and below the long-run trend.
- **Deviations of metals prices from the super cycle + trend component are very large.** This indicates that business and intermediate-term cycles around the super cycle are huge!

Implications for Capital Investment

- How much more profitable is investment in new mining capacity if you know that metal prices are:
  - Currently below their long-run trend?
  - In the early stages of a super cycle expansion?
- Business cycle and intermediate cycle fluctuations in metal prices are still a major source of uncertainty

References

- Adelman, I. (1965). Long Cycles: Fact or Artifact? *The American Economic Review, 55*(3), 444-463.
- Armstrong, C., Chaundry, O., & Streifel, S. (2006). *The Outlook for Metals Markets*. Paper presented at the G20 Deputies Meeting.
- Baxter, M., & King, R. G. (1999). Measuring Business Cycles: Approximate Band-Pass Filters for Economic Time Series. *The Review of Economics and Statistics, 81*(4), 575-593.
- Cashin, P., & Mcdermott, J. (2002). The Long-Run Behavior of Commodity Prices: Small Trends and Big Variability. *IMF Staff Papers, 49*.
- Christiano, L., & Fitzgerald, T. (2003). The Band Pass Filter. *International Economic Review*.
- Cogley, T., & Nason, J. M. (1995). Effects of the Hodrick-Prescott filter on trend and difference stationary time series Implications for business cycle research. *Journal of Economic Dynamics and Control, 19*(1-2), 253-278.
- Cuddington, J. T., Ludema, R., & Jayasuriya, S. A. (2007). Prebisch-Singer Redux. In D. Leiderman and W. F. Maloney (Ed.), *Natural Resources: Neither Curse not Destiny*: Stanford University Press.
- Heap, A. (2005). *China - The Engine of a Commodities Super Cycle*. New York City: Citigroup Smith Barney.
- Heap, A. (2007, April 19th 2007). *The Commodities Super Cycle & Implications for Long Term Prices.* Paper presented at the 16th Annual Mineral Economics and Management Society, Golden Colorado.

References

- Hodrick, R. J., & Prescott, E. C. (1997). Postwar U.S. Business Cycles: An Empirical Investigation. *Journal of Money, Credit and Banking, 29*(1), 1-16.
- Hotelling, H. (1931). The economics of exhaustible resources. *journal of Political Economy, 39*, 137-175.
- Howrey, E. P. (1968). A Spectrum Analysis of the Long-Swing Hypothesis. *International Economic Review, 9*(2), 228-252.
- Nelson, C. R., & Kang, H. (1981). Spurious Periodicity in Inappropriately De-trended Time Series. *Econometrica, 49*(3), 741-751.
- Pindyck, R. S., & Rotemberg, J. J. (1993). The Co-movement of Stock Prices. *The Quarterly Journal of Economics, 108*(4), 1073-1104.
- Prebisch, R. (1950). *The Economic Development of Latin America and its Principal Problems*.
- Radetzki, M. (2006). The anatomy of three commodity booms. *Resources Policy, 31*(1), 56-64.
- Singer, H. W. (1950). U.S. Foreign Investment in Underdeveloped Areas: The Distribution of Gains Between Investing and Borrowing Countries. *American Economic Review, 40*, 473-485.
- Stanley, M. (2006). *Global Commodities Review*: Morgan Stanley.
- Tilton, J. E. (2006). *Outlook for copper prices - up or down?* Paper presented at the CRU World Copper Conference.
- Tilton, J. E., & Lagos, G. (2007). Assessing the long-run availability of copper. *Resources Policy, 32*(1-2), 19-23.

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- Contributions to the CSM Foundation (for the benefit of the Division of Economics and Business) will help fund our graduate research assistants.
- Contact me: John Cuddington, Coordinator of the Mineral Economics Graduate Program. jcudding@mines.edu