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A simple mineral market model: Can it produce super cycles in prices?

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ABSTRACT

This paper develops a stylized supply–demand model for a mineral/nonrenewable commodity. It embodies important distinctions between short-run and long-run mineral supply and the derived demand for minerals as intermediate goods in production sectors with differing intensities of use. This framework is used to address the question: under what conditions might one expect to observe super cycles (i.e. cycles with a period of 20–70 years) in minerals prices? A plausible time path for *GDP* growth and the structural transformation that accompanies economic development in an emerging region is specified. Using these drivers and reasonable supply and demand parameters, price dynamics are simulated. The result is an asymmetric price cycle with a peak price that is about 250% above trend and an expansion phase that lasts for about 20 years. Thus, this simple model is capable of producing a single cycle with a frequency and amplitude in the range estimated in the empirical literature on super cycles. As other regions reach the development 'take-off' phase, additional super cycles should emerge.

Motivation

This paper has two related objectives. The first is to develop a stylized supply–demand model for a mineral commodity that embodies (i) important distinctions between short-run and long-run mineral supply and (ii) the derived demand for minerals as intermediate goods in production sectors with differing intensities of use. The second objective is to use this framework to address the question: under what conditions might one expect to observe so-called 'super cycles' in mineral prices in response to the industrialization and urbanization of a major regional block in the global economy? In the literature (Heap, 2005; Cuddington and Jerrett, 2008; Jerrett and Cuddington, 2008; Jerrett, 2010), super cycles are defined as long cycles having a period between 20 and 70 years (including both the expansion and contraction phases), much longer than business cycle periodicity of, say, 2–8 years.

There has been a renewed interest in long-run trends in real mineral prices since the late 1990s, as real prices have risen sharply. Many analysts claim that the current sustained rise in prices (albeit with considerable year-to-year volatility) reflects a long-term super cycle associated with the rapid industrialization and urbanization in the *BRIC*.[1] countries, especially China (Rogers, 2004; Heap, 2005). Moreover, earlier super cycle episodes appear to match the timing of rapid industrialization in Western Europe, the United States, and the Japanese renaissance of the post-World War II period.

Many economists, however, have a longstanding skepticism about the presence of longer-run cycles, arguing that they may be a statistical artifact caused by inappropriate detrending methods (Adelman, 1965). Cuddington and various coauthors have attempted to measure super cycles in real mineral[2] prices using modern band-pass filtering techniques. These techniques tend to identify super cycles with a timing that supports the super cycle hypothesis regarding industrialization and urbanization of major economies (Cuddington and Jerrett, 2008; Jerrett and Cuddington, 2008; Jerrett, 2010; Zellou and Cuddington, 2012a). Figs. 1 and 2 display the real prices, the super cycles and the trend components for oil and metals.

In spite of the trend-cycle decomposition exercises, considerable skepticism about the presence of super cycles in mineral prices remains – especially given the sharp pull back in prices in late 2008 and early 2009. At the conceptual level, Radetzki et al. (2008) emphasize that the demand expansion associated with industrialization and urbanization may or may not lead to sustained increases in mineral prices, depending on the rapidity of the mineral supply response to changes in demand. In particular, rapid *anticipatory* increases in mineral production capacity

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[1] The *BRIC* countries are Brazil, Russia, India and China.

[2] Throughout this paper, minerals refer to both metals and energy commodities.

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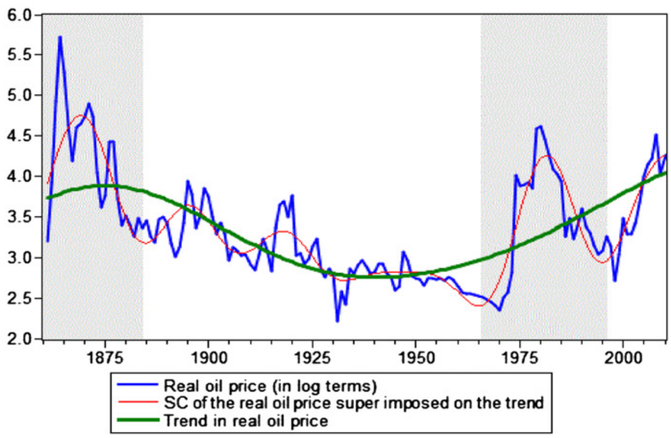

Fig. 1. Real price of oil (in logs) with trend and super cycles (SCs) overlaid on the trend component. The latter equals *Trend*+*SC*, so the difference between the two lines is the SC component shown in Fig. 2. The real price of oil is computed using the U.S. CPI as a price deflator (2005=100). See Cuddington and Jerrett (2008) for a description of the statistical technique used to generate the super cycle and trend components.

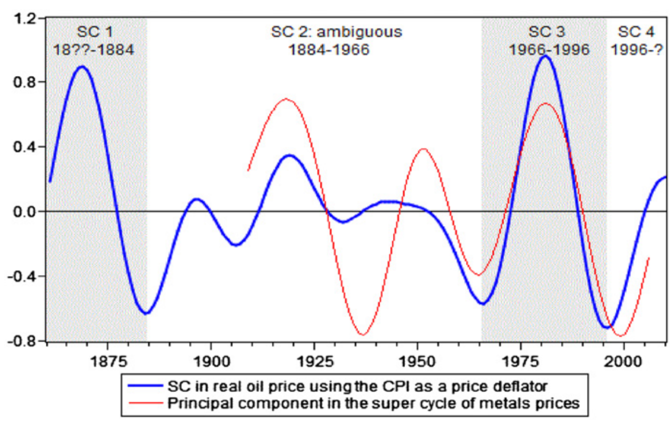

Fig. 2. Super cycles in real oil prices and in metals prices. The units on the vertical axis represent percentage deviations from trend. For example, +0.40 indicates price 40% above the long-term trend. The shading corresponds to the super cycles in real *oil* prices with the corresponding dates (from trough to trough). Four different epochs are identified in Zellou and Cuddington (2012b). There appears to be three obvious SCs in oil prices, the first one between 1861 (or earlier) and 1884, and the last two after 1966 to date. The period 1884–1966 is harder to interpret and has been aggregated into one SC, but it might be better interpreted as an ambiguous or inconclusive period. Note the similarity of metals and crude oil super cycles after WWII. Source: Cuddington and Jerrett (2008) on metals and Zellou and Cuddington (2012b) on crude oil.

in response to the expectation of sustained increases in future demand would prevent prices from exceeding marginal costs for decades at a time. This would prevent super cycles from occurring.

The simple mineral supply–demand model described in this paper captures the issues typically involved when discussing the plausibility of the super cycle hypothesis. Here's a 'bird's eye' view of what is formalized in the model that follows. Consider the typical characterization of mineral supply as being very price inelastic in the short run (*SR*) due to capacity constraints but very price elastic in the long run (*LR*), as shown in Fig. 3.[3] Demand depends on the real price of minerals and a broad measure of

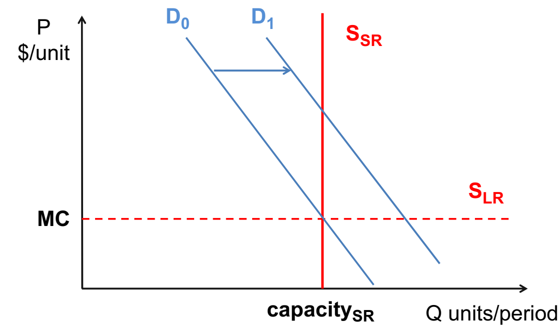

Fig. 3. Supply and demand in the resource market. D_0 represents the initial demand. D_1 simulates the shift in demand as described in the different scenarios. S_{SR} is the short run supply curve and S_{LR} is the long-run supply curve. At each price, there is a higher quantity demanded as income and intensity of use (IOU) rise.

economic activity that captures the level and composition of global *GDP*. A sustained increase in demand for resources during the industrialization and urbanization of a large region in the global economy is represented by a demand curve shift from D_0 towards D_1. (More generally, the demand curve would be shifting rightward more rapidly than it would have in the absence of rapid economic development.) The shift in demand along the short-run supply curve will cause mineral prices to rise sharply. The higher prices will, in turn, induce expansion in productive capacity, thereby pulling prices back towards pre-boom levels. If there is a later deceleration in demand, this process will reverse itself, with mineral prices temporarily falling below *LR* marginal cost (*MC*).[4] The key issues for determining price dynamics are the magnitude and duration of the demand shift and the speed of supply adjustment as the mineral market moves from *SR* to *LR* equilibrium. Presumably a stochastic sequence of development episodes in different parts of the world produces a series of super cycles.[5] (Appendix C extends the model in the text to two regional development episodes, producing two super cycles.)

Second section of this paper provides a simple mineral market model that can be used to analyze the dynamic effects of growth and structural transformation on mineral prices and to ask whether super cycles are likely to occur.[6] Third section reports various simulation exercises to get a sense of the model's characteristics and their implications. The first simulation considers the dynamic effects of a positive one-time (permanent) shift in the level of demand. It shows how the speed of capacity adjustment and the short-run price elasticity of demand affect the time needed for the supply capacity and price to reach the new equilibrium. The model is calibrated to match common belief that

[3] For empirical evidence on short-run and long-run price elasticities of energy demand and supply, see the extensive writings of Carol Dahl (e.g. Dahl, 1994; Dahl and Duggan, 1996) or Krichene (2002). For the copper market, see the classic paper by Fisher et al. (1972, p. 568): "The copper market is found to be

(*footnote continued*)
characterized by low short-run but very high long-run price elasticities, making for considerable sensitivity to exogenous forces."

[4] Firms will continue to operate in the short run as long as price exceeds their variable costs.

[5] We would not expect the emergence economies to occur in a deterministic sequential ('regular') way. Indeed, when macroeconomists study business cycles, they stress that these cycles are neither regular nor symmetric; we would expect the same for super cycles. The band pass filtering technique used to extract cycles, be they business cycles or super cycles, presumes the cycles are stochastic (irregular), not regular waves like sine or cosine functions. The empirical super cycles identified in the Cuddington and Jerrett (2008), Jerrett and Cuddington (2008) and Zellou and Cuddington (2012a,b) papers are not regular, but vary in amplitude, frequency, and asymmetry.

[6] We think it is a virtue that the model is 'simple,' but there are many considerations that it ignores. It is certainly not a multi-sectoral dynamic general equilibrium of a global economy undergoing structural transformation. Indeed the modeling of structural transformation in micro-foundations models of economic development is in its infancy; see Acemoglu (2009, chapter 20).