Journal of International Money and Finance 76 (2017) 16–27

Contents lists available at ScienceDirect

Journal of International Money and Finance

journal homepage: www.elsevier.com/locate/jimf

Industrialization and the demand for mineral commodities ☆

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ARTICLE INFO

Article history:
Available online 3 May 2017

JEL classification:
Q31
O13
N50

Keywords:
Commodities
Non-renewable resources
Elasticity of demand
Non-homothetic preferences
Nonstationary heterogenous panel

ABSTRACT

This paper uses a new data set that begins in 1840 to investigate how industrialization affects the derived demand for mineral commodities. I establish that there is substantial heterogeneity in the long-run effect of manufacturing output on demand across five commodities. A one percent increase in per capita manufacturing output leads to an approximately 1.5 percent increase in aluminum demand and a roughly 1 percent rise in copper demand. Estimated elasticities for lead, tin, and zinc are below unity. My results suggest that the experience of Japan and South Korea's industrialization, for example, may be used to infer the impact of China's industrialization on future demand for metals. The results imply substantial differences across commodities with regard to future demand. Adjustment to equilibrium takes 7–13 years, which helps explain the long duration of commodity price fluctuations.

1. Introduction

The booms and busts in the prices of commodities, such as crude oil and metals, strongly affect the macroeconomic and fiscal conditions of commodities exporting and importing countries (see e.g. Bernanke, 2006; IMF, 2012). These effects are especially important in developing countries, which rely on exports of a rather narrow set of commodities (see Van der Ploeg, 2011, for a survey).

Kilian (2009) and Stuermer (forthcoming) show that these boom and bust periods are primarily driven by global demand shocks. For example, China's rapid industrialization and its recent slowdown strongly affect world commodity prices. Thus, understanding how industrialization affects the derived demand for mineral commodities is important for macroeconomic and fiscal policy making in commodity exporting developing countries. Given that background, this paper poses the following questions: How does a change in manufacturing output affect the quantity demanded of mineral commodities? What is the price elasticity of demand? Can we utilize experience from past periods of industrialization, e.g. in Germany or Japan, to infer the impact of China's industrialization on the demand for metals?

Empirical evidence on the nexus of industrialization and the derived demand for mineral commodities remains limited. Studies on the elasticities of demand with regard to manufacturing output and prices cover only relatively short periods

☆ The views in this paper are those of the author and do not necessarily reflect the views of the Federal Reserve Bank of Dallas or the Federal Reserve System. For helpful comments and suggestions, I thank the Editor, two anonymous referees, Juergen von Hagen, Martin Hellwig, Joerg Breitung, Lutz Kilian, Friedrich-Wilhelm Wellmer, Felix Wellschmied, Gert Poenitzsch, Gregor Schwerhoff, Frank Pothen, Dirk Foremny, Benjamin Born, Martin Uebele, Alexander Chudik, Julieta Yung, Mine Yucel, Michael Plante, Peter Buchholz, Doris Homberg and Ulrich Pfister, as well as participants at the conference on "Commodity Cycles and their Implications" at the Bank of Canada, FRESH workshop at the University of Muenster and the 5th World Conference of Environmental and Resource Economics, Istanbul. I am grateful for editing by Michael Weiss and research assistance by Ines Gorywoda, Rachel Brasier, Justin Lee, Navi Dhaliwal and Achim Goheer. All remaining errors are mine. A supplemental appendix is available online at https://sites.google.com/site/mstuermer1/home.

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http://dx.doi.org/10.1016/j.jimonfin.2017.04.006
0261-5606/

(see Hamilton, 2009; Pei and Tilton, 1999; Kilian and Murphy, 2014, for surveys of the current literature). They typically neither capture the effects of common technological and other factors across countries nor take into account long-term adjustment processes of particular importance in the mineral commodities sector (see Radetzki, 2008; Stuermer, forthcoming).

The literature also rarely addresses the extent of parameter commonality across countries. One would expect that long-run equilibrium relationships in base-metal processing manufacturing are similar across countries, as these markets have been highly integrated over a long time. At the same time, it is less compelling to assume that short-run relationships should be the same. For example, adjusting production capacity of metals-based manufacturing products might differ in the short run due to different labor and capital market frictions across countries.

This paper explores the link between industrialization and the derived demand for mineral commodities based on a new unbalanced panel data set for a period partially going back to 1840. I assemble a new annual data set for 15 countries, covering by country real manufacturing output and by country real prices and consumption of five non-renewable resources—aluminum, copper, lead, tin, and zinc. These five base metals have characteristics, such as a substantial track record of industrial use and integrated world markets, which make a long-run analysis possible.

My estimation strategy relies on an extension of the partial adjustment model, in which I introduce homogeneity of parameters in a stepwise manner following Pesaran et al. (1999). This allows me to stay a priori agnostic about the commonality of coefficients for the short-term and long-term relationships. I also control for common trends and time fixed effects in a stepwise manner. This allows me to take advantage of the data's panel structure and to control for a variety of omitted common factors such as technological change in resource efficiency or world wars, which might affect demand in all countries at the same time.

I find that the long-run elasticity of metal demand with respect to manufacturing output is very similar across 15 countries, while there is substantial heterogeneity in the short-term coefficients. This suggests that one can utilize past industrialization experiences to infer the impact of China's industrialization on metals demand.

Across five examined commodities, I find substantial heterogeneity in the long-run effect of a change in per capita manufacturing output on the per capita quantity demanded of mineral commodities. A 1 percent increase in manufacturing output leads to an approximately 1.5 percent increase in aluminum demand and a roughly 1 percent rise in copper demand in the long run. Estimated elasticities for lead, tin, and zinc are far below unity. Holding all other factors constant, the intensity of use[1] of aluminum in the manufacturing sector increases over the course of industrialization, while the intensity of copper use is constant, and the intensities of lead, tin, and zinc use decrease. Common linear time trends only have a significant negative effect on the demand for lead and zinc.

Heterogeneity in the effect of manufacturing output on the demand for mineral commodities implies large differences in the amplitude of demand shocks on the prices across the examined commodities. For example, an unexpected slowdown in the growth rate of Chinese manufacturing output will have a stronger negative effect on the demand for aluminum or copper than on the demand for zinc, tin, or lead. This observed heterogeneity may drive differences in the relative contribution of demand shocks on real prices, as found by Stuermer (forthcoming), and in overall price volatility across commodities. I find slow speeds of adjustments of 8–15 percent per year, which imply that it takes about 7–13 years for these markets to reach equilibrium after a shock. The lead market is slowest to adjust, while the tin and copper markets return to equilibrium fastest. This helps explain the longitude of price fluctuations in these markets (see also Slade, 1991, who first introduced this argument to the literature).

The estimated long-run price elasticities of demand are rather inelastic for the examined mineral commodities. Again, there are pronounced differences across the examined mineral commodities. While price elasticity is about -0.7 in the case of aluminum, it is about -0.4 for copper demand, and below or equal to about -0.2 for lead, tin and zinc demand. This shows that these mineral commodities are rather essential to manufacturing output, as the processing industry changes its use slowly in response to price.

Based on my results, countries dependent on mineral commodity exports may better judge the long-term perspective of the respective markets and adjust their macroeconomic and fiscal policies accordingly. For example, the estimated manufacturing output elasticities of demand suggest that industrialization in China will cause aluminum demand to increase relative to manufacturing output, while copper will grow in proportion to manufacturing output. The demand for lead, tin, and zinc decreases relative to manufacturing output in the long term. My results also help firms in the extractive sector define their long-term investment strategies and, hence, facilitate smoother markets.

Current theoretical models of the long-run demand for non-renewable resources do not account for the heterogeneity across resources in the elasticity of demand with regard to intermediate goods or aggregate output. Future research may consider using non-homothetic preferences when modeling the long-run demand for non-renewable resources.[2] For example, the environmental effects of non-renewable resource use would not only depend on endogenous technological change (e.g. Acemoglu et al., 2012a), but also on the level of output. Moreover, the likelihood of resource wars would not only be driven by the price elasticity of demand (as in Acemoglu et al., 2012b), but also by the elasticity of demand with regard to output. Stefanski (2014) introduces non-homothetic preferences in a growth model with crude oil. However, in this model non-

[1] The "intensity of use" measures how many units of a certain material are used to produce one unit of output (see Malenbaum, 1978; Tilton, 1990, and others).

[2] The literature typically models other mechanisms, namely substitution by other production factors, triggered by relative price changes (see Solow, 1974; Stiglitz, 1974, and the following literature) and technological change in resource use (e.g. Acemoglu et al., 2012a, and others).