Modeling the Demands for Energy and Material in China's Iron and Steel Industry

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Abstract

1. Overview

China's iron and steel industry achieved rapid expansion and remarkable energy intensity reduction during the 1990's and early 2000's. However, the continuing decline trend in energy intensity stagnated since 2002. Meanwhile, because of its heavy reliance on coal and high consumption of coke, the steel sector becomes the largest energy user and third largest carbon dioxide emitter in China. Therefore, the issues of energy conservation in China's iron and steel industry merit a researching focus.

One important issue to examine energy conservation is the extent to which other factors can substitute for energy in the economy (Ozatalay et. al, 1979). Hence it is necessary to study energy demand and related policy issues based on estimated elasticities of substitution between energy and other factors, and own price elasticities of energy demand. However, as Ma et. al (2010) discussed in an extensive review of energy demand researches of China, studies on inter-factor and inter-fuel substitutions in China's specific sectors or industries remain scare. This paper aims to fill the gap in the literature by focusing on an energy intensive industry, the iron and steel industry.

2. Method

This study examines energy and materials demands in China's iron and steel industry during a period (2002-2008) when China's economy as well as steel output burgeoned, and energy and material prices were skyrocketing. A short-run restricted cost function is estimated with all possible variable inputs and a quasi-fixed input. The empirical analysis studies 16 steel producing regions which encompass the total steel output in China by employing an annual panel dataset from 2002 to 2008.

We assume a typical iron and steel mill needs three different types of energy fuels: coal, electricity, and petroleum products, aggregated from gasoline, diesel, kerosene, natural gas, and fuel oil. These inputs are composed of the total energy input (E) by Divisia Index. In addition, a mill also uses the three variable factors, material (M) which are aggregated from iron ore and coke by Divisia Index, labor (L), and the remaining inputs (R), and one quasi-fixed input, capital stock (N). Following Morrison (1988), a Generalized Leontief cost function with one quasi fixed input will be jointly estimated with four variable input demand functions by GMM (Generalized Method of Moments), which is robust to heteroscedasticity and autocorrelation.

Based on the estimated shadow value of the quasi-fixed input, we will be able to evaluate the substitution possibilities between those inputs both in the short run and in the long run, in which steel firms are able to adjust their capital stock.

The estimated model above provides a base to project input demands in China's iron and steel industry. In particular, it is interesting to understand how the energy and material demands and energy intensity (energy demand per capita of steel output) would vary if a carbon tax was imposed on input prices in the near future. In this study, we jointly simulate the energy, material, labor, the remaining demands, steel output, and capital stock from 2009 to 2020 by assuming a carbon tax imposed on related energy and material input prices. Those input demands and energy intensity in the scenario of carbon tax will be compared with the case without the imposed carbon tax, and then the changes of demand for energy, material, labor, and the remaining, steel output, and energy intensity can be calculated.

3. Expected Results.

We expect that China's iron and steel industry have generated significant flexibility of energy and labor, and relative fixity of material and the remaining inputs. Substitute possibilities between different inputs are found. The potential complexity may arise from the relationship between energy and material in two aspects. On the one hand, most integrated steel plants in China use coal both for a heating fuel and for producing one kind of materials, coke; thus, an explicitly complementary relationship between energy and material is implied as a priori. On the other hand, China's steel firms may introduce more and more low-quality materials, i.e., low-quality coke and iron ore, in production to substitute for standard and high-quality materials since the latter become more and more prohibitive recently. These low-quality materials will absolutely raise energy consumption in steel production; thus, an implicitly substitute relationship between energy and material may correspondingly exist. The estimated elasticities of substitution between energy and material reveal that the complementary relationship overrides the substitute relationship. This relationship sheds light on enacting policies of energy conservation in China's iron and steel industry.

Overall, these results may suggest that China's iron and steel industry has the substantial responsiveness to energy prices' shock and unresponsiveness to material prices' shock. In addition, the simulation based on the estimated model illustrates a 12 dollar carbon tax per ton of carbon dioxide emission would reduce 16% of energy intensity in China's iron and steel industry, which is a desired result of China's future goal of regulation in the 12th Five-Year Plan (2011-2015).

4. Reference

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