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Environmental regulation and production structure for the Korean iron and steel industry

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Abstract

The most important obstacle to studying the structure of production under environmental regulations is the lack of price data for abatement capital. The use of a restricted cost function circumvents the problem of missing prices for some inputs. This paper estimates a restricted cost function for the Korean iron and steel industry based on the quantities of raw material and abatement capital over the period 1982–2001. The Allen elasticities of substitution between abatement capital and other inputs are calculated, and the shadow price of abatement capital is derived.
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1. Introduction

In the presence of emission standards, firms face a pollution constraint in addition to the conventional production technology. Since emissions are reduced by the installation and operation of pollution abatement facilities, abatement capital is included along with conventional inputs as factors in the production function for a two-output technology.[1] The estimation of elasticities of demand and substitution is essential to close investigation of the structure of

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[1] For example, in order to meet the legal emission standards for sulfur dioxide, firms either purchase expensive low-sulfur fuels or install flue gas desulfurization systems (scrubbers).

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production under environmental regulations, especially in order to simulate the demand effects of specific government policies based on the magnitude of the estimated elasticities.

Using a dual cost function to study the regulated production structure has some benefits: exogeneity of the regressors, ease of deriving the input demand function, and simpler formulas for elasticities of demand and substitution. However, the most important obstacle to estimating the dual cost function is the lack of price data for abatement capital. Adoption of the Christensen–Jorgenson (1969) formula requires a great quantity of specific data on each abatement facility: its price index, the interest rate on bonds issued for financing its expense, etc. Those data are rarely obtainable.

The use of a restricted cost function makes it possible to circumvent the problem of missing prices for some inputs (Halvorsen and Smith, 1986). In the theory of restricted cost functions, the quantities of those inputs are assumed to be set equal to the cost-minimizing levels in the short-run (Lau, 1976; McFadden, 1978). Following the approach of Brown and Christensen (1981), one can derive the elasticities of demand and substitution for input factors such as abatement capital for which prices are not available.

The iron and steelmaking industries invest fairly large amounts in environmental facilities in comparison with other manufacturing businesses. The sintering and coking processes generate a variety of pollutants: dust, sulfur oxide, nitrogen oxide, etc. In Korea, an air quality standard for sulfur dioxide was established in 1979. In 1983, the environmental standards were set for other major pollutants: carbon monoxide, nitrogen dioxide, fine particulates, and ozone. Beginning in the early 1980s, firms have made a full-scale investment in pollution abatement facilities. The ratio of environmental investment to total facility investment has been increasing annually.

In this paper, we first assume that abatement capital and raw material are fixed in the short-run and estimate the restricted cost function to examine the structure of production in the Korean iron and steel industry. As discussed in several previous studies, in some manufacturing industries the market prices of raw materials or intermediate goods are not always observable.[2] Then, we derive the formulas for the elasticities of demand and substitution for all inputs, including abatement capital. Differentiation of the restricted cost function with respect to the quantity of abatement capital provides estimates of the shadow price of abatement capital (Halvorsen and Smith, 1984, 1991). We also test for specific characteristics of the production process.

This paper is organized as follows. A restricted cost function is defined and estimated in Section 2. The formulas for the long-run elasticities of demand and substitution for two fixed factors are presented in Section 3. Section 4 analyzes the empirical results. Section 5 contains conclusions.

2. A restricted cost function

A firm facing emissions regulations has the following transformation function for a two-output technology:

$$T(Q, W, \mathbf{X}, M, t) = 0, \tag{1}$$

where Q is net output; W is emissions; $\mathbf{X}$ is a vector of three reproducible inputs (capital K, labor L, and energy E); M is raw material; and t is the time index.

[2] Those include Halvorsen and Smith (1984, 1986, 1991), Lee and Ma (2001), and Ellis and Halvorsen (2002).

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