ELSEVIER

Int. J. Production Economics 69 (2001) 277–285

international journal of
production
economics

www.elsevier.com/locate/dsw

The calculation of shadow prices for industrial wastes using distance functions: An analysis for Spanish ceramic pavements firms

Ernest Reig-Martínez[a,b], Andrés Picazo-Tadeo[a,*], Francesc Hernández-Sancho[a]

[a]*Department of Applied Economics II, University of Valencia, Avda dels Tarongers s/n, 46022 Valencia, Spain*
[b]*Valencian Institute of Economic Research (IVIE), Guardia Civil 22, 46020 Valencia, Spain*

Received 10 August 1999; accepted 27 January 2000

Abstract

This paper deals with the calculation of shadow prices for two industrial wastes generated on their production processes by 18 firms belonging to the Spanish ceramic pavements industry. These prices are then used to calculate an extended productivity index which takes into consideration wastes going with the production of marketable goods. We follow the methodological approach first proposed by Färe et al. (The Review of Economics and Statistics 75 (1993)). A negative correlation is found between absolute shadow prices and wastes production intensity, reflecting a greater marginal cost of eliminating wastes for those firms using less contaminant production processes. Differences between a conventional labour productivity index and an extended productivity index are also statistically related to firms characteristics such as size, previous investments in cleaner technologies and affiliation to a Technological Institute.

Keywords: Shadow prices; Distance functions; Ceramic pavements industry; Environment; Productivity

1. Introduction

The growing recognition of the environment as a public good has unleashed a debate with regard to the convenience of breaking the tradition of assessing the value of industrial production by implicitly assuming that all goods produced are socially desirable. If it is accepted that a part of industrial production is undesirable, and public authorities establish regulations to limit the emissions of polluting wastes, the cost that firms face to fulfil legal environmental restrictions, should be evaluated. Therefore, shadow prices for undesirable outputs have to be computed in order to measure in terms of opportunity costs the impact on firms performance of environmental restrictions preventing free disposal of industrial wastes.

Shadow prices of undesirable outputs are understood in this context as the marginal cost due to a marginal reduction in the possibility of freely disposing of wastes generated in the production

* Corresponding author.
E-mail address: andres.j.picazo@uv.es(A. Picazo-Tadeo).

0925-5273/01/$ - see front matter
PII: S0925-5273(00)00018-9

process.[1] From the point of view of public policies for environmental protection, the availability of these shadow prices reports several important benefits; among them, the possibility of comparing the marginal benefits of environment policies, with the cost they generate for private firms; the chance of checking if all firms face the same shadow prices; and, finally, the feasibility to adapt traditional productivity indexes to allow for the consideration of different intensity of waste production among firms, sectors or even countries.

This paper deals with the calculation of shadow prices for undesirable outputs that are *by-products* of the industrial production of ceramic pavements, with data coming from a sample of Spanish firms located at Castellon, on the Valencian region. We follow the distance function approach suggested by Färe et al. [1] (FGLY henceforth), recently applied by Coggins and Swinton [2]. This method uses output distance functions to derive shadow prices for all outputs (desirable and undesirable) generated by firms in their productive processes. In particular, it makes it feasible to obtain shadow prices for undesirable outputs without having to use exogenous information on wastes elimination costs coming from other studies (as Pittman [3] does in a paper aimed to adapt the multilateral productivity indexes pioneered by Caves et al. [4] for taking stock of polluting emissions). Secondly, this paper aims to propose an *extended* measure of productivity that takes into account residuals emerging as a *by-product* of current industrial production processes. Availability of residuals output data for each of the firms in our sample allows us to undertake this correction.

This introduction is followed by a description of the methodology. Section 3 describes the sample and establishes the main results, while Section 4 concludes.

2. The output distance function and the derivation of shadow prices

In order to illustrate the basic aspects of the methodological approach proposed by FGLY to derive output shadow prices from distance functions, let us assume that we have a set of firms using a vector of inputs $x \in \Re_+^N$ to produce a vector of outputs $u \in \Re_+^M$, some of which can be considered undesirable or *bad* outputs. The *technology of reference* is represented by an output correspondence which is a mapping $P : \Re_+^N \to P(x) \subseteq \Re_+^M$, where the *output set* $P(x)$ represents the set of all feasible vectors of outputs given a vector of inputs x. It is also assumed that the *technology* satisfies the usual axioms initially proposed by Shephard [5], which allows to define the *distance function in outputs* as the inverse of the maximum radial expansion of a given output vector, in such a way that the resulting output vector remains within $P(x)$. The *distance function* can be defined on the output set as[2]

$$D_o(x, u) = \inf\{\theta : (u/\theta) \in P(x)\}. \quad (1)$$

The assumptions made on the disposability properties of the technology are a key issue in order to derive output shadow prices. In particular, it is assumed that firms cannot freely eliminate (without any cost) the industrial wastes (undesirable outputs) that they generate in their production processes, either because it would require a greater use of inputs or because resources would have to be diverted from marketable production in order to eliminate undesirable outputs. This condition can be incorporated to the characterisation of the technology by means of the axiom of weak disposal of outputs, in the sense that if $u \in P(x)$, it will also hold that $\theta u \in P(x)$, being in this case $0 \leqslant \theta \leqslant 1$. This assumption is consistent with the opportunity cost, measurable in terms of the loss of desirable produc-

[1] This can be verified by defining a cost function and setting up a maximising profit problem. Given a vector of (desirable and undesirable) outputs u, with prices r, and being x and p the quantity and price input vectors, respectively, the cost function is $c(u, p) = \min\{px : x \text{ can produce } u\}$, while the profit function can be set up as $\pi(r, p) = \max\{ru - c(u, p)\}$. From first-order condition for undesirable output j we get

$$r_j = \frac{\partial c(u, p)}{\partial u_j},$$

where r_j is the shadow price of waste j.

[2] This expression is equivalent to the reciprocal of the output oriented efficiency measure of Farrell [6,7]. Also note that $u \in P(x)$ if and only if $D_o(x, u) \leqslant 1$.