A Profit Function Approach to Measuring Productivity Growth: The Case of U.S. Manufacturing*

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Abstract

This article proposes a method of estimating productivity growth using an estimated profit function. The approach has the advantage of incorporating endogenous changes in profit-maximizing output levels that would result from productivity changes. As with the cost function, it can be easily adapted to accommodate the presence of quasi-fixed factors. The article first develops the methodology and shows the equivalence between the proposed measure and other measures of productivity based on cost or production functions. An empirical application to the measurement of productivity changes in the U.S. manufacturing industry is presented next. The profit-function measure is compared to a nonparametric measure based on the same data and to the results of other studies of U.S. manufacturing.

1. Introduction

Interest in both the theoretical and the empirical measurement of productivity growth has existed for many years (e.g., Solow [1957]). Economists have studied productivity changes in an attempt to explain either their causes or their economic effects (e.g., Schur, Sonnenblum, and Wood [1983] and Kendrick [1984]).

Two alternative approaches to defining productivity growth can be identified in the literature. The first measures multifactor productivity growth (MFPG) defined to be the percentage change in output minus the percentage change in an aggregate input index. The second approach measures the rate of technical progress (RTP), which reflects autonomous shifts in the production function. Although in general these two approaches are conceptually different and yield different empirical estimates of productivity change over time, they are known to be equivalent under certain conditions. (See, e.g., Denny, Fuss, and Waverman [1981]).

Estimates of MFPG can be obtained directly from observed input and output levels without the need for any knowledge of the firm's production structure. Direct measurement of the RTP, on the other hand, requires information about the firm's technology. This can be obtained directly from econometric estimation of the firm's production function. However, it is well known (Shephard [1953]) that all economically relevant information about the production function can also be obtained from the firm's dual cost function. This duality relationship between the cost and the production functions can be utilized to obtain estimates of the RTP directly from an estimated cost function (Ohta [1974]).

If firms are profit-maximizing, then in some cases it may be more appropriate to use the dual profit function rather than the cost function to represent the firm's (or the industry's)
production decisions (Lau [1978]). Use of the profit function allows both output and input levels to be determined endogenously and yields unconditional rather than conditional input demand functions. While the profit function has been used to measure biases in technological change in many empirical studies (e.g., Weaver [1983], Shumway [1983], and Antle [1984]), there has been no attempt to measure the rate of autonomous shift in the production function (i.e., the RTP) from an econometrically estimated profit function. The purpose of this paper is to provide a theoretical link between the profit function and the RTP and to use that link to measure the rate of technical progress in the U.S. manufacturing industry.

The article is organized as follows. The next section provides a brief review of the different ways of measuring productivity that have been used and examines the relationships between them. This provides the necessary background to relate the profit function approach to measuring RTP outlined in section 3 to any of the other approaches previously used. Because in many empirical applications it is appropriate to treat one or more of the inputs as quasi-fixed, Section 4 discusses the use of the restricted profit function to measure RTP. We then use our approach to measure the RTP in the U.S. manufacturing industry. A translog normalized variable profit function is estimated and the resulting coefficients are used to calculate the RTP for the sample years. The estimates obtained from this approach are compared with the nonparametric approach and with findings from other similar studies of U.S. manufacturing.

2. Alternative measures of productivity growth

Consider a firm that produces a scalar output using a vector of variable inputs and experiences technological progress over time. Let

\[ x = (x_1, x_2, \ldots, x_n) = \text{vector of variable input levels}; \]
\[ w = (w_1, w_2, \ldots, w_n) = \text{vector of variable input prices}; \]
\[ t = \text{time index representing technological progress}; \]
\[ y = f(x, t) = \text{the firm's output level/production function}; \]
\[ C = C(y, w, t) = \text{the minimum cost of producing y}; \]
\[ p = \text{output price}. \]

At least four alternative measures of productivity growth for such a firm has been suggested. Among these are two measures of multifactor productivity growth given by:

\[ (\dot{M}/M)_1 = (\dot{y}/y) - (\dot{X}/X)_1 \quad \text{where} \]
\[ (\dot{X}/X)_1 = \Sigma (w_i x_i / p y) (\dot{x}_i / x_i) \text{ and} \]
\[ (\dot{M}/M)_2 = (\dot{y}/y) - (\dot{X}/X)_2 \quad \text{where} \]
\[ (\dot{X}/X)_2 = \Sigma (w_i x_i / C) (\dot{x}_i / x_i). \]

These two measures differ only in the weights used to define changes in the aggregate input X. \((\dot{M}/M)_1\), used by Nadiri and Schankerman [1981], uses weights based on output shares, while \((\dot{M}/M)_2\) uses cost shares. Although the use of output shares has the advantage