Omega 57 (2015) 176–187

Contents lists available at ScienceDirect

Omega

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

Profit-oriented productivity change ☆

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ARTICLE INFO

Article history:
Received 2 December 2013
Accepted 24 April 2015
Available online 8 May 2015

Keywords:
Data envelopment analysis (DEA)
Directional distance function
Nerlovian
Profit
Productivity change
Lunberger indicator

ABSTRACT

This study develops an applicable profit-oriented productivity indicator when producers pursue profit maximization and can recognize input and output prices. We define the indicator, inspired by the Luenberger indicator and the Nerlovian efficiency measurement, in terms of both quantity distance functions and profit. Hence, the study's first stage decomposes the profit-oriented productivity change into two terms: profit efficiency change and profit technology change. Second, we decompose profit efficiency change into the changes in technical efficiency and allocative efficiency. Finally, profit technology change is separated into two components for capturing the shifts of technology and relative output/input prices. These decompositions provide a more complete picture of the sources of productivity change. We illustrate them with a sample of Taiwanese banks and compute the results using the models of directional distance functions.

1. Introduction

The banking industry plays a very important role in the current global economy. As intermediary institutions, banks transform deposits into loans and investments and promote a country's economic development. Taiwan's banking industry was highly regulated before 1991, and then that year a material change in the financial environment occurred as the authorities allowed 16 new banks to be established. From then on, financial restrictions in Taiwan were gradually relaxed. Different kinds of financial institutions were encouraged to transform into commercial banks ([1]), but eventually the rapid expansion in the number of banks induced over-competition and lower profit. The profits of Taiwanese banks were also impacted by government policy, since they were often required to finance specific industries that the government was promoting. Thus, starting in 2001 the Taiwan government launched a series of financial reforms to improve banks' operating performance. Most importantly, it relaxed the regulations on mergers, resulting in 14 financial holding companies being established and uncompetitive banks withdrawing from the market. The number of Taiwanese banks declined from 53 in 2001 to 37 by 2010 ([1]).

Studies in the literature have focused on the operation performance of banks, such as technical efficiency, productivity change, and its components. The recent examples include Juo et al. [2], Juo [1], Wang et al. [3], Kao and Liu [4] and LaPlante and Paradi [5]. Regarding productivity performance, many papers have used the Malmquist productivity index (MPI), but one of the limitations faced by researchers is that MPI is defined from either an output- or an input-oriented perspective. Chambers et al. [6, 7] and Chambers and Pope [8] defined a difference-based Luenberger productivity indicator that can deal with the above limitation, leading to many applications of this indicator. However, it does not capture an important component, allocative efficiency, which reflects the difference between the maximum profit and the profit under technical efficiency. Thus, the conventional Luenberger indicator does not give a full picture of the sources of productivity change, like those resulting from a change in the output/input mix with the prevailing relative prices. In such cases, decision making units (DMUs) may over time improve their performance by changing the above mix. Thus, as claimed by Coelli et al. [9], the impact of allocative efficiency change on productivity should be explained. Bauer [10] and Balk [11] decomposed productivity change so as to identify the contribution from a change in allocative efficiency. Maniadakis and Thanassoulis [12] developed a cost-oriented Malmquist index to take into account allocative efficiency in productivity measurement.

☆This manuscript was processed by Associate Editor Podinovski.

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http://dx.doi.org/10.1016/j.omega.2015.04.013

The most important aim of a bank is to obviously create or even maximize its profit. A profit-oriented indicator or index is applicable when a DMU is assumed to pursue profit maximization and the prices of outputs and inputs are available. In order to trace the sources of the change in banking profit, Grifell-Tatjé and Lovell [13] differentiated changes in profits into six different components using data envelopment analysis (DEA) in order to consider the relationship between changes in productivity and changes in profit. Following the work of Grifell-Tatjé and Lovell [13], Asaftei [14] used a variant of the above study to divide the change in the return on assets by looking at the differences in technologies and product mixes across distinct groups of banks. Sahoo and Tone [15] implemented the slacks-based measure (SBM) to decompose the change in operating profit so as to address the concerns of slacks. Juo et al. [2] used the SBM model to decompose the change in the profit of Taiwanese banks and to simultaneously consider outputs and inputs. However, all the components of profit decompositions in the above papers are unit dependent.

The measures of profit efficiency with DEA are rather limited in the literature, because there is no generally accepted calculation of profit efficiency, in contrast to the concepts of technical efficiency and cost efficiency, in which the ratios of observed practice performance to best practice performance are commonly employed. Using the ratio of observed profit over maximum profit to measure profit efficiency raises some problems when observed and/or maximal profits are zero or negative. Studies focusing on defining profit performance and the treatment of negative or zero profits include Nerlove [16], Berger et al. [17], DeYoung and Nolle [18], Berger and Mester [19], DeYoung and Hasan [20], Chambers et al. [21], Ray [22], and Das and Ghosh [23].

Nerlove [16] dealt with the issue of negative or zero profits by looking at the difference between maximal and observed profits, but that paper has a weak property in that the unit of measurement matters. Furthermore, what induces the above difference between maximal and observed profits may be a bank's operating performance and the impact from output and input prices. Chambers et al. [21] proposed a profit indicator named after Nerlove [16] to express profit inefficiency – defined by the difference between maximum and observed profits – as the sum of technical inefficiency and allocative inefficiency. Technical inefficiency comes from production that is incurred by less output yield with excessive input usage. Allocative inefficiency occurs when a firm allocates outputs and inputs in wrong proportions, given their prices and the production technology. Furthermore, the price normalization in Chambers et al. [21] makes their profit indicator, the Nerlovian profit measure, independent of the unit of measurement, which helps solve the linear homogeneity problem that Nerlove recognized about his measure.

There are papers that have followed Chambers et al. [21] and used the Nerlovian measurement of profit efficiency to analyze the profit performance of banks. Färe et al. [24] measured the profit efficiency of U.S. banks and considered the effect of risk-based capital requirements on the profit performance of these banks. Koutsomanoli-Filippaki et al. [25] investigated profit efficiency in the banking industries of 11 Central and Eastern European (CEE) countries for the period 1998–2005. They not only divided profit efficiency into technical and allocative components, but also investigated these efficiency measures across countries and across banks with different characteristics, such as bank capitalization, bank size, market concentration, and banking reform. Koutsomanoli-Filippaki et al. [26] employed the Nevlovian profit indicator to estimate profit efficiency in the 25 European Union (EU) member states over the period 1998–2008. They further looked at potential efficiency differences across the old EU region and the new EU member states, across countries, and across banks of different size.

Research papers based on the Nerlovian measure have until now made very few attempts to combine profit efficiency with change in productivity. Ball et al. [27] proposed a normalized profit change indicator, which can be decomposed into the Bennet–Bowley indicator and the price change indicator. However, since the Bonnet–Bowley indicator is a non-frontier measure, the change in productivity in Ball et al. [27] cannot be further decomposed into the changes in technical efficiency and technology.[4] In this paper we intend to implement such a productivity decomposition by employing the Luenberger productivity indicator—a frontier type of measure. In addition, our proposed profit productivity indicator can yield information on allocative efficiency and the price effect.

We develop a profit-oriented productivity indicator that combines the Nerlovian profit efficiency measurement with the conventional Luenberger productivity indicator so as to give a full picture of the sources of productivity change, including changes in technical efficiency, technology, allocative efficiency, and the price effect. The change in allocative efficiency indicates the extent to which a DMU catches up with the optimal output/input mix in light of output/input prices over time. The price effect captures the residual impact of relative output/input price changes on the shift in the profit boundary. Both of the above two components are vital to profit analysis, but were never considered in conventional Malmquist productivity indices or Luenberger indicators. We take data of Taiwanese banks over the period 2006–2010 as our sample.

The remainder of this study is organized as follows. Section 2 proposes the methodology to execute the decompositions of the profit-oriented productivity change. Section 3 presents definitions of variables and data descriptions. Section 4 shows with the empirical results. The conclusions follow in Section 5.

2. Methodology

2.1. Technical specification

Suppose that DMUs use the input vector x^t ($x^t \in R^N_+$) to produce the output vector ($y^t \in R^M_+$) in time period t ($t=1, 2,. , T$). Let the output and input price vectors for period t be $p^t \in R^M_+$ and $w^t \in R^N_+$, respectively. The production technology set can be denoted by $S^t = \{(x^t, y^t) : x^t \text{ can produce } y^t\}$, which is assumed to be convex and closed. This assumption maintains the duality between the directional distance function and the profit function ([29]).

Following Chambers et al. [18], we define the directional distance function (DDF) by:

$$\vec{D}^t(x^t,\ y^t;\ -g_x^t,\ g_y^t) = sup\{\beta : (x^t - \beta g_x^t,\ y^t + \beta g_y^t) \in S^t\} \quad (1)$$

The objective function of Eq. (1) seeks to maximize the expansion of outputs and contraction of inputs with the directional vector $g^t = (-g_x^t,\ g_y^t)$, where $g_x^t \in R^N_+$ and $g_y^t \in R^M_+$, so as to reach the production frontier. In fact, DDF measures the degree of technical inefficiency (TI).

Fig. 1 illustrates the concept of the production technology S^t and DDF. The quantity vector (x, y) of point a is projected along the direction $g^t = (-g_x^t,\ g_y^t)$ to the boundary of S^t at point b in which the quantity vector is $\left(x^t - \vec{D}^t(x^t,\ y^t;\ -g_x^t,\ g_y^t)g_x^t,\ y^t + \vec{D}^t(x^t,\ y^t;\ -g_x^t,\ g_y^t)g_y^t\right)$. The profit function and profit inefficiency

[4] Färe et al. [28] demonstrated that the Bennet–Bowley indicator may be regarded as an "*approximation*" of the Luenberger productivity indicator. Despite such approximation, the Bennet–Bowley indicator cannot measure the source of productivity change.