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Non-radial profit performance: An application to Taiwanese banks ☆

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ABSTRACT

This research modifies the directional Russell measure (DRM) of Fukuyama and Weber (2009) [1] to decompose the Nerlovian profit efficiency in Chambers et al. (1998) [2] so as to obtain a generalized measure that completely excludes technical inefficiency from allocative inefficiency. Based on such a decomposition, we further develop a new slack-based and profit-oriented productivity indicator, combining the Nerlovian profit measure with the conventional Luenberger productivity indicator (LPI), in order to provide a full picture of the sources of productivity change. Productivity change, based on the profit boundary, is decomposed into four components: the change in technical efficiency; the change in allocative efficiency; the shift of technology; and the price effect from outputs and inputs. This decomposition provides a more complete picture of the sources of productivity change. The above indicator is used herein to measure the productivity change of Taiwanese banks in terms of profit.

1. Introduction

For-profit financial institutions such as banks regard profitability performance as one of the most important types of managerial information. However, as compared to technical and cost efficiencies, the estimation of profit efficiency has been rather limited in the banking literature over the past decades due to the difficulty in obtaining reliable and transparent information for output prices (Fethi and Pasiouras [3]). A number of recent studies using DEA have made excellent contributions on estimating banks' profit inefficiency and the decompositions of their profit-oriented productivity change. They have developed new methods to solve some data and key estimation problems, which are often confronted when measuring banks' profit efficiency and productivity change, including: treatments for non-positive profit data and for a unit-dependent efficiency measure; models that consider simultaneous adjustments of inputs and outputs and cope with non-radial slacks; and ways to fully characterize a dynamic bank's profit behavior and incorporate productivity change into the decomposition of profit change. Since most previous studies only address one or two problems, any further studies that can accommodate multiple problems jointly will be of great interest to the related literature.

While profit is generally defined as revenue minus cost, the profit value of a bank may be non-positive in low business periods. The estimation of profit efficiency often encounters this problem of negative or zero profit when such estimation is based on ratios of the observed profit to the best performance profit. To deal with this issue, some studies used the difference form to measure profit performance. Nerlove [4] solved the problem of negative profit by looking at the gap between the maximum and observed profits. Such a gap can then be attributed to a bank's operating performance and the impact of output and input prices. However, even if profit is measured with this difference treatment, the resultant measure of Nerlove [4] still suffers the weak property of unit dependence – that is, the profit measure is affected by the currency used in the research. To deal with the unit-dependent problem in Nerlove [4], Chambers et al. [2] proposed a unit-independent profit efficiency indicator, named the Nerlovian inefficiency measure, to express profit inefficiency as the sum of allocative and technical inefficiencies. The Nerlovian profit inefficiency is defined as the difference between the maximum and observed profits, which is normalized by the value of the direction output–input vectors. The value normalization, which naturally follows the maximum profit and the direction vector, solves the

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linear homogeneity problem that Nerlove [4] recognized about his measure (see Chambers et al. [2]). The work of Chambers et al. [2] has been followed by Färe et al. [5], Koutsomanoli-Filippaki et al. [6], and Koutsomanoli-Filippaki et al. [7] to examine the profit efficiency of banks in the U.S., Central and Eastern European countries, and European Union member states, respectively. While the Nerlovian profit inefficiency is unit-independent, it is a measure under the radial DEA framework that fails to capture the inefficiency from non-radial slacks in outputs and inputs. Ignoring such non-radial slacks, the radial DEA framework will underestimate technical inefficiency, while the residual source of profit inefficiency, allocative inefficiency, will be overestimated.

When focusing on banks' performance across time periods, the Malmquist productivity index (MPI) of Caves et al. [8] and LPI of Chamber et al. [9,10] are often employed. Researchers adopting MPI are forced to choose either an output- or an input-oriented perspective in efficiency estimation only, whereas LPI, composed of the directional distance functions, appears in an additive form that can account for simultaneous adjustments of both outputs and inputs. While the Luenberger shortage function is dual to the profit function, LPI is shown to encompass MPI (Boussemart et al. [11]). Despite LPI being required for evaluating organizations that are assumed to be profit maximizers, LPI is still based upon the quantity distances without resorting to the output and input prices. Therefore, conventional LPI cannot capture any allocative efficiency component and thus does not give a full picture of the source of productivity change, like those resulting from output/input mixes given at the prevailing relative prices. As a result, the conventional LPI loses the important message that a decision making unit (DMU) may improve the profit performance by changing output–input mixes.

Recognizing the importance of price and allocative components on bank profitability performance, a number of previous papers that apply methodologies different from MPI and LPI also attempt to incorporate productivity change into the decomposition of bank profit change. Examples of those decompositions are shown in Grifell-Tatjé and Lovell [12], Asaftei [13], Sahoo and Tone [14], Juo et al. [15], and Juo [16], who differentiated changes in profits into different kinds of components using DEA or SBM models and analyzed the profit performance of Spanish, U.S., Indian, and Taiwanese banks over time, respectively. However, unlike LPI, all the measures in these papers are not unit-independent – that is, the measure of productivity change in them is affected by the currency used.

All the measures of productivity change in the above-mentioned papers are estimated either by radial DEA models or by non-radial DEA models. Radial measures of efficiency overestimate technical efficiency when there are non-zero slacks in the technology defined. To avoid such bias estimation, various non-radial-like DEA models have been developed to account for the slacks of all inputs and outputs. These include the additive models of Charnes et al. [17], the Russell measure of Färe and Lovell [18], the Russell graph or enhanced Russell measures of Färe et al. [19] and Pastor et al. [20], the range-adjusted measure of Cooper et al. [21], and the slack-based-like measures of Tone [22] and Liu and Tone [23].

The application of non-radial DEA models to the productivity change of banks is also quite rare. Some papers have explored this area, including Sahoo and Tone [14], Juo et al. [15], Chang et al. [24], and Fujii et al. [25], yet so far the papers based on non-radial DEA models have never considered productivity change in terms of the Nerlovian profit measure.[4]

Under the non-radial DEA framework, Fukuyama and Weber [1] recently developed a more general slack-based model called DRM. While the DRM measure combines the desirable features of the directional technology distance function and slacks-based measure, it unifies several existing measures of technical inefficiency that account for slacks. However, even though such DRM appears in an additive form, it cannot be used for decomposing profit inefficiency due to its failure to consider the impacts from the prices of inputs and outputs. It also fails to consider productivity change and decompositions over time.

By modifying DRM, we are able to decompose the profit-oriented inefficiency in a more general way, which can attribute technical and allocative inefficiencies to output- and input-specific contributions and thus provide a full picture of the sources of profit-oriented productivity change – that is, we propose a new slack-based LPI, which fills the gap in DRM of Fukuyama and Weber [1] as applied to the profit-oriented productivity change indicator. On the other hand, herein the non-radial decomposition of profit inefficiency extends the work of Chambers et al. [2], followed by Färe et al. [5] and Koutsomanoli-Filippaki et al. [6,7], to obtain unbiased technical and allocative inefficiencies. Finally, the profit-oriented productivity change indicator in this study conquers the unit-dependent problem of Grifell-Tatjé and Lovell [12], Asaftei [13], Sahoo and Tone [14], Juo et al. [15], and Juo [16].

Compared to previous DEA papers, this study makes contributions to the literature in three areas. First, as proved by Fukuyama and Weber [1], DRM generalizes and unifies several measures of technical inefficiency. Based on DRM, we further decompose profit inefficiency into technical and allocative inefficiencies in a more general way. Our proposed model not only fully considers the simultaneous adjustments of inputs and outputs as well as the non-radial slacks, but also combines the Nerlovian profit measure with the conventional LPI and thus provides unit-independent measures. Second, we extend the above decomposition to develop a new slack-based and profit-oriented productivity indicator that can be further decomposed into four useful components: technical efficiency change, allocative efficiency change, technical change, and the price effects of outputs and inputs. Third, this study is the first to use DRM to decompose the profit-oriented productivity change of Taiwanese banks.

The remainder of this study is organized as follows. Section 2 presents an overview of the Taiwanese banking industry. Section 3 proposes the methodology to decompose the profit-oriented productivity change. Section 4 lists the definitions of variables and data descriptions. Section 5 deals with the empirical results. Section 6 offers a discussion on policy implications. The conclusions follow in Section 7.

2. Overview of the Taiwanese banking industry

A material change in Taiwan's financial environment occurred when 16 new banks were allowed to be established in the 1990s. However, the rapid expansion in the number of banks brought about over-competition and lower profit in the domestic financial market, as the number of Taiwanese banks reached its peak of 53 in 2001. The Taiwanese government then launched a series of

[4] We also note the development of the dynamic non-radial DEA model that accounts for carry-over activities. The conventional productivity index or indicator, (*footnote continued*)
such as MPI and LPI, does not consider the effect of carry-over activities between two consecutive time periods. To deal with a long time point of view, Tone and Tsutsui [28] proposed the dynamic slacks-based measure (DSBM) by incorporating carry-over activities into the model, which measures period specific efficiency based on the long time optimization during the whole period. However, DSBM has not been applied to decomposing the profit-oriented productivity indicator as developed in our study.

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