



Interfaces with Other Disciplines

Non-radial cost Luenberger productivity indicator

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ABSTRACT

This study decomposes cost inefficiency into technical and allocative components in a more general way based on the directional Russell measure (DRM) of Fukuyama and Weber (2009), with the allocative component being completely clear of technical inefficiency. Based on this decomposition, we develop a cost-oriented productivity indicator, the cost Luenberger productivity indicator (CL), which completely embraces the concept of cost minimization and provides four sources of productivity change: technical efficiency change, the change in allocative efficiency, the shift of technology, and the effect of input price change. To illustrate the above decompositions of cost inefficiency and productivity change and to investigate whether the establishment of a financial holding company (FHC) offers a bank greater operating efficiency and an improvement in productivity change, this study employs data on Taiwan's banking industry covering the period 2006–2012.

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1. Introduction

Taiwan's financial market was highly regulated before 1990. As surveyed by Chiou (2009), this market experienced three important reforms: (1) opening up to new banks in 1991; (2) financial measures to alleviate the negative impacts of the 1997 Asian financial crisis; and (3) encouraging mergers and acquisitions to deal with overbanking after 2000. The major financial reforms on banks are summarized as follows.

First, in order to enhance the financial structure and bring about competitiveness, the Taiwan government decided to allow domestic and foreign investors to enter the local banking market in 1991, which resulted in sixteen new banks being established. Compared to most of the banks already set up before 1991, the sixteen banks began operation with a small scale. Second, the Asian financial crisis that erupted in 1997 brought negative impacts to Taiwan's small- and medium-sized enterprises. To alleviate the negative impacts on banks, the authority cut their value-added tax rate from 5 percent to 2 percent, which was offered so that banks

could write off their bad loans. Third, overbanking became quite serious after 2000, with the number of Taiwanese banks reaching a peak of 53 in 2001. To deal with this over-competition, the government launched a series of financial reforms, such as improving the quality of banking loans and encouraging financial acquisitions and mergers. The former included measures that forced banks to reduce NPL ratios and increase their capital adequacy, while subsidizing weaker-structured banks so as to write off their bad loans. However, these measures just prevented some banks from going bankrupt, but did not deal with the structural problem of overbanking. Thus, the Taiwan government passed the Bank Mergers and Acquisitions Act in 2000 and the Financial Holding Company Act in 2001 to relax regulations on the mergers of financial institutions and to allow for the establishment of financial holding companies (FHCs). Thus, 14 FHCs in Taiwan have been in operations since 2001. As classified by Lo and Lu (2009), the 14 FHCs in Taiwan are divided into three sub-groups: (1) banking-based FHCs: China Development, Chinatrust, E. Sun, First, Hua Nan, Mega, Sinopac, and Taishin; (2) insurance-based FHCs: Cathay, Fubon, and Shin Kong; and (3) securities-based FHCs: Fuhwa, Jihsun, and Waterland.

As surveyed by Emrouznejad, Parker, and Tavares (2008), banking was found to be one of the most popular applications in the field of data envelopment analysis (DEA). However, there is a very limited number of papers aimed at the

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operating efficiency of Taiwanese FHCs. Compared to the parametric model, the non-parametric approach does not require prior assumptions on the specification of production and cost frontiers. Lu and Lo (2009) focused on resolving the problems associated with ranking both efficient and inefficient decision making units (DMUs) fairly by proposing an interactive benchmark model applied to FHCs in Taiwan. Based on Seiford and Zhu's (1999) model, Lo and Lu (2009) combined the efficiency of profitability as well as the efficiency of marketability to evaluate FHCs' performances in Taiwan. Hu, Lai, and Huang (2009) used a multiple DEA framework to compare the operating and human resource performances of FHCs in Taiwan. Liu (2011) utilized an additive efficiency decomposition approach to measure the profitability and marketability efficiencies of Taiwan's FHCs. Chiou (2009) focused on comparing the operating efficiency of Taiwan's commercial banks in FHCs. This paper used a DEA approach to investigate whether Taiwan's commercial banks establishing a FHC or joining a FHC could promote their own efficiency and productivity and then discussed the determinants of these banks' efficiency and productivity change.

The establishment of FHCs aims at seeking a greater business scope and better resource consolidation, which is expected to achieve an optimum of capital and reduce cost so as to achieve stronger operating efficiency. Although many individual mergers have been quite successful in improving cost performance, many others have worsened their cost efficiency, so that on average there is no significant improvement (Berger & Humphrey, 1997). In order to test whether banks perform well due to them establishing a FHC, joining a FHC, or if they do not establish or join a FHC, we divide Taiwan's banks into those that establish or join FHCs and those that have not established or joined FHCs. The purpose of this study focuses on cost inefficiency, cost productivity change, and their sources.

All the measures of cost efficiency (inefficiency) and productivity change can be estimated either by radial DEA approaches or by non-radial DEA approaches. The former generally underestimate technical inefficiency in the constraint defining the piecewise production frontier. This difficulty motivates alternative efficiency measures, the non-radial models, because they directly deal with the input and output slacks. Examples include Färe and Lovell (1978), Charnes, Cooper, Golany, Seiford, and Stutz (1985), Färe et al. (1985), Cooper, Park, and Pastor (1999), Tone (2001), and Fukuyama and Weber (2009).

The problems of multi-period DEA have been extensively studied in last decades. Amirteimoori and Kordrostami (2010) considered the performance of a DMU in the course of multiple periods. Their proposed DEA models not only measure the efficiency across all periods, but also provide the efficiency measures for each of the periods. It has been further proven that the aggregate efficiency is a convex combination of the efficiency of each period. As for productivity change, the Malmquist productivity index (MPI), which was first introduced by Caves, Christensen, and Diewert (1982a) and 1982b), had been widely applied in literature. Färe, Grosskopf, Norris, and Zhang (1994) employed data envelopment analysis (DEA) approach to further decompose MPI into various sources, including technical efficiency change and technical change. However, the major limitation faced by researchers using MPI is to choose either an input-oriented or an output-oriented perspective. To deal with this difficulty, Chambers, Färe, and Grosskopf (1996a), 1996b) developed, using directional distance functions (DDFs), the Luenberger productivity indicator (LPI) to measure the change in total factor productivity. There have been extended works based on the frameworks of MPI and LPI. Utilizing DRM, Mahlberg and Sahoo (2011) and Chang, Hu, Chou, and Sun (2012) set up the input-specific LPI to address the contributions of individual inputs to productivity change. Mahlberg and Sahoo (2011) applied the input-specific LPI to the eco-productivity performance of 22-OECD

countries over the period 1995–2004. Chang et al. (2012) used the input-specific LPI to investigate the sources of 19 banks' productivity growth in China over the period 2002–2009. Both of their indicators can also be shown as the sum of the individual input-specific changes in productivity, technical efficiency, and technology.

More useful information can be obtained from the decomposition of productivity change when data on input prices are available. Maniadakis and Thanassoulis (2004) developed a cost-oriented MPI, defined in terms of cost boundaries, to provide a clearer picture of productivity change, including the allocative component and the input price change effect that could not be found in the conventional MPI. Following the study of Maniadakis and Thanassoulis (2004), some papers have proposed various non-parametric linear programming models to decompose the cost Malmquist productivity index, such as Ball, Färe, Grosskopf, and Zaim (2005), Yang and Huang (2009), Tohidi, Razavyan, and Tohidi (2012), Wheelock and Wilson (2013), and Wang, Xie, Shang, and Li (2013). Yang and Huang (2009) adopted the assumption of variable returns to scale to obtain a new component, cost scale efficiency change, which could not be found in Maniadakis and Thanassoulis (2004). Tohidi et al. (2012) initiated the circular global cost Malmquist productivity index that is immune to linear programming infeasibility. Ball et al. (2005) proposed the Malmquist cost productivity measure that can account for externalities (undesirable outputs), but does not incorporate the allocative components of inputs. Based on Ball et al. (2005), Wheelock and Wilson (2013) presented a decomposition that enables an estimation of cost and scale efficiencies. Wang et al. (2013) developed a new method that combines the cost Malmquist index with the Luenberger to measure the cost efficiency of China's 30 thermal power industries with the undesirable output of carbon emissions.

Another work on the cost indirect productivity measurement has been done in several papers such as Färe, Grosskopf, and Lovell (1992), Färe and Grosskopf (1994), Balk (1995) and Färe and Grosskopf (2004). Färe et al. (1992) introduced the cost indirect Malmquist productivity index in which DMUs maximize revenue while constrained by a given budget.¹ Balk (1995) has further shown that under certain assumptions the cost indirect Malmquist productivity index could be approximated as the ratio of the Fisher output quantity index and the cost index.

In the field of DEA, research on cost efficiency and cost productivity change seldom considers input slacks that induce biased measures of technical and allocative efficiencies (inefficiencies). Fukuyama and Weber (2009) proposed a more general non-radial DEA model, DRM, which unifies several measures of technical inefficiency. Modifying DRM, we decompose cost inefficiency into technical and allocative inefficiencies in a more general way. Based on this decomposition, we further propose a new slack-based LPI that uses not only the production frontiers, but also the cost boundaries as benchmarks so as to give a full picture of the sources of productivity change.

Compared to previous DEA papers, this study makes three contributions to the literature. First, DRM is a generalized measure that unifies several measures of technical inefficiency. Modifying DRM, cost inefficiency in this study is decomposed into technical and allocative components in an unbiased way. Second, based on this decomposition, we develop a new productivity indicator, the cost Luenberger productivity indicator, which completely embraces the concept of cost minimization so as to give a more complete picture of productivity change - that is, this study fills the gap of

¹ The parallel concept appears in the revenue indirect Malmquist productivity index where DMUs minimize cost while constrained by a target revenue. The theory of cost and revenue constrained production has been further developed by Färe and Grosskopf (1994).

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