

Nonlinear Efficiency in DEA Relative to “Ideal Reference”

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INTRODUCTION

Since the original publication on Data Envelopment Analysis (DEA) by Charnes et al. (1978) measuring the efficiency of decision making units, there has been a rapid and continuous growth in this area of study. A considerable amount of research publications have appeared, a significant portion of which focusing on DEA applications of efficiency and productivity in the banking sector. For example, a comprehensive survey of literature on bank efficiency could be found in Fethi and Pasiouras (2010). They have examined bank branch efficiencies in more than 30 studies over the period 1998-2009. All these studies are using DEA to estimate bank efficiency. Thompson et al. (1995) introduced nonlinear LC-AR efficiency measure to DEA literature, where they discussed the single-output multiple-inputs model subject to linked-cone (LC) assurance-regions (AR).

A major criticism leveled against DEA is that DEA measures only relative efficiency of decision making units (DMUs) participating in the study. While highlighting this as a drawback in DEA methodology, some authors in the past have suggested incorporating best-practice efficiency analysis by including an industrial benchmark among the DMUs. Lei Li et al. (2013), Dharmapala et al. (2007), Cook and Zhu (2006), Zhu (1996), Thanassoulis and Dyson (1992), and Golany (1998) are among those suggested. In this paper, we compute the nonlinear LC-AR measure against the linear radial measures of CCR (Charnes et al., 1978), BCC (Banker et al., 1984), CCR/AR and BCC/AR (Thompson et al., 1992), relative to an “ideal reference”- an industrial benchmark. We demonstrate the computations in an application to

a set of banks and show that the nonlinear measure is stricter. To our knowledge, we may be the first to carry out such a comparative study.

LITERATURE REVIEW

As a nonparametric method based on linear programming, DEA has been used to assess performance efficiency in many areas of decision science. A comprehensive listing and analysis of DEA research that covers the first 30 years of its history could be found in Emrouznejad et al. (2008). But in this paper, we narrow our search to the banking sector. Ji et al. (2012) researched in rating and ranking Chinese commercial banks, using DEA, in the presence of an undesirable output, non-performing loans. Minh et al. (2012) proposed a method to rank efficient units in DEA based on slack-based measure of efficiency, with an application to agricultural bank branches in Vietnam. Dharmapala and Edirisuriya (2011) reported a decision model to predict profitability of banks using LC-AR efficiency and profit ratios. Cooper et al. (2011) proposed a new method to measure and decompose profit inefficiency through the weighted additive model. Fadzlan (2010), using DEA, provided empirical evidence on the evolution of the Indonesian banking sector's efficiency during the post Asian financial crisis period of 1999-2008. His findings suggested that Indonesian banking sector's inefficiency stems largely from pure technical rather than scale. Malhotra et al. (2009), while claiming that during the recent financial crisis they had seen a substantial decline in the profitability and liquidity of the financial services, used DEA to evaluate the strength of

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thirteen leading financial services firms in USA by benchmarking financial ratios of a firm against its peers. Das and Ghosh (2009), using DEA, examined the impact of financial deregulation on cost and profit efficiency of Indian commercial banks during the post-reform period 1992–2004. Premachandra, Bhabra, and Sueyoshi (2008) applied the additive DEA model, which allowed the negative values of financial ratios in assessing corporate bankruptcy of US companies. They revealed that DEA outperformed logistic regression in the case of a large data set. Tortosa-Ausina et al. (2008) performed a sensitivity analysis of efficiency with an application to Spanish savings banks. Pramodh et al. (2008) introduced a novel technique, DEA-Fuzzy Multi Attribute Decision Making hybrid model, to measure the productivity levels of Indian banks and rank them. Camanho and Dyson (2006) developed measures based on DEA-Malmquist index that enabled the assessment of bank branches’ performance. Rajesh and Gaurav (2005) evaluated the relative efficiency of Indian banks using DEA and suggested that the foreign banks, as a group, have been considerably more efficient than all other bank groups, followed by the Indian private banks. Casu et al. (2004) analyzed the productivity change in European banking with a comparison of parametric and non-parametric approaches.

In this paper, we measure nonlinear LC-AR efficiency vis-à-vis linear radial efficiency of fifty five banks, relative to an “ideal reference”- an industrial average.

METHODOLOGY

Thompson-Thrall LC-AR Efficiency Model

Thompson et al. (1993) presented a new DEA theory, which did not require the use of non-Archimedean principle used in the original DEA theory developed by Charnes et al. (1978), and it allowed

zero data entries. In this paper, we use Thompson et al.’s methodology as described below.

A DEA data domain consists of n decision-making units (DMUs), n input vectors (each with m inputs), and n output vectors (each with r outputs). The selected DMU _{c} ($c = 1, 2, \dots, n$) is characterized by an input vector $X_c (x_{1c}, x_{2c}, \dots, x_{mc})$ and an output vector $Y_c (y_{1c}, y_{2c}, \dots, y_{rc})$. U -output multiplier of r unknowns ($u_k; k = 1, 2, \dots, r$) and V -input multiplier of m unknowns ($v_i; i = 1, 2, \dots, m$) need to be determined by solving the respective nonlinear/linear programming (NLP/LP) models stated below.

Here we consider the following four inputs ($m=4$) and one output ($r=1$) for the banks:

- X_1 : Total deposits include demand deposits, time and savings deposits, CDs, and purchased funds
- X_2 : Fixed assets in terms of bank premises, furniture, and equipment
- X_3 : Total non-interest expenses include employee salaries, benefits, and expenses on fixed assets
- X_4 : Loan loss provisions. Accounting allocations to cover possible loan defaults
- Y : Total loans include commercial, industrial, real-estate, and installment loans

We now formulate the General LC-AR efficiency model with nonlinear objective function (Thompson et al., 1995)

$$\text{Max } \theta_c = \left[\sum_{k=1}^r u_k y_{kc} / \sum_{i=1}^m v_i x_{ic} \right] \text{ (for DMU}_c\text{)}$$

$$\sum_{k=1}^r u_k y_{kj} - \sum_{i=1}^m v_i x_{ij} \leq 0 \quad j = 1, 2, \dots, n \quad (1)$$

$$\alpha_i v_j < v_i < \beta_i v_j \quad j < i; j = 1, \dots, m-1; i = 2, \dots, m \text{ (input cone)} \quad (2)$$

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