Do undesirables matter on the examination of banking efficiency using stochastic directional distance functions

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\textbf{A B S T R A C T}

This paper aims to gain further insights into whether the First Financial Restructuring (FFR) policy improves the technical efficiency of Taiwan’s banks during the period 1999–2012, using the directional technology distance function (DDF). DDF simultaneously allows for the expansion of the desirable and the contraction of the undesirables, which is able to depict a bank’s true production activities. We find that the banks have a lower technical inefficiency with the preferred model compared to the other models. Before 2002, the technical inefficiency exhibits a gradual upward trend and then posts a downward trend during the FFR period, due to enhanced banking and benefits obtained from compliance with FFR. The inefficiency scores deteriorate sharply, during the "credit card and cash card crisis" in 2006 and "the subprime mortgage crisis" in 2008. Public and financial holding company (FHC) banks are respectively more efficient than private and non-FHC banks.

\section{1. Introduction}

There has been increasing interest in the relationship between regulatory reforms and technical efficiency of the banking industry. To enhance the banking industry’s competitive viability and to restructure the financial system, Taiwan authorities launched a series of financial reforms, referred to as “First Financial Restructuring (henceforth, FFR)” from 2002 to 2003. The current study adopts the parametric stochastic frontier approach (SFA) in the context of the directional technology distance function (DDF) to examine the production efficiency of Taiwan’s banks. We then investigate whether the FFR policy does improve the technical efficiency of banks in Taiwan. In particular, we split the sample period into four sub-periods: pre-reform period (1999–2001), reforming period (2002–2003), post-reform period I (2004–2007), and post-reform period II (2008–2012). In our research case, during the process of granting various loans to their customers, banks sometimes experience loan defaults that result in non-performing loans (NPLs), which are a form of undesirable outputs. We include undesirable outputs in DDF to depict a bank’s true production activities along with environmental variables to account for the impacts from various macro- and micro-factors, as proposed by Battese and Coelli (1995). This allows one to estimate the shadow price of the non-marketable bad output.

For the purpose of comparison, we also estimate a stochastic DDF without environmental variables. To further highlight the role of the undesirable outputs in the application of the banks’ frontier model emphasized herein, we simultaneously subsume the estimation results of the stochastic DDF, which ignores the undesirable outputs as the comparison group. Moreover, the conventional stochastic input distance function is estimated with and without connecting a set of environmental variables with the inefficiency term. It is well-known that the standard input and output distance functions are unable to consider bad outputs. Consequently, their efficiency estimates may fail to reflect the real managerial abilities of bank managers.

Desirable and undesirable outputs are jointly produced. The former are often marketable, but the latter are not, and their disposal is frequently subject to regulation. Thus, it is necessary to explicitly
model the effects of producing both forms of outputs. Since there are, in general, no markets for undesirables, their (shadow) prices must be estimated and contain valuable information. The estimation of DDF allows us to calculate the shadow price of undesirables. Färe, Grosskopf, Noh, and Weber (2005) are the first to use DDF to measure environmental efficiency and estimate the shadow price of the undesirable output. Fukuyama and Weber (2008) and Ke, Li, and Chiu (2011) employ the method of Färe et al. (2005) to estimate the shadow price of problem loans via a parametric DDF. This paper follows these previous works to examine the shadow price of NPLs using the stochastic DDF.

About three decades ago, banks in Taiwan were rigorously regulated by the government with total assets of state-owned banks taking up more than three quarters of the entire banking industry. At the outset of the 1990s, Taiwan’s government took steps to privatize public banks and liberalize the financial market by allowing the new entry of private and foreign banks. As a result, the degree of competition in the industry largely intensified, which is expected to prompt the performance of domestic banks. These policies appear to have helped Taiwan’s banking sector successfully weather the Asian financial crisis in 1997–1998, but over-banking has caused excessive competition and lowered interest margins, such that the existing banks suffer from a low level of profits. Even worse, the quality of loans has deteriorated in order for the banks to seize and keep a larger market share. The aftermath of the Asian crisis saw soaring NPLs and declining capital adequacy ratios, hurting asset quality and profitability within the banking sector. Among them, high NPLs are thought to be the most serious problem, substantially reducing the liquidity of some banks and bringing them to the edge of insolvency.

The major target of the FFR aims to write off the NPLs of financial institutions. Many important laws on regulating financial institutions were legislated and revised at the same time, which are designed to enhance the performance of commercial banks. The ratio of NPLs to total loans largely dropped after the enforcement of the “2-5-8 policy”.

A bank is said to be technically efficient if it can produce maximum output from a given set of inputs (an output-oriented measure) or can employ a minimum input mix to manufacture the same output level (an input-oriented measure). SFA and the non-parametric data envelopment analysis (DEA) are two major frontier techniques suitable for measuring the efficiency and productivity change of firms. However, there is no consensus on the preferred method (Berger & Humphrey, 1997). Frontier efficiency is useful for financial institution managers and industry consultants to assess performance. Many researchers apply either SFA or DEA to study the effects of financial deregulation on the efficiency and productivity gains of banks and insurance firms, as well as the effects of mergers and acquisitions and capital regulations on banks’ profitability and performance. The results may provide valuable policy implications to regulatory analysis.

A bank has to spend additional resources to disentangle itself from these NPLs. This lowers either its input-oriented efficiency score due to the fact that the extra input usage curtails the amount of undesirable NPLs, instead of raising quantities of desirable outputs, or cuts its output-oriented efficiency score since parts of input quantities are used toward the disposal of the undesirables. The implication is that the conventional radial measures of technical efficiency may not be able to reflect the true managerial abilities of banks due to the presence of undesirables that are not freely disposable. In other words, undesirable outputs are not allowed to be disposed of costlessly. “Cleaning up” these outputs requires a reallocation of inputs away from the production of desirable outputs. To date, the recently developed DDF appears to be the sole model that is useful to explicitly model the effects of producing both desirable and undesirable outputs, taking into account their characteristics and their interactions.

Specifically, DDF allows one to measure a firm’s technical efficiency along with a given direction that measures how much quantities of outputs (desirables and/or undesirables) and inputs should be increased and decreased, respectively, to reach the efficient frontier. The Shepherd’s (1953) input and output distance functions can be viewed as special cases of DDF. Dorfman and Koop (2005) point out that the undesirable output is one of the major issues in the field of the measurement of efficiency and productivity growth under the framework of multiple inputs and outputs. The first research utilizing DDF is attributed to Chambers, Chung, and Färe (1996) who generalize the model of Luenberger (1992, 1995) to a benefit function.

DDF has three salient features. First, in contrast to Shepherd’s (1953) output distance function that seeks to increase both desirable and undesirable outputs, DDF simultaneously allows for the expansion of the desirables and the contraction of the undesirables (and/or inputs). Second, DDF has an additive structure such that the efficiency indices of individual firms can be aggregated into the industry level. Third, when a functional form is required to be specified for DDF neither the dependent nor the explanatory variables have to be transformed by taking the natural logarithm, which avoids the calculation with respect to non-positive entries for some observations.

So far, most empirical studies employ DEA, except for Feng and Serletis (2014) and Huang, Chiang, and Tsai (2015), to estimate efficiency in the context of DDF. See, for example, Färe, Grosskopf, and Hernandez-Sancho (2004), Färe et al. (2005), Färe, Grosskopf, and Weber (2006), Hsiao, Chang, Cianci, and Huang (2006), Koutsomanoli-Filippaki, Margaritis, and Staikouras (2009b), and Park and Weber (2006). DEA is function-free and hence is advantageous in that it does not suffer from the possible specification error on the production frontier. Nevertheless, the main shortcoming of DEA comes from its omission of the random disturbance, so that the resulting efficiency estimates tend to be confounded with noises (Berger & Humphrey, 1997; Das & Ghosh, 2006; O’Donnell & Coelli, 2005). Conversely, a particular functional form has to be specified to represent the production technology if SFA is employed. This approach is able to separate the effects of noises on estimated efficiency scores and, more importantly, environmental variables can be easily incorporated and linked with technical efficiencies.

The rest of this paper is organized as follows. Section 2 briefly reviews the literature. Section 3 introduces the background of Taiwan’s banking industry. Section 4 specifies a parametric DDF to be estimated, and Section 5 describes the data set. Section 6 discusses the empirical findings, while the last section concludes the paper.

2. Literature review

2.1. Effects of regulation on banking efficiency

Many researchers have investigated the nexus of deregulation and banking efficiency, but the results are mixed (Berger & Humphrey, 1997). Das and Ghosh (2006) find that medium-sized Indian public banks performed reasonably well and the efficiency scores of the banking sector are quite high during the period 1992–2002. Isik and Hassan (2003) conclude that the performances of all types of Turkish banks, with the exception of state-owned banks, have recorded significant improvements after deregulation.

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1 The Taiwan government enacted the 2-5-8 policy, which requires all banks within 2 years to reduce their NPL ratio to be less than or equal to 5% and to maintain a capital adequacy ratio above 8%.
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