Economic Modelling 36 (2014) 298–308

Contents lists available at ScienceDirect

Economic Modelling

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

Cost efficiency of the Chinese banking sector: A comparison of stochastic frontier analysis and data envelopment analysis

Yizhe Dong [a,*], Robert Hamilton [b], Mark Tippett [c,d,e]

[a] School of Management and Business, Aberystwyth University, Aberystwyth SY23 3AL, UK
[b] School of Business and Economics, Loughborough University, Loughborough LE11 3TU, UK
[c] Business School, University of Sydney, Codington Street, Sydney, NSW 2008, Australia
[d] School of Accounting and Commercial Law, Victoria University of Wellington, Pipitea 6011, New Zealand
[e] Department of Accountancy and Finance, University of Otago, Dunedin North 9054, New Zealand

ARTICLE INFO

Article history:
Accepted 24 September 2013

JEL classification:
D24
G21

Keywords:
Cost efficiency
Stochastic frontier analysis
Data envelope analysis
Chinese banking

ABSTRACT

This paper investigates the consistency of efficiency scores obtained from the stochastic frontier analysis and data envelopment analysis methods. We estimate cost efficiency and economies of scale based on an unbalanced panel data set of Chinese banks over the period 1994 to 2007. The results suggest moderate consistency between parametric and non-parametric frontier methods in efficiency scores rankings, identification of best and worst practise banks, the stability of efficiency scores over time and correlation between frontier efficiency and accounting based performance measures. Based on the findings, we conclude that the use of multiple frontier techniques for efficiency analysis is to be strongly recommended and that this methodological cross-checking analysis will result in more robust and convincing assessments of bank performance.

1. Introduction

Banking sectors throughout the world have witnessed significant developments over the last three decades as changes in the environment in which they operate have had substantial implications for their business activities. Deregulation, globalization, financial innovation and technological progress all have gradually reduced the costs of information processing and transmission and have been major forces impacting on the performance of the international banking sector (Girardone et al., 2004). Given this, there is a pressing need to investigate and measure the impact of various macro-economic factors and/or institutional policy changes on banks' performance as this type of analysis will assist government instrumentalities and banking regulators in policy choice. It will also enable bank management to improve the way in which they allocate resources across the various investment opportunities available to them. Here, academic research has increasingly focused on frontier (productive, cost or profit) efficiency analysis, which measures the deviation in performance from that of best-practise banks on the derived efficient frontier.

There are two principal methods evidenced in the literature through which to measure frontier efficiency: the parametric (econometric) approach and the non-parametric (mathematical programming) approach. These two approaches differ primarily in the underlying assumptions applied in estimating the efficient frontiers. The most commonly employed parametric procedure is the stochastic frontier approach (SFA) as it allows for the effect of statistical noise to be separated from the effect of inefficiency, thereby resulting in a stochastic frontier. However, this approach requires a specific functional form that presupposes the shape of the efficient frontier (production, cost or profit) and assumes a specific probability distribution for the efficiency level. Additionally, if the assumptions are mis-specified, the measured efficiency will contain errors. The non-parametric approach, commonly referred to as data envelopment analysis (DEA), avoids this type of specification error because it does not require *a priori* assumptions about the analytical form of the production (or cost) function or an assumed probability distribution for efficiency. However, it suffers from one major drawback in that it does not allow for random errors (e.g., measurement errors, good or bad luck) in the optimization problem and all deviations from the frontier are measured as inefficiency. Consequently, this will exaggerate the average inefficiency if any noise is present. Therefore, as both parametric and non-parametric approaches have their own merits and limitations and since the true level of efficiency is unknown, the choice of a suitable efficiency estimation procedure has been quite controversial. However, some researchers (e.g. Bauer et al., 1998; Eisenbeis et al., 1999; Huang and Wang, 2002; Weill, 2004) have argued that it is not necessary to have a consensus on which is the best method for measuring frontier efficiency. Rather they recommend a checking process

* Corresponding author. Tel.: +44 1970622508; fax: +44 1970 62240.
E-mail addresses: yid1@aber.ac.uk (Y. Dong), R.Hamilton@lboro.ac.uk (R. Hamilton), M.Tippett@econ.usyd.edu.au (M. Tippett).

0264-9993/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.econmod.2013.09.042

which uses more than one methodology to assess the robustness of any efficiency results obtained.

Over the last thirty years, China has been one of the world's fastest growing emerging economies and in 2010 became the world's second largest economy in terms of nominal GDP. China's banking sector has played a very important role in its rapid economic growth. Since 1979, the Chinese authorities have embarked on a series of significant reforms designed to address the institutional, political and organizational problems faced by the banking industry. The reforms have included inter alia: establishing a two-tier banking system; separating so-called policy lending from commercial lending; removing the credit ceiling on deposits and loans; reducing the systemic risk of the banking sector; gradually privatising state-owned banks; encouraging state-owned banks to seek a listing on the stock exchange; and relaxing the restrictions on foreign bank entry into local Chinese markets.[1] These reforms were intended to create a sound and effective banking system and in turn enhance the efficiency and productivity levels of Chinese banks. It is important, therefore, to use both the parametric (SFA) and non-parametric (DEA) frontier methodologies to estimate the cost efficiency of Chinese banks over the reform period (1994–2007). More specifically, we employ a parametric estimation procedure that is closely related to Battese and Coelli's (1995) efficiency model. For the non-parametric approach we employ two alternative models — the traditional DEA model developed by Färe et al. (1985) and a more recent DEA model developed by Tone (2002).

The primary objective of this paper is to compare the empirical cost efficiency results between the above parametric and non-parametric approaches by checking the five consistency conditions advocated by Bauer et al. (1998). This methodological cross-checking process provides more convincing and useful information and diagnosis for regulatory analysis and the decision maker.[2] Additionally, another important objective of this study is to examine the effects of certain factors such as bank type and China's admission to the World Trade Organization (WTO) on the cost efficiency of Chinese banks and the policy implications that flow from them. Our paper also provides information on the measurement of scale economies as obtained from both the parametric and non-parametric methods for the Chinese banking sector over the period 1994–2007. The rationale for estimating economics of scale is that they are closely related to a bank's optimal behaviour and have implications for regulatory policy regarding industry consolidation and antitrust enforcement.

The remainder of the paper is organized as follows. Section 2 briefly reviews some existing studies that employ two or more frontier approaches using a common data set for the estimation of bank efficiency. Section 3 explains the methodology and Section 4 details the variables and data employed in the study. Section 5 and Section 6 present and discuss the empirical results and Section 7 concludes.

2. Related literature review

While there is a large literature looking at banking efficiency, only a relatively few studies have used two or more frontier approaches for the estimation of bank efficiency on the same data set — especially in relation to developing counties. In the 1990's proponents of methodological cross-checking started to debate the relative merits of the parametric and non-parametric approaches for measuring bank efficiency. Such studies applied both linear programming and econometric methods to common data sets and conducted explicit comparisons of the results obtained from the two methods for measuring efficiency. This type of comparative analysis continues a practise initiated by Ferrier and Lovell (1990), who analyzed the cost efficiency of 575 U.S. banks by applying both SFA and DEA methodologies. They found that both DEA and SFA methodologies generally lead to similar conclusions on the level of average cost efficiency, but, that the rank correlations between DEA and SFA efficiency scores are quite low. Additionally, when they disaggregated cost inefficiency into technical inefficiency and allocative inefficiency components, both techniques led to different conclusions on the magnitude of the two types of inefficiency scores. A European perspective was provided by Resti (1997) who examined cost efficiencies for a panel sample of 270 Italian banks using multiple frontier techniques. He showed that there was a very high positive correlation for efficiency score rankings between DEA and SFA and concluded that the results obtained from the two approaches do not differ significantly. Drake and Weyman-Jones (1996) come to a similar conclusion when they used SFA and DEA to estimate the cost efficiency of 46 British building societies.

Bauer et al. (1998) applied four frontier techniques[3] on a panel data set of 683 large U.S. banks over the 12 year period from 1977 to 1988 and noted in particular that the approach taken in their study provided a comprehensive investigation of the consistency of the various frontier approaches that had not previously appeared in the banking efficiency literature. Bauer et al. (1998) found that the mean cost efficiency of parametric models is much higher than that of nonparametric models. They also found that the rank–order correlation between DEA and parametric techniques is typically in the vicinity of 10%, suggesting that the nonparametric and parametric approaches provide only very weak consistency in their efficiency scores. On the other hand, there is noticeable similarity in the distributional characteristics of the efficiency scores and the efficiency rank–order correlation when, instead of comparing the nonparametric with the parametric approaches, the comparison is within each of the two methods (i.e. parametric and nonparametric). Moreover, (i) the identification of best and worst practise banks is not consistent between the DEA and parametric techniques, (ii) all approaches are stable over time, although DEA generally shows slightly better stability than the parametric techniques and (iii) the parametric methodologies seem to be consistent with the standard non-frontier (that is, financial ratio) performance measures, whereas nonparametric measures are only weakly related to financial ratio performance measures. Therefore, in summing up, Bauer et al. (1998)'s results show a low degree of consistency between the parametric approaches and the nonparametric approaches.

Huang and Wang (2002) is the only published study using an Asian data set which compares more than one variant of each efficiency assessment methodology. They evaluated the economic efficiency and economies of scale of 22 Taiwanese commercial banks over the period from 1982 until 1997, using DEA, SFA and DFA (Distribution Free Approach) and found that the average efficiency score generated by DEA is roughly the same as that for the SFA and DFA approaches. However, the Spearman rank correlation coefficients between the parametric (SFA and DFA) and non-parametric (DEA) efficiency measures were quite small indicating that these two techniques are not consistent in their efficiency rankings. Moreover, Huang and Wang (2002) also investigated the scale economies in the Taiwanese banking sector where they found evidence of scale economics under the parametric approaches, but no evidence of scale economies under the DEA methodology. Finally, Huang and Wang (2002) concluded that the particular frontier method used to measure efficiency can result in significantly different conclusions across several different dimensions of the efficiency spectrum (e.g., relative value of the efficiency score, correlation between efficiency scores over time, the existence of scale economies).

Weill (2004) provided further evidence about the consistency of efficiency frontier techniques on a European banking data set when he used DEA, SFA and DFA to measure the cost efficiencies of banks in

[1] For more general and detailed information about the background to the Chinese banking sector, see Fu and Heffernan (2007), Cousin (2007), and Berger et al. (2009).

[2] Methodological cross-checking is advocated by Charnes et al. (1988).

[3] This included three parametric methods — stochastic frontier analysis (SFA), distribution free analysis (DFA) and thick frontier analysis (TFA) and one non-parametric method — data envelopment analysis (DEA).