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Chinese bank efficiency during the global financial crisis: A combined approach using satisficing DEA and Support Vector Machines☆

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ABSTRACT

The paper examines Chinese bank efficiency with a unique sample of 127 banks during the peak period of the global financial crisis. We apply an innovative Data Envelopment Analysis method under a stochastic environment. In the first stage, within the ambit of the satisficing Data Envelopment Analysis model, the probabilities of achieving a minimal performance threshold are computed in a stochastic way. In the second subsequent stage, Support Vector Machine regression is applied to discriminate between high/low efficiency groups within each performance threshold. The results reveal that the overall efficiency level of the Chinese banks remains still low. This is considerably determined by the contextual variables of the ownership structure and cost structure of the Chinese banks. Policy implications are derived how to improve the corporate governance and credit allocation.

1. Introduction

The unpredictable and questionable development of the Chinese banking system have attracted an attention from both sides – academics and practitioners. There exists unequivocal evidence that the performance of the Chinese banks has been deteriorating over the last decade. One of the key factors has been inefficient allocation of loans to the Chinese economy. That is consequently reflected in spiraling volumes of non-performing loans (NPLs). The deterioration of banks financial position as a whole is frequently linked with the potential jeopardy of the systemic crisis. The empirical research that focuses on Chinese bank efficiency and productivity is rather extensive, e.g. Dong, Girardone, and Kuo (2017), Zha, Liang, Wu, and Bian (2016), Jiang, Yao, and Feng (2013), Sun, Harimaya, and Yamori (2013), Chang, Hu, Chou, and Sun (2012), Berger, Hasan, and Zhou (2009, 2010). These studies analyze among other the Chinese bank performance from a range of aspects that might have a potential impact on bank performance but also on the performance of the Chinese economy. The majority of studies indicate that the state-owned banks are less efficie3nt compared to other forms of ownership. In the case of China, the traditional research methods are based on DEA (Data Envelopment Analysis) and SFA (Stochastic Frontier Analysis) models. There is extensive research that show the limitations ofr these methods. In particular, if one analyses efficiency determinants these models cannot cope with the inherent limitations as, for example, the inconsistency problem of estimators obtained in the second stage of the analysis (Simar & Wilson, 1998, 2007).

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This study further explores the peculiarities of the Chinese banking system and observed structural changes within the Chinese economy as a reaction to the Global Financial Crisis. Chinese banking system is one of the largest and relevant financial systems in global context. The paper advances the contemporary research on bank efficiency in general and the Chinese bank efficiency in particular. The particular attention is given to the assessment of Chinese bank efficiency and the major drivers along different performance thresholds. As for the methodological contribution, to our best knowledge, this is the first study on the Chinese bank efficiency that deploy in a stochastic fashion, chance constrained programming to solve DEA models at different efficiency thresholds. See the previous methodological approaches, e.g. Barros, Chen, Liang, & Peypoch, 2011; Wang, Huang, Wu, & Liu, 2014; Dong, Hamilton, & Tippett, 2014; Dong et al., 2017; Huang, Lin, & Chen, 2017, among others. Such an analysis allows to assess how the impact of variables associated with the ownership structure, size, governance, financial strength, and cost structure changes in importance towards the efficient frontier.

Two main contributions of the paper are as follows: Firstly, the study contributes to the contemporary research on bank efficiency and productivity by developing a novel two-stage approach where chance constrained DEA model is used to compute efficiency levels upon a given threshold. Machine learning techniques are employed to explore how efficiency determinants behave at each threshold. It offers a different perspective from traditional bootstrapped confidence intervals (Chronopoulos, Girardone, & Nankervis, 2015; Fukuyama & Matousek, 2017) by avoiding the intrinsic pitfall where the relationships between efficiency scores and its drivers tend to be biased when moving towards one. Secondly, the model developed here is used in the Chinese banking industry to assess probabilistically the performance of 127 banks from 2008 to 2011. Departing from the bootstrapping technique for the generating resampled inputs and the outputs, not only the efficiency probability distributions for each bank are computed, but also their satisficing probabilities in terms of different performance thresholds (i.e., what is the probability of the efficiency of a given bank to be higher than 80%, 90% etc). The specifically selected data span allows to trace up the behavioural changes of the Chinese banks during the peak period of GFC.

In terms of the applied methodological framework, we start our discussion by reviewing well established Chance-constrained programming (CCP), as presented in Charnes and Cooper (1963) and Kall (1976). This approach is one of the possible ways of how to handle stochastic variations in DEA. Under CCP, the performance of a DMU (Decision Making Unit) is considered to be the random realization of a stochastic phenomenon. It has to be stressed that the chance constrained DEA models present a major pitfall because they do not allow for the concept of “satisficing”. Indeed, Cooper, Huang, and Li (1996) showed that the above CCP models are very close to concept of “satisficing”, which can be incorporated into the DEA, thus, developing a satisficing DEA model. The concept of “satisficing” has its roots in psychology, where Simon (1957) created this term in an alternative fashion to the detriment of an “optimizing” behavior, which prevails in the economic analysis. For a more recent contribution on satisficing DEA in the field of banking, the reader is referred to the work of Tsolas and Charles (2015).

In this study, a satisficing DEA model to assess efficiency in the banking industry under a stochastic environment is presented. Wanke, Barros, and Chen (2015) and Wanke, Azad, and Barros (2016) discussed the relevance of using performance models with higher discriminatory power towards the efficiency frontier – i.e. models that allow the computation of lower efficiency scores when compared to traditional CCR and BCC DEA – when evaluating the efficiency of Angolan and Malaysian banks. Additionally, these authors also suggested the systematic use of alternative predictive techniques to accurately measure the impact of contextual variables on performance, especially when efficiency are biased towards the efficiency frontier. Hence, we present an innovative approach, firstly by conducting a comprehensive review of Chinese banks and, secondly, by employing a satisficing DEA model combined with regressions based on Support Vector Machine (SVM) in a two-stage approach as a research tool. SVM regression allows the discrimination between high/low efficiency groups within each performance threshold in light of a given set of contextual variables, thus allowing the identification of the most impacting efficiency drivers at each performance level.

The rest of the paper is organized as follows: an overview of the Chinese banks is presented in Section 2, followed by the review of the literature in Section 3. Then, the methodology discussion, in which the two-stage satisficing DEA/SVM regression is further presented, is explained in Section 4. Section 5 presents the data, followed by the analysis and the interpretation of the results in Section 6. Section 7 concludes.

2. An overview on Chinese banks

In the last two decades, the Chinese debt in nonfinancial sector has unprecedently spiraled. Bank for International Settlements (BIS) reports that the total debt in the corporate, household and government reached $ 26.6 trillion in outstanding debt as of 2015. In terms of the ratio of total debt to GDP the ratio is 255 percent. That is the highest leverage ratio among the segment of emerging economies. A further striking factor is the speed of credit growth. Credit increased by an annualized 18.1 percent between 2010 and 2015 that significantly outpaced the Chinese nominal GDP growth.

The corporate and household debts are channeled through the banking sector that is based on the fact that the Chinese financial market is dominated by commercial banks. On the other hand, the bond market is substantially less developed and the funds raised through this market is several times lower compared bank loans. This is the same as for the Chinese stock market where the capitalization is lower than 50 percent of GDP but it is higher than the bond market.

Similar to Japan and Germany, which are both typical examples of countries that have a bank-based financial system, commercial banks have been the cornerstone of the Chinese banking industry. In 1948, the People's Bank of China (PBC), currently the Central Bank of China, was inaugurated and operated simultaneously both as central and commercial bank until 1978, observing a single banking regime (Barros et al., 2011; García-Herrero, Gavilá, & Santabárbara, 2009). From 1979 to 1984, four specialized banks were created to attain specific economic purposes: the Agricultural Bank of China (ABC), the Bank of China (BOC), the China Construction