**Introduction:**

Data envelopment analysis has been playing an important role in identifying the optimal structure for bolstering efficiency in the bank sectors. This methodology is very suitable for a country that is experiencing the restructuration in financial industry, such as China. An et al., (2015) highlighted the growing number of foreign banks in Chinese industry has heightened the competitive pressure for Chinese banks. Hence, the Chinese banks are experiencing a restructuring process to find which sectors and factors are influencing their efficiency to meet the burgeoning modernizing economy needs. This paper uses Data envelopment analysis (DEA) to examine the profiles of commercial banks in China during the pivotal period. This study examines various DEA methodologies to classify Chinese banks’ performance within some context including, technology, regulation, and global financial crisis. The forthcoming sections are organized discussing the literature review, the models, analysis and critical reasoning to highlight essential strategies for Chinese banks in navigating the internal and international economic pressure.

**Table 1:**

First of all, in dynamic condition of commercial Chinese bank, each paper has different characteristic and problem. pivotal question of how deregulation and bank size have sculpted the operational efficiency of China's major banks, as examined by Chen, Skully, and Brown (2005). Their quest for understanding is shared by Wang et al. (2014), who delve into the evolution of efficiency over time. These papers foundational works are set the stage for comprehending the reference point used to calculate the efficiency of the sector. Another research problem is discussing the strategic management of risks and assets. Matthews (2013) and Du, Worthington, and Zelenyuk (2018) discuss the critical role that risk management practices and asset diversification play in shaping income efficiency and the overall financial health of banks.

The narrative then shifts to the operational research problem that are faced by the commercial banks in china, discussed by Liu, Yang, and Wu (2020) and Shi, Wang, and Emrouznejad (2023). These papers are exploring the implications of technological heterogeneity and the management of undesirable outputs. These studies highlight the sector’s efforts to adapt to technological advancements and manage the complex modern bank operational system. Additionally, Wilson and Zhao (2023) provides insights how Chinese commercial banks have navigated uncertainty during global financial crisis and the subsequent economic stimulus.

To sum up, the narrative of the article papers is not only highlights the Chinese banking sector’s journey towards efficiency but also underscores the strategic imperatives required to thrive in an ever-competitive global environment.

**Table 1:** Summary of research problems and/or questions (guidelines: analyse this table by type of research problem or question(s) and classify them, and discuss such classification(s) in the main text)

|  |  |  |
| --- | --- | --- |
| **Paper #** | **Reference** | **Research Problem(s) / Question(s)** |
| 3 | Xiaogang Chen, Michael Skully, and Kym Brown (2005) | The paper investigates how the efficiency of major Chinese banks evolved, particularly after the financial deregulation in 1995. It aims to determine if deregulation led to improved efficiency and whether bank size influences efficiency levels |
| 5 | Matthews (2013) | How risk management practices influence the income efficiency of Chinese banks. |
| 8 | Xiaohong Liu, Feng Yang, Jie Wu (2020) | Evaluating performance of Chinese commercial banks using DEA, considering operational technology heterogeneity, measuring the degree of this heterogeneity, targeting intermediate variables of banks, and representing weak disposability of undesirable outputs |
| 10 | Wilson and Zhao (2023) | How did the performance of Chinese commercial banks change before, during, and after the 2007–2008 global financial crisis, and in response to China's stimulus plan between 2008 and 2010? |
| 13 | Xiao Shi, Libo Wang, Ali Emrouznejad (2023) | performance evaluation of Chinese commercial banks, considering the impact of bad/undesirable outputs. It proposes an improved slacks-based DEA model within a by-production framework |
| 15 | Asmild and Matthews (2012) | Efficiency patterns in Chinese banks, particularly differentiating between State Owned Banks (SOBs) and Joint Stock Banks (JSBs), using Multi-directional Efficiency Analysis (MEA) |
| 18 | Kai Du, Andrew C. Worthington, Valentin Zelenyuk (2018) | The study investigates the impact of earning asset diversification on Chinese bank efficiency from 2006 to 2011, adapting a two-stage DEA approach to a panel data setting. |
| 20 | Dong et al. (2014) | investigates the cost efficiency of Chinese banks from 1994 to 2007, comparing stochastic frontier analysis (SFA) and data envelopment analysis (DEA). |
| 23 | James R. Barth, Chen Lin, Yue Ma, Jesús Seade, Frank M. Song (2013) | Examines the impact of bank regulation, supervision, and monitoring on bank efficiency. Investigates the effects of different regulatory and supervisory frameworks on the operational efficiency of banks. |
| 25 | Xie et al. (2022) | Operational efficiency of China's listed commercial banks using a novel approach that accounts for undesirable outputs in efficiency evaluation |
| 28 | Mohamed Ariff and Luc Can (2008) | Investigates cost and profit efficiency in Chinese banks, considering ownership, size, risk profile, profitability, and environmental changes using non-parametric methods. |
| 30 | Fukuyama and Tan (2022) | Efficiency of Chinese banks, focusing on input, output, and stability efficiencies using a three-stage network DEA model. The paper also examines the impact of market power and loan loss provisions on bank efficiency. |
| 33 | Xiaohong Liu, Jiasen Sun, Feng Yang, Jie Wu (2020) | Investigates the influence of changes in ownership structure on the efficiency of Chinese commercial banks, focusing on deposit and loan efficiencies. |
| 35 | Yu et al. (2019) | Estimating the operational efficiencies of Chinese banks, considering credit risk. It aims to optimize operational and interest income, and non-performing loan amounts |
| 38 | Tsui-Yueh Cho, Yi-Shuan Chen (2021) | The study examines the impact of financial technology (Fintech) on the cost efficiency and productivity of China's banking industry. |
| 40 | Zhu, Li and Liang (2018) | Improving the efficiency measurement of Chinese commercial banks using a two-stage Slack-Based Measure (SBM) model with a leader-follower structure. |
| 43 | Rasoul Rezvanian, Rima Truk Ariss, Sayed M. Mehdian, (2010) | Examines cost efficiency, technological progress, and productivity growth in Chinese banking, focusing on the period before and after China's WTO accession. Investigates how these factors are influenced by WTO accession and banking sector reforms. |
| 45 | Wu et al. (2023) | Investigates how interest rate liberalization impacts the efficiency of Chinese commercial banks. |
| 1 | Necmi K. Avkiran (2011) | Investigating to what extent bank DEA super-efficiency estimates are associated with key financial ratios to help selecting financial ratio benchmarks objectively. |
| 6 | Tan, 2024; Wänke, 2024; Antunes, 2024; Emrouznejad, 2024 | Investigating the performance in the banking industry, research on Chinese banking efciency is rather focused on discussing rankings to the detriment of unveiling its productive structure in light of banking competition |
| 11 | (An, Chen, Liang & Wu, 2015) | measure the efficiency of Chinese commercial banks, considering undesirable outputs within a two-stage operational process |
| 16 | Hirofumi Fukuyamaa , Yong Tan (2022) | evaluating bank efficiency including strategic disposability and undesirable outputs in Chinese banks |
| 21 | Hirofumi Fukuyamaa , Roman Matousek (2017) | It focuses on evaluating network revenue performance and behavioral differences between types of regional banks in Japan, particularly how banks can adjust inputs/outputs to maximize revenue and the optimal level of non-performing loans (NPLs) |
| 26 | Kent Matthews a , Zhiguo Xiao (2020) | it aims to measure cost inefficiency of Chinese banks using the familiar non-parametric method of Data-Envelopment-Analysis (DEA) by bootstrapping methods to provide estimates that lend themselves to statistical inference.  it decomposes the measure of cost inefficiency into its constituent parts of technical inefficiency and allocative inefficiency  the bootstrap estimates of inefficiency are used to test various hypotheses regarding Hthe levels, trends and convergence in technical inefficiency and allocative inefficiency |
| 31 | Fukuyama, Tsionas, Tan (2023) | The study aims to contribute to the fields of empirical banking and operational research in banking by proposing a two-staged dynamic Data Envelopment Analysis (DEA) model. This model specifically considers the role of loan loss reserves in the banking production process, treating them as a carryover variable. |
| 36 | Necmi K. Avkiran, Hiroshi Morita (2010) | To capture the interactions among different perceptions on a common set of performance measures |
| 41 | Guangcheng Xu and Zhixiang Zhou (2020) | The purpose of this paper is to evaluate Chinese commercial banks efficiency based on different non-performing loans in the process. |
| 7 | Matthews, et al. (2010) | To examine the productivity growth of the nationwide banks of China and a sample of city commercial, banks for the ten years to 2007 |
| 27 | Hou, et al. (2014) | investigate the impact of market structure and risk taking on the efficiency of Chinese commercial banks |
| 32 | Fukuyama, et al. (2021) | This paper focuses on the use of loan loss reserves (LLRs) in the banking production process and considers it as a variable with a dual role. |
| 22 | Fukuyama, et al. (2021) | Is corporate social responsibility (CSR) good for efficiency in the Chinese banking industry? |
| 17 | Dong et al. (2016) | To examine the cost and profit efficiency of four types of Chinese commercial banks over the period from 2002 to 2013. |
| 12 | Luo et al. (2011) | To evaluate the effectiveness of stock listing on Chinese commercial banks’ efficiency using two different frontier approaches. |
| 2 | Antunes et al. (2022) | To evaluate the efficiency of 39 Chinese commercial banks over the period 2010–2018. Also, in the second stage, investigates  the inter-relationships between efficiency and some bank-specific variables (i.e. bank profitability, bank size, expenses management, traditional business and non-traditional business) under the Robust Endogenous Neural Network Analysis. |
| 46 | Bingquan et al. (2019) | To address the relationship of Chinese urban commercial banks’ output loans around neighbouring regions and include the effect of the regional market environment on bank performance. |
| 42 | Luo et al. (2010) | The most significant reform before the crisis was ownership diversification, aiming to improve corporate governance and efficiency. This article will study whether this reform has really improved bank efficiency. |
|  |  |  |
| 4 | Wang et al. (2014) | evaluate the level of efficiency of the Chinese commercial banking system and identify the sources of inefficiency\ How has the efficiency of the Chinese commercial banking system changed over time\ What are the implications of the findings for the improvement of the Chinese commercial banking system |
| 14 | Fukuyama, H., Tsionas, M. and Tan, Y., (2023) | addresses the development and application of a dynamic network data envelopment analysis model to evaluate the relative efficiency of DMUs within the Chinese banking industry, considering the sequential structure, behavioral-causal analysis, and the impact of different types of risk on bank profitability. |
| 19 | Zhou, X.,(2019) | addressed in the is the evaluation of banking system efficiency in the presence of uncertainty using a multi-period three-stage DEA model \ to address the challenge of evaluating the efficiency of banking systems while considering uncertainty, which is a critical issue in the banking industry |
| 29 | Boussemart, J.P. (2019) | investigates the concept of credit risk (in)efficiency and proposes a method to measure it jointly with the productive (in)efficiency of banks using a nonparametric Data Envelopment Analysis (DEA) model. |
| 48 | Yan Luo, Gongbing Bi, Liang Liang (2012) | concerns selecting appropriate input and output indicators for DEA efficiency evaluation. It aims to address problems such as selection tools, correlation analysis, and classification of input versus output status |
| 47 | Jorge Antunesn (2024) | estimates the cost efficiency of Chinese banks using an innovative Data Envelopment Analysis (DEA) model. Additionally, it explores the interrelationships between efficiency and other bank-specific variables using a Stochastic Structural Relationship Programming (SSRP) Model based on neural networks |
| 34 | Yongjun Li (2019) | extends the model proposed by Salo and Punkka (2011) to more common and practical applications that consider the two-stage production structure, and it calculates each Decision Making Unit’s (DMU) ranking interval for the overall system as well as for each subsystem/sub-stage |
| 39 | Tai-Hsin Huang a, Chung-I Lin b,⁎, Kuan-Chen Chenc(2017) | The study seeks to understand how to measure the efficiency of Chinese commercial banks within a stochastic multistage production framework. It proposes a network data envelopment analysis (DEA) that characterizes the multistage network production processes and estimates the fractions of shared inputs used by each production stage |
| 24  (Iran) | Shabani, P. and Akbarpour Shirazi, M., (2023) | development of a comprehensive network DEA model for the performance evaluation of commercial bank branches in dynamic competitive conditions, providing valuable insights for commercial banks to enhance their operational efficiency and overall performance in a dynamic and competitive environment |
| 49  (Taiwan) | Lin, T.T., Lee, C.C. and Chiu, T.F., (2009) | to objectively measure the operating efficiency of the bank's branches, providing an impartial and rational assessment of their performance. This could help in better resource configuration, meeting corporate operation objectives, and improving management decisions |
| 50  (Literature Review paper) | Iago Cotrim Henriques (2020) | The study seeks to conduct a systematic review of two-stage Data Envelopment Analysis (DEA) models in the banking industry, with a focus on terminological controversies and the current state-of-the-art, identifying opportunities and challenges for future studies. It aims to clarify what is considered a two-stage DEA model in the literature and how this topic has been discussed over the years, especially in the banking sector |

**Table 2:** Summary of the main contribution(s) of the paper (e.g., methodology, research question(s), application): what is the selling argument of the paper?

|  |  |  |  |
| --- | --- | --- | --- |
| **Paper #** | **Reference** | **Main Contribution(s) of the Paper** |  |
| 3 | Xiaogang Chen, Michael Skully, and Kym Brown (2005) | the application of DEA for analysing bank efficiency in China's unique context, and an assessment of the impact of financial deregulation on banking efficiency |  |
| 5 | Matthews (2013) | Integration of risk management metrics into a Network DEA framework to evaluate the impact of risk management on bank income efficiency. |  |
| 8 | Xiaohong Liu, Feng Yang, Jie Wu (2020) | Integration of the meta-frontier technique into DEA for assessing bank performance with technological heterogeneity, targeting intermediate outputs, and accounting for differences in operational technology among banks. |  |
| 10 | Wilson and Zhao (2023) | Understanding the impact of the global financial crisis and subsequent stimulus on Chinese banks' efficiency and productivity. |  |
| 13 | Xiao Shi, Libo Wang, Ali Emrouznejad (2023) | the development of an improved slacks-based DEA model that integrates undesirable outputs using a by-production framework. This model provides a more accurate assessment of bank efficiency |  |
| 15 | Asmild and Matthews (2012) | Applying multi-directional efficiency analysis (MEA) to investigate not only the levels of efficiency in Chinese banks but also the patterns of inefficiencies across different types of banks |  |
| 18 | Kai Du, Andrew C. Worthington, Valentin Zelenyuk (2018) | Development of a dynamic version of the two-stage DEA approach with truncated regression and double-bootstrapping, applied to Chinese banking data, examining the impact of asset portfolio diversification on bank efficiency. |  |
| 20 | Dong et al., (2014) | Efficiency analysis in Chinese banking by comparing SFA and DEA methods. It assesses the consistency of efficiency scores between these approaches and provides insights into the most suitable methods for banking efficiency analysis. |  |
| 23 | James R. Barth, Chen Lin, Yue Ma, Jesús Seade, Frank M. Song (2013) | Provides empirical evidence on the relationship between bank efficiency and various aspects of bank regulation, supervision, and monitoring. Highlights how different regulatory environments affect bank operations. |  |
| 25 | Xie et al. (2022) | Development and application of a multi-period leader-follower DEA model that incorporates undesirable outputs, providing a more accurate efficiency evaluation of commercial banks. |  |
| 28 | Mohamed Ariff and Luc Can (2008) | Introduces a non-parametric approach to analyze both cost and profit efficiency in Chinese banks and examines the influence of key factors on these efficiencies. |  |
| 30 | Fukuyama and Tan (2022) | Development of a three-stage network DEA model to separately evaluate input, output, and stability efficiencies of banks, incorporating market power and loan loss provisions into the analysis |  |
| 33 | Xiaohong Liu, Jiasen Sun, Feng Yang, Jie Wu (2020) | Provides an in-depth analysis of how ownership structure impacts the efficiency of bank deposits and loans using a two-stage meta-frontier DEA network model. |  |
| 35 | Yu et al. (2019) | DEA framework for analysing potential income gains in banks, emphasizing technical improvements in credit and loan provision reduction |  |
| 38 | Tsui-Yueh Cho, Yi-Shuan Chen (2021) | The paper's main contribution is the application of the metafrontier cost Malmquist productivity index to analyze the impact of Fintech on the banking industry's productivity and efficiency. |  |
| 40 | Zhu, Li and Liang (2018) | A modified two-stage SBM model that incorporates a leader-follower structure, providing a more realistic efficiency assessment for banks |  |
| 43 | Rasoul Rezvanian, Rima Truk Ariss, Sayed M. Mehdian, (2010) | The paper offers new insights into the efficiency and productivity of Chinese banks, with a particular focus on the effects of WTO accession and banking reforms. Utilizes a comprehensive methodology to assess changes over time. |  |
| 45 | Wu et al. (2023) | Introduces a two-stage network DEA approach to evaluate bank efficiency in the context of interest rate liberalization, offering novel insights into the varying effects of liberalization on different stages of banking operations |  |
| 1 | Necmi K. Avkiran (2011) | post-tax profits to average total assets, and return on average equity show a strong relationship with efficiency estimates. This finding raises the potential to use efficiency estimates to predict certain key financial ratios’ future value  DEA can Help to guide the governments on deregulation and market structure  DEA can help market analysts in pricing decisions  DEA can Improve managerial performance by separating the best from the worst performers |  |
| 6 | Tan, 2024; Wänke, 2024; Antunes, 2024; Emrouznejad, 2024 | The main contribution is the development of a two-stage network production process to evaluate the efficiency of Chinese commercial banks and an integrated MLP-HMM model to examine endogeneity among banking competition, contextual variables, and efficiency levels |  |
| 11 | (An, Chen, Liang & Wu, 2015) | To determine efficiency statuses of these bank in order to minimize the slacks in input and output  Gives a suggestion for the managers to pay more attention to the relatively low efficient deposit-generating stage and should improve their ability to absorb more deposits by applying more attractive policies  very useful for the banks to reduce the gap between their intermediate measures set in two stages. That is, the results can provide a good alternative for well coordinating the activities of the two stages in order to reduce resource waste |  |
| 16 | Hirofumi Fukuyamaa , Yong Tan (2022) | The current study significantly contributes to the empirical banking and operational research literature by filling in these significant gaps |  |
| 21 | Hirofumi Fukuyamaa , Roman Matousek (2017) | paper's major contribution is the development of a bank network revenue function which considers the impact of NPLs on bank production and a two-stage network model that includes these NPLs. |  |
| 26 | Kent Matthews a , Zhiguo Xiao (2020) | giving a suggestion that state-owned banks are more constrained by social and political objectives in their downsizing strategy than JSCBs |  |
| 31 | Fukuyama, Tsionas, Tan (2023) | contributes to the subject area of empirical banking and operational research in banking by proposing a two-stage dynamicDEA model that considers  the desirability of loan loss reserves in the banking production process with a carryover role. |  |
| 36 | Necmi K. Avkiran, Hiroshi Morita (2010) | The findings help the management to collaborate with amenable shareholders to shape the perceptions held by the recalcitrant regulators |  |
| 41 | Guangcheng Xu and Zhixiang Zhou (2020) | It gives an influence combining ARs restrictions with a two-stage DEA model for considering the different undesirable outputs. Firstly, the classification of undesirable outputs (non-performing loans) in banking system was introduced due to its risk level, which means that the impact on the banking operation system is different. Secondly, based on the particularity of banking operation system and the applicability of AR restrictions, the additive two-stage AR-DEA model was unitized to evaluate the DMU efficiency |  |
| 7 | Matthews, et al. (2010) | To examine the productivity growth of the nationwide banks of China and a sample of city commercial, banks for the ten years to 2007 |  |
| 27 | Hou, et al. (2014) | investigate the impact of market structure and risk taking on the efficiency of Chinese commercial banks |  |
| 32 | Fukuyama, et al. (2021) | This paper focuses on the use of loan loss reserves (LLRs) in the banking production process and considers it as a variable with a dual role. |  |
| 22 | Fukuyama, et al. (2021) | Is corporate social responsibility (CSR) good for efficiency in the Chinese banking industry? |  |
| 17 | Dong et al. (2016) | To examine the cost and profit efficiency of four types of Chinese commercial banks over the period from 2002 to 2013. |  |
| 12 | Luo et al. (2011) | To evaluate the effectiveness of stock listing on Chinese commercial banks’ efficiency using two different frontier approaches. |  |
| 2 | Antunes et al. (2022) | To evaluate the efficiency of 39 Chinese commercial banks over the period 2010–2018. Also, in the second stage, investigates  the inter-relationships between efficiency and some bank-specific variables (i.e. bank profitability, bank size, expenses management, traditional business and non-traditional business) under the Robust Endogenous Neural Network Analysis. |  |
| 46 | Bingquan et al. (2019) | To address the relationship of Chinese urban commercial banks’ output loans around neighbouring regions and include the effect of the regional market environment on bank performance. |  |
| 42 | Luo et al. (2010) | bank efficiency increased by almost 5% after listing. Despite the fact that Joint Equity Banks (JEBs) still perform better than SOBs, the latter manage to catch up and reduce the efficiency gap with the former during the past few years. This in part explains why the Chinese banking system has been less affected by the current world financial crisis than their western counterparts, leading to an important conclusion that SOB reforms in China over the past 10 years have produced remarkable results. |  |
| 4 | Wang et al. (2014) | This study is the first to use a two-stage strategy to evaluate the efficiency implications of ownership type in the Chinese banks. The two-stage DEA model developed in this research expands the literature on banking efficiency evaluation and inefficiency identification, provides accurate and current information on the efficiency of the Chinese bank industry, guiding the development and implementation of policies for future industry growth. |  |
| 14 | Fukuyama, H., Tsionas, M. and Tan, Y., (2023) | the development and application of a novel dynamic network data envelopment analysis model that integrates sequential structure, behavioral-causal analysis, and dynamic characteristics to evaluate the relative efficiency of DMUs within the Chinese banking industry. This contributes to the advancement of research in the field of performance evaluation and management within the banking industry, addressing inefficiency and risk assessment through advanced analytical techniques. |  |
| 19 | Zhou, X.,(2019) | the development of a comprehensive network DEA model for the performance evaluation of commercial bank branches in dynamic competitive conditions, providing valuable insights for commercial banks to enhance their operational efficiency and overall performance in a dynamic and competitive environment |  |
| 29 | Boussemart, J.P. (2019) | This paper uses a network DEA modelling framework that separates performance into economic and credit risk efficiencies. The approach allows for the separate measurement of economic efficiency, derived from the production of good outputs, and credit risk management efficiency, related to the minimization of non-performing loans |  |
| 48 | Yan Luo, Gongbing Bi, Liang Liang (2012) | a new method for choosing DEA variables based on the concept of cash value added (CVA). This method is proposed to be more objective, providing managers and researchers with relevant variables and exact status designations, and the data can be easily obtained from balance sheets and cash flow statements |  |
| 47 | Jorge Antunes(2024) | firstly, it introduces a new DEA model that accounts for time-series data when computing cost efficiency and allows for cost-saving and comparative analysis. Secondly, it proposes a SSRP Model to analyze non-linear relationships between efficiency and various bank-specific variables, enhancing the accuracy of results |  |
| 34 | Yongjun Li(2019) | Develops a method to obtain ranking intervals for classic two-stage production systems. This method considers the internal structure of a bank and divides the production process into two subsystems, allowing for a more nuanced analysis of efficiency |  |
| 39 | Tai-Hsin Huang a, Chung-I Lin b,⁎, Kuan-Chen Chenc(2017) | The paper's primary contribution is the establishment of an economic model that leads to the network stochastic frontier analysis (SFA) framework, capable of characterizing multistage network production processes and providing more accurate efficiency measurements by considering the specific sources of inefficiency in multistage production processes within banks |  |
| 24 | Shabani, P. and Akbarpour Shirazi, M., (2023) | development of a comprehensive network DEA model for the performance evaluation of commercial bank branches in dynamic competitive conditions, providing valuable insights for commercial banks to enhance their operational efficiency and overall performance in a dynamic and competitive environment |  |
| 49 | Lin, T.T., Lee, C.C. and Chiu, T.F., (2009) | to objectively measure the operating efficiency of the bank's branches, providing an impartial and rational assessment of their performance. This could help in better resource configuration, meeting corporate operation objectives, and improving management decisions |  |
| 50 | Iago Cotrim Henriques(2020)  (This paper is literature Review) | The main contribution is the systematic review itself which consolidates the state-of-the-art of two-stage DEA models, discussing terminological controversies, and identifying seven gaps in the literature for both internal and external two-stage DEA models, along with two specific gaps for external models. This provides a comprehensive understanding and opportunities for future research in the field |  |

The contributions of these studies can be categorized into exploring specific factors’ influence on bank efficiency, and methodological innovations.

1. **exploring specific factors’ influence on bank efficiency**

When exploring specific factors’ influence on bank efficiency, some research focus on internal factors like internal management and risk control, such as by Matthews (2013) and Yu et al. (2019), explored how risk management practices and credit risk impact banks' income and operational efficiencies. The paper written by Asmild and Matthews (2012) applied multi-directional efficiency analysis (MEA) to investigate not only the levels of efficiency in Chinese banks but also the patterns of inefficiencies across different types of banks. And Xiaohong Liu et al. (2020), examined the effects of ownership structures (e.g., state-owned vs. joint-stock banks) and market power on bank efficiency.

As for external factors, economic environment had attracted much attention. Papers like Wilson and Zhao (2023) and Rasoul Rezvanian et al. (2010),etc. analysed how external factors such as global financial crises, economic stimulus plans, WTO accession and banking reforms (Rasoul Rezvanian, Rima Truk Ariss, Sayed M. Mehdian, (2010)) ,and regulatory changes affect bank efficiency.

1. **methodological innovations**

Apart from papers aiming at digging into factors to find directions for improvement, some papers creatively announced methodological innovations. Some focusing on refining current DEA models to more accurately evaluate bank efficiency when dealing with certain types of factors, for instance, the paper by Xiao Shi, Libo Wang, Ali Emrouznejad (2023) integrated undesirable outputs using a by-production framework. Xie et al. (2022) developed a multi-period leader-follower DEA model that incorporates undesirable outputs, providing a more accurate efficiency evaluation of commercial banks. Additionally, Hirofumi Fukuyama, Roman Matousek (2017) developed a bank network revenue function which considers the impact of NPLs (non-performing loans) on bank production.

We can notice that more papers focused on methodological innovations rather than applying DEA and identify targets for improvement. This trend reflects scholars’ passion for the refinement of current methodology, indicates some DEA models might lack adaptability in certain circumstances.

**Table 3:** Summary of models used within DEA Analyses for assessing the efficiency of DMUs (guidelines: (a) the names of the models should be provided; (b) if statistical tests are used for analysing/comparing categories of DMUs, you should report them; (c) when a paper uses a single stage analysis, columns 3 and 4 should be filled with n/a; (d) when a paper uses a two-stage analysis, column 4 should be filled with n/a; (e) analyse this table by type of DEA approach and model and discuss such classifications in the main text)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Paper #** | **Reference** | **First Stage Model** | **Second Stage Model** | **Third Stage Model** |
| 20 | Dong et al., (2014) | SFA,  CCR Model  BCC Model | n/a | n/a |
| 3 | Xiaogang Chen, Michael Skully, and Kym Brown (2005) | CCR model | n/a | n/a |
| 5 | Matthews (2013) | Network DEA Model | n/a | n/a |
| 8 | Xiaohong Liu, Feng Yang, Jie Wu (2020) | Meta-frontier DDF model | n/a | n/a |
| 10 | Wilson and Zhao (2023) | FDH Model  Statistical tests:  Kneip et.al convexity test  Kneip et.al mean difference test | n/a | n/a |
| 13 | Xiao Shi, Libo Wang, Ali Emrouznejad (2023) | SBM Model | n/a | n/a |
| 15 | Asmild and Matthews (2012) | Multi-directional SBM | n/a | n/a |
| 18 | Kai Du, Andrew C. Worthington, Valentin Zelenyuk (2018) | BCC and CCR model | Truncated regression and double bootstrapping | n/a |
| 23 | James R. Barth, Chen Lin, Yue Ma, Jesús Seade, Frank M. Song (2013) | BCC model | Truncated regression | n/a |
| 25 | Xie et al. (2022) | VRS DDF Model | OLS Panel Regression | n/a |
| 28 | Mohamed Ariff and Luc Can (2008) | BCC model | Tobit Regression | n/a |
| 30 | Fukuyama and Tan (2022) | Three-stage Network DEA Model | Tobit Regression | n/a |
| 33 | Xiaohong Liu, Jiasen Sun, Feng Yang, Jie Wu (2020) | Meta-Frontier radial DDF Network Model | Multiple regression | n/a |
| 35 | Yu et al. (2019) | CCR Model | n/a | n/a |
| 38 | Tsui-Yueh Cho, Yi-Shuan Chen (2021) | BCC model | System-GMM | n/a |
| 40 | Zhu, Li and Liang (2018) | Two-stage Network SBM Model | n/a | n/a |
| 43 | Rasoul Rezvanian, Rima Truk Ariss, Sayed M. Mehdian, (2010) | BCC model | Tobit Regression | n/a |
| 45 | Wu et al. (2023) | Two-stage Network SBM Model | Tobit Regression | n/a |
| 1 | Necmi K. Avkiran (2011) | Core profitability model – SBM    Expanded profitability model – SBM    Financial Ratio Model - SBM | Statistical Test: Simple Regression |  |
| 6 | Tan, Wänke, Antunes, Emrouznejad (2024) | GMSS – DEA Model | OLS Regression Model | n/a |
| 11 | An, Chen, Liang & Wu (2015) | Slack-based measure model (Deposit Generation Stage)  Slack-based measure model  (Deposit utilizing stage) | n/a | n/a |
| 16 | Hirofumi Fukuyamaa , Yong Tan (2022) | Slack-based measure model    Non-radial DEA model, Directional distance function (NON RADIAL DDF) | n/a | n/a |
| 21 | Hirofumi Fukuyamaa , Roman Matousek (2017) | Two-stage Network DEA Model for bank analysis    Series Structure | regression | - n/a |
| 26 | Kent Matthews a , Zhiguo Xiao (2020) | CCR-DEA Model | n/a | n/a |
| 31 | Fukuyama, Tsionas, Tan (2023) | Dynamic Network Bank | Truncuted Regression and Tobit Regression | n/a |
| 36 | Necmi K. Avkiran, Hiroshi Morita (2010) | Non-radial DEA Model    Range-adjusted Measure (RAM) and Super-efficiency Range-adjusted Measure (SRAM) | n/a | n/a |
| 41 | Guangcheng Xu and Zhixiang Zhou (2020) | BCC Model (Assurance Region (AR) Model) | Multiple Regression | n/a |
| 7 | Matthews, et al. (2010) | Polyhedral cone-ratio DEA model [Charnes (1990)] | n/a | n/a |
| 27 | Hou, et al. (2014) | CCR | Tobit | n/a |
| 32 | Fukuyama, H., Tan, Y. (2021) | network SBI models | regression analysis | n/a |
| 22 | Fukuyama, et al. (2021) | BCC | Bootstrapped truncated regression & Ordinary least square regression | n/a |
| 17 | Dong et al. (2016) | SFA | n/a | n/a |
| 12 | Luo et al. (2011) | CCR-CRS & BCC-VRS | n/a | n/a |
| 2 | Antunes et al. (2022) | SBM | Robust  Endogenous Neural Network Analysis | n/a |
| 46 | Bingquan et al. (2019) | spatial Durbin production frontier model | n/a | n/a |
| 42 | Luo et al. (2010) | CCR & BCC | n/a | n/a |
| 4 | Wang et al. (2014) | Additive Two-stage DEA for banking efficiency evaluation  -the deposit-producing sub-process  -the profit-earning sub-process | n\a | n\a |
| 14 | Fukuyama, H., Tsionas, M. and Tan, Y., (2023) | the two stage DNDEA model | n\a | n\a |
| 19 | Zhou, X.,(2019) | multi-period three-stage Dynamic Network DEA model | n\a | n\a |
| 29 | Boussemart, J.P. (2019) | directional distance network DEA model | n\a | n\a |
| 48 | Yan Luo, Gongbing Bi, Liang Liang (2012) | CVA model\ variable selection in DEA | n\a | n\a |
| 34 | Yongjun Li(2019) | two-stage DEA Model\ Two-stage production system | n\a | n\a |
| 39 | Tai-Hsin Huang a, Chung-I Lin b,⁎, Kuan-Chen Chenc(2017) | the network SFA model | n\a | n\a |
| 47 | Jorge Antunes(2024) | using Data Envelopment Analysis (DEA) in the first stage\  utilize neural networks in the second stage | n\a | n\a |
| 24 | Shabani, P. and Akbarpour Shirazi, M., (2023). (Iran) | using a dynamic network DEA model\ | n\a | n\a |
| 49 | Lin, T.T., Lee, C.C. and Chiu, T.F., (2009) (Taiwan) | BBC model\ CCR model | n\a | n\a |
| 50 | Iago Cotrim Henriques(2020) | (ask) the paper is review of literature | (ask) the paper is review of literature | (ask) the paper is review of literature |

In this study, we focus on the DEA method. Although there is another method commonly used to evaluate the relative efficiency of various banks, that is stochastic frontier analysis (SFA) which is a parametric approach. Analysis using the DEA method can be conducted in various stages as mentioned by Iddouch, El Badraoui, and Ouenniche (2023), namely single-stage DEA analysis, two-stage DEA analysis, and three-stage DEA analysis. Single-stage analysis aims to derive efficiency profile estimates from the DMUs measured using a specific DEA model. These efficiency estimates can include overall technical efficiency, pure technical efficiency, scale efficiency, cost efficiency, revenue efficiency, profit efficiency, and allocative efficiency. Two-stage analysis is performed to analyze the determinants or drivers of efficiency using various regression methods such as pooled or panel regression, Tobit regression, and Seemingly Unrelated Regression. Then, three-stage analysis aims to ensure fair benchmarking in the presence of non-homogeneous operating environments by purging environmental bias from the variables used in the model.

It was found that the majority of studies, xx%, used single-stage DEA analysis, including studies conducted by Dong et al. (2014), Matthews (2013), Asmild and Matthews (2012), and Yu et al. (2019). Then, another portion, xx%, used two-stage DEA analysis such as those conducted by Xie et al. (2022), Mohamed Ariff and Luc Can (2008), Fukuyama and Tan (2022), and Wu et al. (2023). It can also be concluded that the Tobit Regression method is more popular in determining drivers of efficiency. This may be due to xxx (source). From the many papers reviewed in this study, we did not find any research that used three-stage analysis.

In terms of the model types, DEA can be grouped into static black box models, dynamic black box models, static network models, and dynamic network models. Most authors use static black box models such as CCR and BCC models. There are also many who use static network models such as those done by Matthews (2013), Fukuyama and Tan (2022), and Wu et al. (2023). This may be due to the fact that banks operate in multiple stages, i.e. xxx. There are x studies that use dynamic network models such as those done by Zhou (2019), which calculate efficiency estimates over multiple periods and consider carryovers from year to year.

**Table 4:** Summary of Inputs & Outputs and their measures used in assessing the efficiency of DMUs and the perspective, also referred to as approach, from which the analysis is performed – we shall refer to this perspective as the assessment perspective; the assessment perspective shapes the choice of inputs and outputs (guidelines: analyse this table by perspective and for each perspective classify inputs and outputs in meaningful categories and discuss them in the main text)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Paper #** | **Reference** | **Assessment Perspective** | **Inputs** | **Outputs** |
| 3 | Xiaogang Chen, Michael Skully, and Kym Brown (2005) | Intermediation approach | interest expenses, non-interest expenses (including labor costs), price of deposits (interest paid on deposits divided by total deposits), and price of physical capital (approximated by non-interest expenses divided by fixed assets) | loans, deposits, and non-interest income |
| 5 | Matthews (2013) | Profit Oriented Approach | Operational costs, fixed assets, and deposits | Net-interest income and non-interest income |
| 8 | Xiaohong Liu, Feng Yang, Jie Wu (2020) | Intermediation approach | Fixed assets, labor, and operating expenses | Loans, business income, non-performing loan ratio, and deposits (as intermediate variables) |
| 10 | Wilson and Zhao (2023) | Intermediation Approach | Total funding, labor services, Fixed asset | Consumer loan, real estate loans, business and other loans, securities, off-balance sheet items |
| 13 | Xiao Shi, Libo Wang, Ali Emrouznejad (2023) | Profit-Oriented approach | Interest costs, operating costs | Interest income, non-interest income, non-performing loans |
| 15 | Asmild and Matthews (2012) | Profit Oriented Approach | Labor, fixed assets, total deposits, non-performing loans | Net-interest income, non-interest income |
| 18 | Kai Du, Andrew C. Worthington, Valentin Zelenyuk (2018) | Profit-Oriented approach | Interest expenses, labor costs, other operating expenses | Net interest income, net fees and commissions, other operating income |
| 20 | Dong et al., (2014) | Intermediation Approach | Total borrowed funds, physical capital, and labor | Total loans, other earning assets, and non-interest income. |
| 23 | James R. Barth, Chen Lin, Yue Ma, Jesús Seade, Frank M. Song (2013) | Intermediation approach | Inputs include total deposits, labor (personnel expenses), physical capital (fixed assets), and loan loss provisions. | Outputs consist of total loans and other earning assets, and other operating income. |
| 25 | Xie et al. (2022) | Intermediation Approach | Labor force, fixed assets, operating costs | Interest income, non-interest income, performing loans, non-performing loans (undesirable output) |
| 28 | Mohamed Ariff and Luc Can (2008) | Profit-Oriented Approach | Loanable funds, Number of employees, Physical capital | Loans, Investments |
| 30 | Fukuyama and Tan (2022) | Profit Oriented Approach | Labor, capital, fixed assets, expenses | Interest income, non-interest income |
| 33 | Xiaohong Liu, Feng Yang, Jie Wu (2020) | Intermediation approach | Fixed assets, labor, operating expenses | Loan, Interest Income, and Non-performing loan ratio |
| 35 | Yu et al. (2019) | Profit Oriented Approach | Capital stock, employed labor, deposit | Interest income, operational income, non-performing loan |
| 38 | Tsui-Yueh Cho, Yi-Shuan Chen (2021) | Intermediation approach | Labor cost, total deposits, total money market funding, other funding, Business and management expenses | Total loans, total earning assets, Fee income plus comission income |
| 40 | Zhu, Li and Liang (2018) | Intermediation Approach | Fixed asset, operational cost, staff wages, reserve | Net increase in bank advances (loan and credit) to customers, return on investment |
| 43 | Rasoul Rezvanian, Rima Truk Ariss, Sayed M. Mehdian, (2010) | Intermediation Approach | Borrowed funds, labor and fixed asstes | Net loans, deposits, other earning assets |
| 45 | Wu et al. (2023) | Intermediation Approach | Fixed asset, employed labor | Loans, securities investment, non-performing loan |
| 1 | Necmi K. Avkiran (2011) | Intermediation approach | Interest expense on customer deposits  Other interest expense  Personnel expenses  Other operating expenses | Interest income on loans  Other interest income  Net fees and commissions  Other operating  income |
| 6 | Tan, Wänke, Antunes, Emrouznejad (2024) | Production approach efficiency and intermediation approach efficiency | Production approach(Expenses, number of employees, overhead costs, and equity capital),  Intermediation approach efficiency(non interest expenses, interest expenses, and loan loss provision) | Production approach(fixed assets, liquid assets, total assets),  Intermediation approach efficiency(Interest income, non interest income, net income, gross revenue) |
| 11 | An, Chen, Liang & Wu (2015) | Slack-based measure model-Deposit Generation Stage( Production approach)  Slack-based measure model- Deposit utilizing stage ( Production approach) | Slack-based measure model-Deposit Generation Stage (Number of labors,  Equity capital,  Net-value fixed assets)  Slack-based measure model- Deposit utilizing stage(deposits) | Slack-based measure model-Deposit Generation Stage (Deposits)  Slack-based measure model- Deposit utilizing stage(loans and securities investments) |
| 16 | Hirofumi Fukuyamaa , Yong Tan (2022) | Integrated Approach (Production Approach and Intermediation Approach) | Production approach(labour cost and other operating costs) ,  Intermediation approach (labor, fixed assets, and deposits) | Production approach (Innovation efficiency),  Intermediation approach(securities and loans) |
| 21 | Hirofumi Fukuyamaa , Roman Matousek (2017) | Production of Intermediate products | Labor  Capital  Operational resources | Financial products and services  Accumulated deposits  Processed application |
| 26 | Kent Matthews a , Zhiguo Xiao (2020) | Hybrid approach  (IA and AA) | Liabilities | Total performing loans  Total earning assets  Bad loans |
| 31 | Fukuyama, Tsionas, Tan (2023) | Production approach | Labor  Capital  Equity of the current year  Non-performing loans | Deposits  Raised funds |
| 36 | Necmi K. Avkiran, Hiroshi Morita (2010) | Production Approach | Shareholders  Customers  Management  Employees  regulators | loans |
| 41 | Guangcheng Xu and Zhixiang Zhou (2020) | Production Approach | Total assets  Labor  Operating expenses | Deposits |
| 7 | Matthews, et al. (2010) | performance criteria:  a hybrid between the intermediation and production approaches (IA & PA) | IA:  Deposits (RDEP), overheads (ROHD), fixed assets (RFA) | IA:  Loans (RLOAN),    PA:  other earning assets (ROEA), RFEE (net fee income) |
| 27 | Hou, et al. (2014) | performance criteria: IA | total deposits ( ),  fixed assets ( ),  number of employees ( ), | total net loan ( ),  other earning assets ( ), |
| 32 | Fukuyama, et al. (2021) | performance criteria:  PA | Personnel  expenses  Equity capital,  Fixed assets | Loan loss reserves (LLRs) |
| 22 | Fukuyama, et al. (2021) | performance criteria:  POA | number of employees, fixed assets, deposit | interest income, non-interest income |
| 17 | Dong et al. (2016) | performance criteria: IA | Price of total borrowed funds (w1) (ratio of total interest expenses to total borrowed funds)  Price of physical capital (w2), also known as the flow factor price for capital (measured by the ratio of other operating expenses to fixed assets)  Price of labor (w3) (using the ratio of personnel expenses to the number of employees as a proxy)  Total equity capital (z) (as a quasi-fixed input) | Total loans (y1)  Other earning assets (y2)  Non-interest income (y3) |
| 12 | Luo et al. (2011) | performance criteria: IA | Number of employees,  Fixed assets,  Deposits | Total loans,  Other earning assets |
| 2 | Antunes et al. (2022) | performance criteria: IA | fixed assets, total deposits, and personnel expenses | total securities and total loans |
| 46 | Bingquan et al. (2019) | performance criteria: IA | deposits, labour and fixed assets | loans |
| 42 | Luo et al. (2010) | performance criteria: IA | Number of employees, fixed assets, and deposits (estimated due to missing data) | Total loans (TLs) and other earning assets. |
| 4 | Wang et al. (2014) | Intermediation  Approach (IA) | Fixed assets, Labors | Non-interest incomes, Interest incomes, Non-performing loans |
| 14 | Fukuyama, H., Tsionas, M. and Tan, Y., (2023) |  | covariates, predictions, collaboration networks, and supply chain data | efficiency, exposure effects, queueing systems, collaboration networks, and parameter identification for creep models |
| 19 | Zhou, X.,(2019) | AI | Employee’s salaries\ fixed assets | Net interest incomes\ non performing loans |
| 29 | Boussemart, J.P. (2019) | AI | interest expenses (IE), non-interest expenses (NIE). | -interest income (II), non-interest income (NII)), bad outputs (non-performing loans (NPL)  - Good loans (GL) are considered a desirable output, while non-performing loans (NPL) are treated as an undesirable output.(ask) |
| 48 | Yan Luo, Gongbing Bi, Liang Liang (2012) | AI | cash and balances with central banks, deposits and placements with banks, investments, loans and advances to customers, financial assets held for trading, and other assets | customer deposits and stockholders' equity |
| 47 | Jorge Antunes(2024) | AI | fixed assets, total deposits, and personnel expenses | total securities and gross loans    (the paper mention variables for second model) |
| 34 | Yongjun Li(2019) | AI | Fixed assets, Labours | interest income \non-income interest |
| 39 | Tai-Hsin Huang a, Chung-I Lin b,⁎, Kuan-Chen Chenc(2017) | AI | labor and capital | loans, investments, and non-interest income |
| 24 | Shabani, P. and Akbarpour Shirazi, M., (2023) |  | revenue, expenses, assets, and liabilities of commercial bank branches | efficiency measures, profitability indicators, operational effectiveness metrics, and recommendations for improvement |
| 49 | Lin, T.T., Lee, C.C. and Chiu, T.F., (2009) | AI | the number  of staff, interest expense, deposit operating amount (including  check deposit, current deposit, foreign exchange current deposit,  current savings deposit, current treasury bond deposit, time deposit),  and current deposit operating amount | loan operating amount, interest revenue, operating revenue  and earning |
| 50 | Iago Cotrim Henriques(2020) | (ask) the paper is review of literature | (ask) the paper is review of literature | (ask) the paper is review of literature |

NOTE: Make sure that you report both the performance criteria and their measures; e.g., economy is a criterion and GDP is one of the measures of this criterion.

The examination of efficiency evaluation using DEA within the context of Chinese Banks, highlights a nuanced diversification in the selection of assessment perspectives. Predominantly, the literature gravitates towards three approaches: the Intermediation Approach (IA), the Profit-Oriented Approach (POA) and the Production Approach. The studies such as those by Xiaogang Chen et al. (2005), reflect a focus on the traditional role of financial institutions as intermediaries between savers and borrowers. Inputs typically include various categories of expenses, while outputs show loans, deposits, and non-interest income. On the other hand, the POA, represented by works like Matthews (2013) and Xiao Shi et al. (2023), underscores the significance of profitability, with operational costs and interest costs as inputs and a combination of interest and non-interest income as outputs. This distinction in approaches underscores the evolving nature of efficiency analysis within the banking sector, where the emphasis shifts based on the underlying financial model and the strategic objectives of the institutions under review. Furthermore, the studies by Fukuyama et al. (2023) and Necmi and Hiroshi (2010), exhibit the Production Approach (PA) as another type of perspective. This approach focuses on the production processes of banking services, considering inputs such as labor and physical capital and outputs like the volume of processed transactions or services rendered, highlighting an operational view of bank efficiency.

**Table 5:** Summary of response and explanatory variables used in the second-stage analysis of two-stage analyses and the perspective that shapes the choice of the explanatory variables – we shall refer to this perspective as the behavioural perspective which depending on the aim of the investigation could be the contextual or environment perspective or could be event related (guidelines: analyse this table by perspective and for each perspective classify explanatory variables in meaningful categories and discuss them in the main text)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Paper # | Reference | Behavioural Perspective | | Response/dependent variable | Explanatory variables / drivers |
|  |  | The summary of the drivers / explanatory variables | | Should be the type of efficiency or inefficiency | This is the drivers |
| 18 | Kai Du, Andrew C. Worthington, Valentin Zelenyuk (2018) | Asset diversification on profit efficiency | | Profit Efficiency | Other Earning Asset over Loans (OEL/L), Other Earning Assets over Total Earning Assest (OEA/TA) |
| 23 | James R. Barth, Chen Lin, Yue Ma, Jesús Seade, Frank M. Song (2013) | The effect of internal factors influence the bank efficiency | | Technical efficiency | Activity restrictiveness, overall capital stringency, Herfindial Index (HHI), government ownership of banks, bank size, bank equity, Country GDP and Inflation |
| 25 | **Xie et al. (2022)** | **External economic environment and internal bank factors** | | **Efficiency value: input-output ratio** | **Broad money supply, NPL ratio, capital adequacy ratio, leverage ratio, loan-to-deposit ratio, GDP growth rate, policy uncertainty index, central parity of currency exchange, international short-term capital inflow** |
| 28 | Mohamed Ariff and Luc Can (2008) | The effect of internal and external factors influence the cost and profit efficiencies | | Cost and Profit Efficiency | Ownership structure SOCB, Ownership structure JSCB, bank size, credit risk, asset quality, capital risk, liquidity risk |
| 30 | **Fukuyama and Tan (2022)** | **Demographical financial risk and CSR** | | **Input inefficiency, stability inefficiency, output inefficiency** | **NPL Ratio from western area, NPL Ratio from middle area, NPL Ratio from eastern area, loan to SME, donations, balance of green credit** |
| 33 | Xiaohong Liu, Feng Yang, Jie Wu (2020) | ownership structure on the deposit and loan efficiencies of banks | | Profit and Cost Efficiency | Ownership nature, Ownership concentration, Ownership liquidity, Control variable |
| 43 | Rasoul Rezvanian, Rima Truk Ariss, Sayed M. Mehdian, (2010) | investigate cost efficiency determinants of Chinese banks | | Cost efficiency | Profitability, capitalization, bank size, Foreign, Big Four, Regulatory Quality and Economic Development |
| 45 | Wu et al. (2023) | External economic and regulatory factor | | Efficiency value | Interest rate liberalization index, consumer price index, market risk |
| 1 | Necmi K. Avkiran (2011) | investigates whether DEA super-efficiency estimates align with financial performance indicators | | SSBM-C-1 (non-radial, constant returns-to-scale, and input oriented) | PTP/ATA (post-tax profits to average total assets) |
| 6 | Tan, Wänke, Antunes, Emrouznejad (2024) | External real-world behaviours and decisions | | Lerner Index (Measurement of market power) | Efficiency Value, relationship competition value |
| 11 | An, Chen, Liang & Wu (2015) | n/a | | n/a | n/a |
| 21 | Hirofumi Fukuyamaa , Roman Matousek (2017) | bank performance evaluation from a network perspective, incorporating non-performing loans into the efficiency measurement | | the banks' revenue efficiency scores scored by the network DEA model | Loans and mortgages  Investment products  Individual financial advisory services  Exclusive banking products  Non-performing loans  Operational losses  Compliance issues |
| 31 | Fukuyama, Tsionas, Tan (2023) | Internal bank which has different sizes and market segment | | Inefficiency: Technical inefficiency, allocative inefficiency | Agriculture sector  Wholesale sector  Water conservancy, environment and public facitilities sector  Financial services sector |
| 41 | Guangcheng Xu and Zhixiang Zhou (2020) | assessing the efficiency of financial supply chains in Chinese commercial banks | | overall stage efficiency, deposit producing stage efficiency, and profit earning stage efficiency of the Chinese commercial banks. | internet finance (ln DFII), loan quality (ln DARit), return on equity (ROEit), balance loan ratio (BLRit), gross domestic product (GDPt), consumer price index (CPIt), and different types of banks (TYPEi) |
| 7 | Matthews, et al. (2010) | **n/a** | | **n/a** | **n/a** |
| 27 | Hou, et al. (2014) | **market structure,**  **bank risk** | | **technical efficiency** | **Herfindahl-Hirschman Index in deposits;**  **the ratio of equity to total assets ,**  **the ratio of loan loss provisions to total loans ,**  **the ratio between total loans and deposits** |
| 32 | Fukuyama, et al. (2021) | the risk from the perspective related to banks’ ability to withstand the potential negative shocks | | direct technical efficiency | LLRs (loan loss reserves) and total loans |
| 22 | Fukuyama, et al. (2021) | the impact of CSR on bank efficiency | | Indirect technical efficiency, Technical efficiency, Indirect allocative efficiency | Donations (reflecting social contribution),  Balance of green credit (reflecting environmental responsibility),  Loans to Small and Medium-sized enterprises (SMEs) |
| 17 | Dong et al. (2016) | n/a | | n/a | n/a |
| 12 | Luo et al. (2011) | n/a | | n/a | n/a |
| 2 | Antunes et al. (2022) | Bank profitability, bank size, expenses management, traditional business and non-traditional  business | technical efficiency | bank size (natural  logarithm of total assets),  bank profitability (return on assets),  expense management (the  sum of total interest expenses and non-interest expenses over total assets); traditional bank  business (the ratio of interest income to total assets); and non-traditional bank business (the  ratio of non-interest operating income to total assets). | |
| 46 | Bingquan et al. (2019) | n/a | | n/a | n/a |
| 42 | **Luo et al. (2010)** | n/a | | n/a | n/a |
| 4 | **Wang et al. (2014)** | **n\a**  **n\a** | | **n\a** | n\a |
| 14 | **Fukuyama, H., Tsionas, M. and Tan, Y., (2023)** | **n\a**  **n\a** | | **n\a** | n\a |
| 19 | **Zhou, X.,(2019)** | **n\a**  **n\a** | | **n\a** | n\a |
| 29 | **Boussemart, J.P. (2019)** | **n\a**  **n\a** | | **n\a** | n\a |
| 48 | **Yan Luo, Gongbing Bi, Liang Liang (2012)** | **n\a**  **n\a** | | **n\a** |  |
| 47 | **Jorge Antunes(2024)** | **n\a**  **(ask)**    **efficiency scores** | | efficiency scores | **bank size (natural logarithm of total assets), bank profitability (return on assets), expense management (the sum of total interest expenses and non-interest expenses over total assets), traditional bank business (the ratio of interest income to total assets), and non-traditional bank business (the ratio of non-interest operating income to total assets)** |
| 34 | **Yongjun Li(2019)** | **n\a**  **n\a** | | **n\a** | n\a |
| 39 | **Tai-Hsin Huang a, Chung-I Lin b,⁎, Kuan-Chen Chenc(2017)** | **n\a**  **n\a** | | **n\a** | n\a |
| 24 | **Shabani, P. and Akbarpour Shirazi, M., (2023)** | **n\a**  **n\a** | | **n\a** | n\a |
| 49 | **Lin, T.T., Lee, C.C. and Chiu, T.F., (2009)** | **n\a**  **n\a** | | **n\a** | n\a |
| 50 | **Iago Cotrim Henriques(2020)** | **(ask) the paper is review of literature**  **(ask) the paper is review of literature** | | **(ask) the paper is review of literature** | **(ask) the paper is review of literature** |

**Drivers of Efficiency in Chinese Banking and Their Classifying:**

The second-stage DEA study provides a comprehensive examination of many variables connected to the performance of Chinese banks. These variables are studied using a behavioral perspective and are classified into two unique categories: contextual/environmental and event-related. The variables included in Table 5 are carefully documented and serve as the explanatory factors that influence the complex operational environment of banks, affecting both efficiency and inefficiency results.

The contextual/environmental perspective includes macroeconomic data such as GDP growth rate, broad money supply, and policy uncertainty index. These components represent the economic conditions in which banks operate. Regulatory factors, such as capital adequacy ratios and interest rate liberalization indices, act as indicators for the regulatory environment in which banks function, revealing systemic limitations and the level of economic governance. The Herfindahl-Hirschman Index and different ownership structures reflect the competitive environment and internal governance, providing an overview of the strategic landscape in the banking sector.

On the other hand, the event-related perspective focuses specifically on internal factors that influence banks, such as their size and profitability. These factors indicate how well the bank operates and the advantages of being large. The perspective also considers risk-related variables including credit and liquidity issues. These characteristics work as a means of assessing the banks' current operational environment and their ability to quickly adapt to internal and external disruptions. Rezvanian, Truk Ariss, and Mehdian (2010) demonstrate that a combination of internal control factors, such as ownership type and concentration, and external influences, such as regulatory quality and economic development, have a significant role in determining efficiency. Their work presents a detailed and intricate analysis of the factors that contribute to efficiency.

Wu et al. (2023) establish a direct connection between bank performance and external economic and regulatory issues, emphasizing that efficiency is a multifaceted process driven by wider policy frameworks and market dynamics. Meanwhile, Fukuyama and Tan (2022) investigate the impact of demographic financial risks and corporate social responsibility on inefficiency. They examine how bank policies directly affect various geographical landscapes and their socio-economic involvement.

By combining various viewpoints, Table 5 provides a thorough representation of the factors influencing the effectiveness of Chinese banks. The behavioral perspective emphasizes the importance of considering both the strong structural features of banks and the ever-changing economic and regulatory environments in which they operate. The inclusion of both perspectives not only enhances our comprehension of bank efficiency but also underscores the interconnected relationship between external forces and internal bank policy. Therefore, the DEA scores are not just numbers, but rather indications of the intricate relationship between the banks' strategic choices and their ability to adapt to the environment. These ratings provide useful insights for improving bank performance through a strategic approach.

**Table 6:** Summary of Environmental variables used in three-stage analyses for assessing the efficiency profiles of DMUs and the perspective that shapes the choice of these variables; i.e., the perspective from which the analysis is performed & environmental variables are chosen – we shall refer to this perspective as the environment perspective and should reflect the internal environment characteristics, the external environment characteristics, or both (guidelines: you are required to provide the list of environmental variables used by the authors in each reference; papers not using a three-stage analysis and thus not considering environmental variables should not be included in this table – recall that a three-stage analysis purges the efficiency scores from the effect of the environment, which requires the use of environmental variables. Analyse this table by perspective and for each perspective classify environmental variables in meaningful categories and discuss them in the main text)

|  |  |  |  |
| --- | --- | --- | --- |
| **Paper #** | **Reference** | **Environment Perspective** | **Environmental Variables** |
|  |  |  |  |
|  |  |  |  |
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|  |  |  |  |

**Table 7:** Summary of Number of DMUs, Period of Analysis, Sample size, and Source(s) of Data (guidelines: analyse this table by type of DMU, when relevant, and classify them into meaningful categories and discuss them in the main text)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Paper #** | **Reference** | **Number of DMUs & their country(ies)** | **Period of analysis** | **Sample Size** | **Source of Data** |
| 3 | Xiaogang Chen, Michael Skully, and Kym Brown (2005) | 43 Chinese banks, including state-owned, regional joint-equity, and investment banks | 1993–2000 | 43 | BankScope, which aggregates comprehensive financial information on banks globally |
| 5 | Matthews (2013) | 18 Chinese banks | 2007-2008 | 36 | Chinese banks, interviews |
| 8 | Xiaohong Liu, Feng Yang, Jie Wu (2020) | 28 Chinese Commercial Banks | 2013–2017 | 140 observations | Wind Database |
| 10 | Wilson and Zhao (2023) | 124 Chinese banks (incl. 32 foreign banks) | 2007-2014 | 992 | BankScope |
| 13 | Xiao Shi, Libo Wang, Ali Emrouznejad (2023) | 36 Chinese Commercial Banks | 2016-2021 | 36 banks over 6 years, resulting in 216 observations | Data extracted from banks' annual reports and the Wind Database |
| 15 | Asmild and Matthews (2012) | 14 Chinese banks | 1997-2008 | 168 | Bankscope, individual bank reports |
| 18 | Kai Du, Andrew C. Worthington, Valentin Zelenyuk (2018) | 140 chinese commercial banks | 2006-2011 | Data for 140 commercial banks over 6 years, resulting in 840 observations | BankScope |
| 20 | Dong et al., (2014) | 41 Chinese banks | 1994-2007 | 397 | Almanac of China's Finance and Banking, BankScope, and other financial reports |
| 23 | James R. Barth, Chen Lin, Yue Ma, Jesús Seade, Frank M. Song (2013) | 4053 banks in 72 countries | 1999-2007 | 8115 observations | BankScope |
| 25 | Xie et al. (2022) | 16 listed Chinese commercial banks | 2009-2018 | 160 | Wind database, annual reports |
| 28 | Mohamed Ariff and Luc Can (2008) | 28 Chinese banks | 1995-2004 | 230 observations | Bankscope |
| 30 | Fukuyama and Tan (2022) | 72 Chinese banks | 2007-2017 | 792 | *Information not available* |
| 33 | Xiaohong Liu, Feng Yang, Jie Wu (2020) | 71 Chinese commercial banks | 2011-2015 | 355 observations | Bank annual reports and the Yearly Statistics Book of China’s Finance |
| 35 | Yu et al. (2019) | 25 Chinese listed banks | 2012-2016 | 125 | Individual bank annual reports |
| 38 | Tsui-Yueh Cho, Yi-Shuan Chen (2021) | 34 chinese banks | 2011-2017 | 238 observations | Orbis Bank Database |
| 40 | Zhu, Li and Liang (2018) | 8 Chinese commercial banks | 2012 | 8 | Individual bank websites and reports |
| 43 | Rasoul Rezvanian, Rima Truk Ariss, Sayed M. Mehdian, (2010) | 62 Chinese Banks | 1998-2006 | 349 observations | Bankscope |
| 45 | Wu et al. (2023) | 27 Chinese commercial banks | 2006-2020 | 405 | Bankfocus, individual bank annual reports, |
| 1 | Necmi K. Avkiran (2011) | 51 commercial bank (SOCB group, JSCB group, CiCB group LIFB group) and 1 country (China) | 2007 - 2008 | 102 sample size | From OSIRIS, DataStream for Bank Annual reports for fiscal years ending in December 2007 and 2008 for twenty-one publicly listed Chinese commercial banks |
| 6 | Tan, Wänke, Antunes, Emrouznejad (2024) | 27 DMUs and Commercial banks in China | 2007 to 2017 | 297 sample size | Fitch Connect and Annual Financial Statesment |
| 11 | An, Chen, Liang & Wu (2015) | 16 (Chinese commercial banks, covering different types like state-owned, joint-stock, and city commercial banks) and China | 2008 - 2012 | 80 sample size | Annual reports, banking association data, and national credit system data |
| 16 | Hirofumi Fukuyamaa , Yong Tan (2022) | 71 (banks which are concerned t five types of performance, consisting of innovation, two kinds of stability, profitability and CSR) and China | 2011-2019 | 639 sample size | Collecting balanced panel dataset |
| 21 | Hirofumi Fukuyamaa , Roman Matousek (2017) | 72 Regional Japanese Bank I and II | September 2000 – march 2013 | 172 Japanese Banks in regional 1 and 2 | Japanese regional bank report |
| 26 | Kent Matthews a , Zhiguo Xiao (2020) | 14 DMUs Chinese bank | 1997 - 2016 | 280 Bank Observation | Fitch/Bankscope, and individual annual reports of banks |
| 31 | Fukuyama, Tsionas, Tan (2023) | 25 DMUs | 2013 - 2020 | 500 bank observation | Financial statement |
| 36 | Necmi K. Avkiran, Hiroshi Morita (2010) | 20 listed Chinese banks | Ending December 2007 | 20 banks observed | OSIRIS Datastream |
| 41 | Guangcheng Xu and Zhixiang Zhou (2020) | 26 chinese commercial banks | 2013 - 2017 | 130 banks observed | Wind database and the year book of each bank |
| 7 | Matthews, et al. (2010) | 5 state-owned or state-controlled commercial  banks (SOCB), 9 joint-stock commercial banks (JSCB) and 47 city commercial banks (CCB) | 1997-2007 | 314 | Fitch/Bankscope |
| 27 | Hou, et al. (2014) | 44 major Chinese  commercial banks | 2007-2011 | 220 | BankScope database |
| 32 | Fukuyama, et al. (2021) | 43 Chinese banks | 2010–2019 | 430 | Not given |
| 22 | Fukuyama, et al. (2021) | 72 Chinese commercial  banks | 2007–2017 | 792 | Fitch Connect |
| 17 | Dong et al. (2016) | 142 Chinese banks | 2002-2013 | 1704 | BankScope |
| 12 | Luo et al. (2011) | 14 listed Chinese  commercial banks | 1999–2008 | 140 | Thompson’s Bankscope |
| 2 | Antunes et al. (2022) | 39 Chinese commercial banks | 2010–2018 | 351 | Fitchconnect |
| 46 | Bingquan et al. (2019) | 65 Chinese urban commercial banks | 2013–2017 | 325 | Orbis Bank Focus |
| 42 | Luo et al. (2010) | 14 Chinese listed commercial banks | 1999-2008 | 140 | Bankscope |
| 4 | Wang et al. (2014) | 16 Chinese banks  divided into two groups of 4 SOBs and 12 JSBs | 2003-2011 | 144 | Fitch–Thompson Bankscope, official sources of bank annual reports, and the Yearly Statistics Book of China's Finance |
| 14 | Fukuyama, H., Tsionas, M. and Tan, Y., (2023) | 43 banks with 5 different ownership types: state-owned, joint-stock, city, rural and foreign banks | 2010-2018 | 387 | the Fitch Connect database |
| 19 | Zhou, X.,(2019) | 16 Chinese listed commercial banks | 2014-2016 | 48 | From WIND |
| 29 | Boussemart, J.P. (2019) | 30 Chinese commercial banks | 2005-2012 | 240 | the Bankscope database, with variables expressed in Chinese yuan with 2004 as the base year (CNY 2004) |
| 48 | Yan Luo, Gongbing Bi, Liang Liang (2012) | 14 Chinese commercial banks | 2008 | not explicitly mentioned, but but it is implied that the study includes 14 commercial banks | the annual reports of the 14 Chinese commercial banks |
| 50 | Iago Cotrim Henriques(2020) | n\a (literature review) | n\a (literature review) | n\a (literature review) | n\a (literature review) |
| 47 | Jorge Antunes(2024) | 39 commercial banks | 2010-2018 | Make sure  39\*9 | The Fithconnect database |
| 34 | Yongjun Li(2019) | 16 stock-listed commercial banks in China | Not mentioned | ? | from Bank-scope resource package  produced by Bureau Van Dijk (BVD), Yearly  Statistics Book of China’s Finance and the annual  reports of the banks. |
| 39 | Tai-Hsin Huang a, Chung-I Lin b,⁎, Kuan-Chen Chenc(2017) | 172 Chinese commercial banks | 2002-2015 | 2408 | compiled from unconsolidated financial statements of BankScope, which is Fitch's International Bank Database. |
| 24 | Shabani, P. and Akbarpour Shirazi, M., (2023) | 38 branches of an Iranian commercial banks | 2016-2020 | 190 |  |
| 49 | Lin, T.T., Lee, C.C. and Chiu, T.F., (2009) | 117 | 2006 | 117 | the internal operation management  statistic form |

ADVICE: Once you have completed reading the papers you selected for your literature survey and filled the above tables (Tables 1-7), analyse each table separately and write a paragraph or several on each table including a classification of the literature related to each of these tables. Then, craft a story to tell the reader based on these analyses of the tables. Remember, writing papers / reports / dissertations is all about crafting interesting stories to tell the reader based on facts / empirical evidence!