



Analysis of the operational efficiency of China's bank card industry and its influencing factors: Based on data from 12 listed banks

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Abstract

Bank card credit payment instruments play a pivotal role in the financial industry, and bank card business is also one of the important business segments of commercial banks, but there is little current research in the academic community on the operational efficiency of China's bank card industry. Based on this background, this paper selects 12 large listed commercial banks in China as industry representatives to analyze the efficiency of bank card business operation, and finds that the efficiency varies greatly within the industry, and the return on net assets and business income ratio have a significant impact on the industry efficiency. Finally, according to the analysis results, the corresponding constructive suggestions are put forward to provide some mirrors for the development of bank card industry.

Keywords: Bank cards, commercial banks, SBM model, influencing factors

1. Introduction

As a credit payment instrument with multiple financial functions, bank cards play an important role in the development pattern of the modern financial industry ^[1]. By the end of 2020, the number of bank cards in use in China reached an unprecedented 8.954 billion, up 6.36% year-on-year; a total of 345.426 billion bank card transactions, amounting to 888 trillion yuan, up 7.28% and 0.18% year-on-year, respectively ^[1].

Although the development of the bank card industry in recent years remains stable, but from the internal and external point of view, the development of China's bank card industry is still facing a more serious situation. From the external point of view, with the development of Internet finance and digital currency technology, the traditional way of relying on bank cards for fund transfer has a huge challenge, and the industry ecology is facing unprecedented risk threat in the context of technological development ^[2]; the bank card market is gradually opened to the outside world, and the card issuing body and clearing institution are inevitably affected by external competition, and the traditional bank card industry is in crisis ^[3]. And from the internal point of view, the disorder of the bank card industry is still frequent, with irregular card issuance, privacy leakage, anti-fraud inefficiency and other problems becoming the industry's persistent problems ^[4].

Under the influence of various intertwined factors, China's bank card industry is in the transition period from the traditional crude development to a more refined new development mode ^[5]. In such a context, examining the development efficiency of the bank card industry in the past period and exploring its influencing factors is not only a stage summary of the whole industry, but also a way to deepen the research in the field at the theoretical level. Therefore, this paper selects the data of 12 representative listed banks from 2015-2020, applies the SBM model to measure their operational efficiency, and compares the possible influencing factors for Tobit regression based on the measurement results to further deepen the research results on the efficiency of the bank card industry.

2. Literature Review

Data envelopment analysis, originally proposed by Charnes (1978) ^[6] and others, is a nonparametric method for evaluating the efficiency of a set of homogeneous decision units (DMUs) in which one or more inputs are consumed to produce one or more outputs the.

DEA method makes no assumptions about the production function and has no subjective weight restrictions on the inputs or outputs of the decision units, so its output variables are ideal indicators. The more inputs, the more outputs. Domestic scholars have long applied this method to the study of banking industry. Weiyu and Wangli (2000) [7] was the first to apply the DEA method to the measurement of the operational development efficiency of commercial banks in China, selecting the data of 12 large banks in 1997 for analysis, and providing corresponding suggestions based on the results of the efficiency analysis. Zhaoxu (2000) [8], on the other hand, focused on the operational efficiency of the four major state-owned banks, conducted an efficiency analysis based on dynamic data from 1993 to 1997, and provided suggestions for the development of large state-owned banks from the perspective of the upcoming market entry. Zhang Jianhua (2003) [9] divided commercial banks into three major types based on this basis: state-owned, joint-stock and city commercial banks, and measured the operating efficiency of each type of bank through an improved DEA method, which showed that joint-stock banks were the most efficient, but the X-efficiency that existed in the industry over time would allow large state-owned banks to make more rational use of resources to improve efficiency in the future. Lu Feng *et al.* (2012) [10], on the other hand, address the problem of savings positioning, which is difficult to identify in previous studies, and use the network DEA method in a new perspective to measure savings as both input and output, which enriches and expands the application of DEA method in the measurement of efficiency in the banking industry.

In recent years, more and more scholars have applied the DEA method to research in more niche areas and perspectives within commercial banks. For example, Heng Zhang (2014) [11] *et al.* started from the perspective of green finance, and measured the green management efficiency of 16 commercial banks by constructing indicators of green inputs and outputs in the banking industry and pointed out that commercial banks in China should make efficiency improvements in four areas such as environmental policy making. Zeng Wei *et al.* (2016) [12] used two-stage DEA to examine the inhibition of financial regulation on the efficiency of product innovation of commercial banks in China, expanding the efficiency evaluation approach in the field of banking industry innovation and highlighting the role of regulation on the multidimensional development of commercial banks. In a similar way, Lu Yi Zhou *et al.* (2019) [13] also constructed an efficiency evaluation system for risk management in the banking industry, expanding the research in related fields. Bank cards, as an important part of the business operation segment of commercial banks, have also been evaluated by scholars for their efficiency, and Wang Xueping *et al.* (2007) [14] have selected bank card data of 16 commercial banks from 1999-2004 and measured the efficiency of bank card business among banks through DEA-Malmquist model, and found that the efficiency of large state-owned banks is lower compared with that of small and medium. The results show that the efficiency of large state-owned banks is lower than that of small and medium-sized commercial banks, and the main reason for this phenomenon is the poor technical efficiency. In summary, the DEA data envelope method has been maturely applied to measure the efficiency of commercial banks in China, and the research perspective has been gradually shifted to the internal modules of banks for multi-perspective efficiency measurement. Therefore, based on the

above research results, this paper selects the most current and comparable 2015-2020 data of 12 representative bank card operators and chooses the improved SBM model for efficiency measurement, in order to make a stage review of the development of China's bank card industry and provide relevant practical suggestions. The purpose is to summarize the development of China's bank card industry and provide relevant realistic suggestions.

3. Models and data indicators

3.1. SBM model

The SBM model is a variant of the DEA analysis method established by Tone (2001) [15]. Unlike the traditional BCC or CCR models, SBM takes into account the relaxation and improvement paths of all input-output variables and embodies them in the objective function, making the final efficiency values obtained strictly limited and more comparable.

The SBM model is non-radial in nature, which can eliminate radial bias and directional bias and ensure the validity of the efficiency results. Assuming that there are k units and a single unit with g inputs ($i=1,2,\dots,g$) obtains s outputs ($r=1,2,\dots,s$), the SBM model under input-oriented variable scale payoffs for a given decision unit is specified as follows:

$$\min \rho = \frac{1 - \frac{1}{m} \sum_{i=1}^m \frac{s_i^-}{x_{io}}}{1 + \frac{1}{s} \sum_{r=1}^s \frac{s_r^+}{y_{ro}}}$$

$$s.t. X\lambda + s_i^- = x_{io}$$

$$Y\lambda - s_i^+ = y_o$$

$$\lambda \geq 0, \quad s^- \geq 0, \quad s^+ \geq 0$$

Among them s^- and s^+ are the slack vectors corresponding to the inputs and outputs, respectively. Model (4.1) is a fractional programming, which can be transformed into an equivalent linear programming solution by the Charnes-Cooper transformation, and its equivalent form is shown below:

$$\min \tau = t - \frac{1}{m} \sum_{i=1}^m \frac{S_i^-}{x_{io}}$$

$$s.t. \min \rho = t + \frac{1}{s} \sum_{r=1}^s \frac{S_r^+}{y_{ro}}$$

$$tx_o = X\theta + S^-, \quad ty_o = Y\theta - S^+$$

$$\theta \geq 0, \quad S^- \geq 0, \quad tS^+ \geq 0, \quad t > 0$$

$$\text{where } t = \frac{1}{1 + \frac{1}{s} \sum_{r=1}^s \frac{S_r^+}{y_{ro}}}, \quad S^- = tS^-, \quad \text{and } S^+ = tS^+ \quad \text{and } \theta = t\lambda$$

For each input variable, its slack variable cannot exceed itself in any case, i.e. $S_i^- \leq x_{io}, \forall i=1,2,\dots, m$; for the output variable, its slack variable can exceed the value of the output variable as long as it is a number greater than or equal to 0. Examining the objective function of model (4.1), we can obtain:

$$0 \leq \frac{1}{m} \sum_{i=1}^m \frac{S_i^-}{x_{io}} \leq I \leq \frac{1}{s} \sum_{r=1}^s \frac{S_r^+}{y_{ro}} \geq 0$$

Therefore, the objective function value should satisfy $0 \leq \rho \leq 1$, and note that the optimal solution of the objective function of model (4.1) is ρ^* .

3.2. Indicator selection and data description

After considering the market position, scale and representativeness of each commercial bank, and excluding some banks with incomplete data sources, this paper selects 12 banks with a relatively large share of the bank card industry and more complete data disclosure as the research sample. In 2020, the asset scale of these 12 commercial banks reached 165 trillion yuan, accounting for more than 50% of the market; the number of bank cards issued even reached 6.476 billion, accounting for 72% of the overall 8.954 billion cards in the country, which can well represent the development of the whole industry. Moreover, considering the nature of banks, this paper selects not only five super large state-owned banks, such as Industrial and Commercial Bank of China, Bank of Communications, China Construction Bank, Bank of China and Agricultural Bank of China, but also large private banks, such as China Merchants Bank, and large city and agricultural commercial banks, such as Bank of Shanghai and Chongqing Agricultural Commercial Bank, to ensure the richness and comparability of the sample. To ensure the timeliness and longitudinal comparability of the empirical

results, this paper selects data from these 12 banks for a total of six years from 2015 to 2020.

In the selection of indicators, three input indicators, namely, total assets, card issuance and number of outlets, and three output indicators, namely, card revenue, credit card loans and total deposits, are selected with reference to existing studies and according to the characteristics of card industry operations. The reasons for the selection of indicators are as follows.

For the selection of input indicators, firstly, the number of cards issued by [1] is the initial element of card business operation, so the annual cumulative number of cards issued by each bank is included in the input indicators; secondly, the overall scale of banks is considered, as one of the business segments of banks, the card business must rely on the comprehensive strength of banks to achieve efficient development, so the asset scale is selected to measure the support capacity that banks can provide for the development of their card business. Finally, considering the important role of bank network in the development of bank card business, it is also included in the input index.

For the selection of output indicators, considering the direct and indirect income that debit and credit cards can bring to banks, the card revenue, total credit card loans and total deposits of each bank in a year are selected as output indicators to measure the economic benefit output brought to banks by the card business.

Descriptive statistics for each variable are shown in the following table.

Table 1: Descriptive statistics of variables (Unit: million, pcs, Billion)

	Input Indicators			Output Indicators		
	Number of bank cards issued	Number of network points	Total Assets	Bank Card Revenue	Credit Card Loans	Total deposits
Average value	44186.87	9636.04	112676.23	166.75	3631.76	267276.27
Standard deviation	43714.70	11602.22	91965.25	137.07	2017.99	1590722.84
Minimum value	637.83	146	7168.05	0.84	123.9	4702.28
Maximum value	135200.23	39638	333450.58	526.21	8289.43	251347.26

In order to meet the special condition that the input-output variables increase and decrease at the same time necessary for the SBM model, this paper conducted the Person

correlation coefficient test on the input-output indicators, and the results are shown in Table 2.

Table 2: Pearson correlation coefficients of input-output indicators (Unit: million, pcs, Billion)

	Number of bank cards issued	Number of network points	Total Assets
Bank Card Revenue	0.5744	0.3897	0.9284
Credit Card Loans	0.6382	0.8987	0.5943
Total deposits	0.6743	0.5353	0.9942

4. Operating efficiency results and comparisons

4.1. Cross-sectional comparison of efficiency values

In this paper, we select the relevant data of each bank for 2015-2020, and the results of the efficiency measurement of

each bank using the SBM model and the results of the average efficiency values of different types of banks are shown in Table 3.

Table 3: Efficiency scores of SBM model analysis for each bank sample

Type	Bank Name	2015	2016	2017	2018	2019	2020	Annual average efficiency	Ranking
Five major banks	Bank of Communications	0.436	0.470	0.491	0.416	0.320	0.378	0.419	1
	Bank of China	0.122	0.239	0.243	1.000	0.239	0.275	0.353	2
	Construction Bank	0.145	0.298	0.296	0.287	0.275	0.306	0.268	3
	ICBC	0.119	0.251	0.262	0.244	0.256	0.303	0.239	4
	Agricultural Bank	0.096	0.166	0.159	0.150	0.143	0.171	0.147	5
	Average value	0.183	0.285	0.290	0.419	0.247	0.287	0.285	
Other commercial banks	Chongqing Farmers and Merchants	1.000	0.828	0.689	0.800	0.888	1.000	0.867	1

Bank of Nanjing	0.886	1.000	1.000	0.739	0.625	0.843	0.849	2
Pudong Development Bank	0.542	1.000	0.907	0.763	0.610	0.429	0.708	3
Societe Generale	0.452	1.000	0.844	0.566	0.396	0.402	0.610	4
China Merchants Bank	0.585	0.607	0.582	0.528	0.462	0.450	0.536	5
Bank of Shanghai	0.128	0.339	0.355	0.302	0.213	0.189	0.254	6
Post and Reserve Bank	0.100	0.142	0.141	0.119	0.125	0.078	0.118	7
Average value	0.528	0.702	0.645	0.545	0.474	0.484	0.563	
Total average	0.384	0.529	0.497	0.493	0.379	0.402	0.447	

From the efficiency evaluation results, the highest annual average efficiency of bank card business among the five major banks, Bank of Communications of China, reached 0.419, while the lowest, Agricultural Bank of China, was only 0.147. Only Bank of China had an efficiency value of 1 in six years, reaching the efficiency preamble. While the highest efficiency among other commercial banks is Chongqing Agricultural and Commercial Bank, the lowest is China Postal and Reserve Bank, and Chongqing Agricultural and Commercial Bank and Bank of Nanjing had efficiency values of 1 in many years during the period under examination, reaching the efficiency optimum. Overall, the traditional top five banks perform poorly in terms of efficiency values, while the emerging ones such as Chongqing Agricultural and Commercial Bank and Bank of Nanjing and Pudong Development Bank show better development. The reason for this result may be due to the fact that the five major banks have been developing for a long time and their businesses are spread across the country, and they are approaching the bottleneck of the existing foundation in the process of bank card business development, and the problems such as low live card rate caused by blind promotion are becoming persistent, and due to their characteristics of state-controlled banks, their businesses need to undertake national policies and cannot be fully oriented to market interests. Emerging joint-stock banks, city merchant banks and agricultural merchant banks,

on the other hand, generally cultivate their regions or businesses deeply, and are able to accumulate customers quickly with light assets, with fast growth, high live card rates and high user stickiness, thus generally having high efficiency values. It is worth noting that the relatively less efficient Agricultural Bank of China and Postal Reserve Bank of China both have their important policy positioning and play an important role in the grassroots financial system, and thus their debit card numbers generally account for a larger share and their customer base is relatively sunken, achieving more inclusive financial effectiveness, which to some extent affects the efficiency of their bank card business operations [16]

4.2. Longitudinal comparison of efficiency values

In order to deepen the comparison of the operational efficiency of the card industry of each bank, and to examine longitudinally the characteristics shown by different types of banks in the process of operating the card industry from the perspective of time change, this paper conducts a longitudinal comparison of the traditionally recognized five major commercial banks, other large commercial banks and the overall average industrial efficiency to explore the path of change in the operational efficiency of the card industry from 2015 to 2020. The results of the analysis are shown in Figure 1.

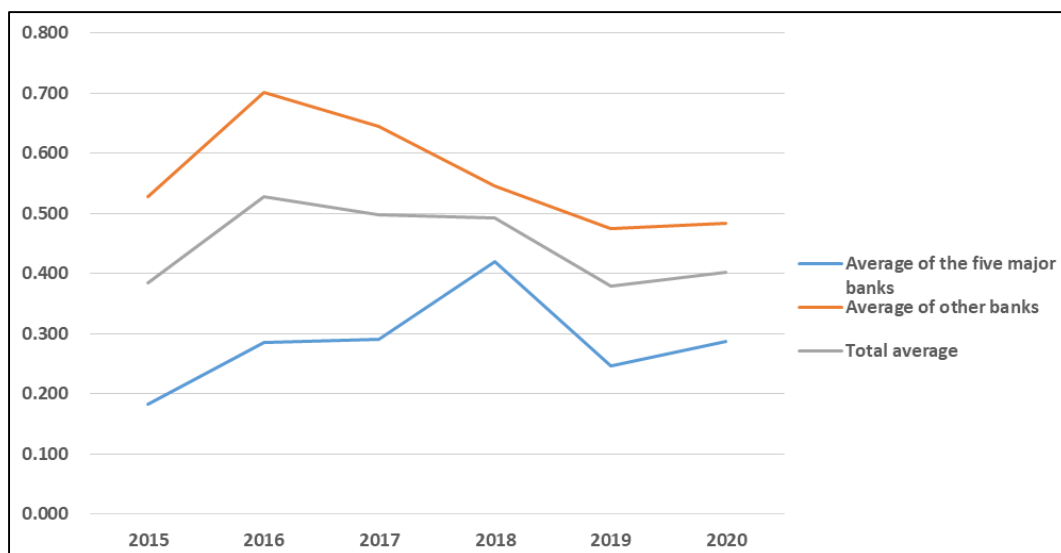


Fig 1: Comparison of average efficiency scores by year among different types of banks

From the perspective of vertical annual changes, the banking card business operation efficiency of the five state-owned commercial banks is generally low, but the overall trend is steadily improving, with a higher average value in 2018 due to the efficiency of Chinese banks reaching the frontier surface, and the rest of the years are more stable. Other commercial banks, on the other hand, have an overall downward trend. After the dividend of rapid expansion fades

away, how to ensure the stable and efficient development of their own bank card business becomes an important issue for banking entities like joint-stock commercial banks, city commercial banks and agricultural commercial banks.

5. Analysis of the factors affecting efficiency

5.1. Research hypothesis and model setting

After the cross-sectional and vertical comparison of the

efficiency analysis results, the general characteristics of the current development of China's bank card industry can be seen, but the mechanism of the formation of these characteristics is still unknown. Therefore, this paper chooses to use the results of SBM model analysis as the explanatory variables and use Tobit model for regression analysis. For the selection of explanatory variables, it is generally done from both external and internal perspectives. Since external macro factors are generally difficult to directly influence the development of the bank card industry, this paper chooses to select possible influencing factors from internal perspectives, and a total of five possible factors are selected as follows.

1. Return on net assets: it is the percentage of net profit and average shareholders' equity, which represents to some extent the efficiency of the enterprise's use of its own capital. Since the decision units selected in this paper are all listed large commercial banks, the return on net assets can better reflect the company's ability to create value with its own capital [17], and the efficiency of the bank card industry is closely related to the company's operation level, so the return on net assets is chosen as its possible influencing factor.

2. Number of employees: the number of marketing and middle and back office support staff is also an important factor affecting the development of bank card business. Since the number of employees in the credit card business is not disclosed by each bank, this paper considers that the employees of the Bank generally act as users and promoters of the Bank's bank cards, so a larger number of employees generally means that the bank card industry will develop better, so this paper selects the number of employees of each bank as a possible influencing factors.

3. Return on manpower input: Considering the special role of human resources in the process of banking card business operation, it may be biased to examine only the impact of the

number of employees, so this paper chooses the index of return on manpower input to represent the impact of employee efficiency on banking card business operation, in order to conduct an in-depth analysis from both quantitative and qualitative aspects.

4. Non-performing loan rate: credit card loans are an important source of business and income for commercial banks, and the ability to control loan quality is an important indicator of the profitability and sustainability of the company's loan business [18]. Non-performing loan rate can represent the ability of credit card business operation to a certain extent, so it is chosen as one of the possible influencing factors.

5. Business revenue share: Generally speaking, a larger share of banking business in a company's overall business module also generally means that it receives more resource support and is more conducive to operation and development [19]. Considering that the data of total revenue of banking card business is difficult to obtain, this paper chooses to measure the proportion of business revenue by the share of banking card fee revenue to total revenue and uses it as a possible influencing factor for regression analysis.

$$EF_{it} = \beta_0 + \beta_1 ROE_{it} + \beta_2 ST_{it} + \beta_3 ROP_{it} + \beta_4 NP_{it} + \beta_5 BP_{it} + \varepsilon_{it} \dots \dots (2)$$

In model (2), i and t denote firm and year, respectively, β is the coefficient, ε is the disturbance term, EF represents operating efficiency, ROE represents the return on net assets, ST represents the number of employees, ROP represents the return on human input, NP represents the non-performing loan rate, and BP represents the business revenue share. The statistical description of each variable is shown in Table 4.

Table 4: Descriptive statistics of influencing factors

Variable Name	Symbolic representation	Average value	Maximum value	Minimum value	Standard deviation
Return on Net Assets	ROE	14.15%	18.89%	9.28%	2.17%
Number of employees	ST	458788	3018100	7390	743565
Return on Manpower Investment	ROP	264%	369%	117%	61%
Non-Performing Loan Ratio	NP	1.39%	2.39%	0.75%	0.36%
Business revenue share	BP	5.16%	16.64%	0.29%	3.39%

5.2. Results of the empirical analysis

The results of the panel Tobit regression analysis using

STATA 15.0 software with each of the above data as explanatory variables are shown in Table 5.

Table 5: Panel Tobit regression results

Explanatory variables	Coefficient estimates	Standard error	t-value	P-value	Confidence interval
Return on Net Assets	0.0337077	0.0165807	2.03***	0.046	0.0006126~0.0668029
Number of employees	-0.0002265	0.0006789	-0.33	0.740	-0.0015816~0.0011286
Return on Manpower Investment	-0.1662051	0.155929	-1.07	0.290	-0.4774406~0.1450305
Non-Performing Loan Ratio	-2.37E-08	6.65E-08	-0.36	0.723	-1.56E-07~1.09E-07
Business revenue share	2.731043	1.252738	2.18***	0.033	0.2305669~5.231518
Constant term	0.1437569	0.2885444	0.5	0.62	-0.4321802~0.719694

From the results of Tobit regression, there is a significant positive relationship between the return on net assets, business income ratio and the operational efficiency of bank card business, which indicates that the ability of banking enterprises to utilize capital well represents their operational ability, and this operational ability brings about the stable operation of bank card business, while the business income ratio also well represents the importance of bank card business in the business segment of banks on the business

The positive impact of the importance of card business in the business segment on business efficiency. This may be due to the fact that the number of employees and the quality of human resources represented by the number of employees and the return on human investment are only the characteristics of banks in general, and the unique characteristics of the card business cannot be reflected by this data. The impact of the NPL ratio, which represents the non-performing ratio of the bank's overall lending business, is

mainly reflected in its impact on the bank as a whole, but has no direct impact on the credit card-related business operations.

6. Conclusions and Recommendations

In summary, this paper focuses on the operation and development of China's bank card industry, and selects panel data of 12 listed commercial banks for a total of 6 years from 2015 to 2020 for efficiency analysis, and uses the SBM model to deeply portray and explore the efficiency performance and time-series characteristics of each bank in the process of bank card industry operation, and finds that there is a large gap in the overall operation efficiency of China's bank card industry, and the efficiency gap between the traditional five major The efficiency gap between the traditional top five commercial banks and the emerging commercial banks is large, but the efficiency performance is relatively stable vertically. Subsequently, in view of the efficiency evaluation results, the possible influencing factors of bank card business operation were selected by considering the internal operating characteristics of banks, and it was found that the return on net assets and business income ratio were significantly and positively correlated with the operating efficiency of bank card business, while the number of employees, return on human investment and non-performing loan rate were not significantly correlated with the operating efficiency of bank card business.

Based on the results of theoretical and empirical analysis, this paper proposes the following three recommendations: first, different banking institutions of different sizes and types should choose different development strategies, such as the traditional five major banks have already gained a large market share and market reputation, they should strengthen the improvement of their existing business, enhance the live card rate, improve customer experience, and achieve stable development under the premise of stabilizing the market; while emerging joint-stock commercial banks and The new joint-stock commercial banks, urban commercial banks and agricultural commercial banks should specialize their bank card business and enhance their industrial competitiveness through new marketing methods and related services. Secondly, each bank should improve its own management ability and capital utilization efficiency, and pay more attention to the development of bank card business in order to realize the improvement of bank card business efficiency and bring more income to the company. Finally, in order to ensure the long-term and stable development of the bank card industry, the regulatory authorities should strengthen the regulation of the industry, improve laws and regulations, strengthen anti-money laundering checks and pay attention to the risks that may exist and be exposed in the integration of Internet companies, emerging technologies and the bank card industry, so as to prevent systemic risks and promote the long-term and stable development of the bank card industry.

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