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Evaluation of Commercial Banks' Comprehensive Competitiveness Based on Multivariate Statistical Analysis

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Abstract

This paper selects 13 domestic commercial banks as representatives, takes the relevant index data of each bank as the research object, and uses SPSS statistical analysis tools for factor analysis and cluster analysis. Based on the ranking of comprehensive factor scores and the classification of cluster analysis, the comprehensive competitiveness of each commercial bank was discussed comprehensively.

Keywords: commercial bank, factor analysis, cluster analysis

1. Introduction

The commercial banks have always been the pillar of China's financial system and are closely related to China's economic development, economic strength, and economic policies. It is inseparable from people's life and people's property. Therefore, it is particularly critical to explore the competitiveness of commercial banks.

In terms of commercial bank competitiveness evaluation, authoritative organizations such as Moody's, Standard & Poor's, and The Banker magazine in the UK use bank credit ratings or tier 1 capital as indicators. The evaluation results have important reference values, but lack of comprehensive analysis in these processes. In academia, most domestic and foreign scholars use the single factor analysis method or comprehensive evaluation method to evaluate the competitiveness of commercial banks.

Zhao Xin, Xue Junbo and Yin Kedong (2002) used an improved input-output DEA model and linear programming method to conduct empirical analysis on seven commercial banks (Zhao, X., Xue, J.-B., & Yin, K.-D., 2002). Wang Xue (2016) adopted AHP to study the financial competitiveness of listed banks (Wang, X., 2016). Lin Gui and Guo Peijun (2015) constructed an evaluation system based on 14 factors such as market share, profitability, growth ability, and security. They evaluated the competitiveness of 16 commercial banks in China by cluster analysis (Lin, G., & Guo, P.-J., 2015). Huang Yan (2014) used hierarchical clustering to classify the competitiveness of commercial banks, and pointed out the different types and characteristics of the competitiveness of different commercial banks (Huang, Y., 2014). Despite DEA model, analytic hierarchy process, cluster analysis and other methods can give an objective and comprehensive evaluation of the competitiveness of commercial banks, they cannot effectively reflect the factors that affect the competitiveness of banks. Whereas, the factor analysis method can not only obtain the ranking of the competitiveness of each bank, but also analyze the main influencing factors of competitiveness. It can draw the ranking of the banks on the main influencing factors, thus clearly revealing the strengths and weaknesses of the banks' competitiveness. Therefore, the factor analysis method is more widely applied in the evaluation of bank competitiveness in recent years. Zhu Hongjie(2016) conducted principal component factor analysis on 16 commercial banks in terms of growth ability, liquidity, capital adequacy, asset quality, and return performance (Zhu, H.-J., 2016). He Liang and Cao Qingyu (2018) used factor analysis to study the competitiveness of commercial banks from the perspectives of profitability, safety, liquidity and growth capabilities (He, L., & Cao, Q.-Y., 2018). Yuan Chong (2018) selected profitability, safety, and liquidity indicators to evaluate the competitiveness of 20 listed commercial banks by factor analysis (Yuan, C., 2018).

It can be discovered from previous surveys that factor analysis could more effectively analyze the competitiveness of commercial banks and point out their influencing factors. On this basis, it is possible to analyze the reasons for the bank's enhanced competitiveness and put forward practical suggestions. Nonetheless,

most of the evaluation factors selected in the analysis are financial indicators, leading to incomplete evaluation analysis. Furthermore, when there are excessive amounts of indicators in factor analysis, the evaluation results of the competitiveness of commercial banks will lack hierarchy, and the results will be affected by unrelated factors, making the analysis inaccurate.

In the present paper, we selected seven indicators from three aspects of profitability, asset security and growth ability, and used factor analysis and cluster analysis to comprehensively evaluate the competitiveness of commercial banks. The study is design to make up for the deficiencies in previous studies and improve the evaluation method of bank competitiveness, so as to more comprehensively assess the competitiveness of China's commercial banks.

2. Methods

This study consisted of two procedures. The first procedures uses factor analysis to rank the competitiveness of commercial banks and extracts three common factors. The second procedures was design to use cluster analysis to classify the competitiveness of commercial banks based on the common factors obtained in the previous step. The details of these research procedures are presented below in three subsections.

2.1 Indicators and Data

This article chooses three angles to comprehensively analyze the comprehensive competitiveness of each commercial bank. These three aspects are: profitability, asset security and growth ability.

In terms of profitability, two indicators are used to express the performance of banks in this regard, one is the rate of return on average assets (RROA), and the other is the return on equity(ROE) (Xu, X.-H., Yu, K.-J., & Xu, X.-S., 2012). RROA is a measure of the net profit generated per unit of assets. ROE is used to measure the efficiency of the company's use of its own assets. The higher the value of the index, the higher the return on investment, and the ability of its own capital to obtain net income.

In terms of asset security, three indicators including capital adequacy ratio(CAR), non-performing loan ratio, and provision coverage ratio were used to reflect the property security status of each bank. CAR is the ratio of a bank's total capital to its risk-weighted assets. It reflects the extent to which the bank can bear the losses with its own capital before the assets of depositors and creditors are lost. The NPL ratio is the proportion of the bank's non-performing loans to the total loan balance (Liu, T.-Y., & Xu, H., 2018). The higher the ratio, the more serious the negative impact on the profitability of the bank and the negative impact on its comprehensive competitiveness. This data is forward processed. The provision coverage ratio is the ratio of the use of the bank loan's dead debt and bad debt reserves. It examines whether the bank's finances are healthy and whether the risks are controllable.

In the investigation of the bank's growth ability, we choose the growth rate of deposits and the growth rate of loans to measure (Yu, L., & Hu, K.-M., 2013). The higher the deposit growth rate, the stronger the bank's ability to absorb deposits, and the lower the cost of funds. The higher loan growth rate also reflects the more sufficient the bank's capital reserves and the stronger its profitability.

In summary, this study will select seven indicators: rate of return on average assets, return on equity, capital adequacy ratio, NPL ratio, provision coverage ratio, deposit growth rate and loan growth rate to measure the competitiveness of various commercial banks. The relevant data of each indicator comes from the 2017 annual reports of various commercial banks. In addition, the commercial banks selected for the study include Industrial and Commercial Bank of China (ICBC), Agricultural Bank of China (ABC), Bank of China, China Construction Bank (CCB), Bank of Communications (BCM), China Merchants Bank, CITIC Bank, China EVERBRIGHT Bank, China Minsheng Bank (CMBC), Shanghai Pudong Development Bank (SPDB), Industrial Bank, Ping An Bank, and Hua Xia Bank .The raw data is shown in Table 1.

Table 1. Raw data of various indicators of various commercial banks in 2017

Bank name	RROA	ROE	CAR	NPL ratio	Provision coverage	Deposit growth rate	Loan growth rate
ICBC	1.14	14.35	15.14	1.55	154.07	7.90	9.00
ABC	0.95	14.57	13.74	1.81	208.37	7.70	10.30
Bank of China	0.98	12.24	14.19	1.45	159.18	5.55	9.26

CCB	1.13	14.80	15.50	1.49	171.08	8.65	9.75
BCM	0.81	11.40	14.00	1.50	153.08	4.27	8.63
China Merchants Bank	1.15	16.54	15.48	1.61	262.11	6.90	9.30
CITIC Bank	0.74	11.67	11.65	1.68	169.44	6.37	11.08
China EVERBRIGHT Bank	0.78	12.75	13.49	1.59	158.18	7.16	13.19
CMBC	0.86	14.03	11.85	1.71	155.61	-3.76	13.92
SPDB	0.92	13.28	12.02	2.14	132.44	1.20	15.63
Industrial Bank	0.92	15.35	12.19	1.59	211.78	14.55	16.87
Ping An Bank	0.75	11.62	11.20	1.70	151.08	4.09	15.48
Hua Xia Bank	0.82	13.53	12.37	1.76	159.11	4.80	14.60

2.2 Factor Analysis

Factor analysis uses several potential, unobservable random variables to describe the covariance or correlation between the original variables. The starting point is to use a small number of representative common factors to represent a larger part of the original amount of information, thereby simplifying the statistical observation range, and making the entire statistical analysis process more concise and clear.

The following is the mathematical model used in factor analysis:

$$X_i = \mu_i + a_{i1}f_1 + a_{i2}f_2 + a_{i3}f_3 + \varepsilon_i \qquad i=1, 2, ...7$$

Among them, μ_i is the average value of x_i; f_1, f_2, and f_3 indicate three factors, which become common factors. Each primitive variable can be approximated as different linear combinations of f_1, f_2, and f_3. a_{ij} is the factor load which is the load of the i-th original variable on the j-th variable. ε_i is a special factor, which means that the original variable cannot be explained by the factor variable.

This study uses SPSS for factor analysis. Factor analysis can be divided into the following steps: The first step is to extract eigenvalues and eigenvectors. The principle of factor extraction is: the initial eigenvalue should be greater than 1, and the cumulative variance contribution rate should be above 70%.The second step is to establish a factor loading matrix and name the common factor. The third step is to calculate the factor score and comprehensive score. The coefficient matrix can be used to obtain the score expression of each factor, and the factor scores of each commercial bank are calculated and ranked according to the expression.

2.3 Cluster Analysis

Based on the common factors obtained by factor analysis, we next perform cluster analysis. Cluster analysis refers to an analysis process that groups a set of objects into multiple classes composed of similar objects. The goal is to collect data for classification on a similar basis. The research uses K-means clustering method to classify the competitiveness of commercial banks. The purpose is to classify similar objects into the same cluster and further compare and analyze them to observe the distribution level more intuitively. The research tool used in the analysis is SPSS, and its research steps are shown below. **The first step** is to scan the samples one by one, and each sample is classified into the previous class or a new class is generated according to its distance from the scanned sample. **In the second step**, the types are merged according to the distance between the classes in the first step, and the merger is stopped according to certain standards. After cluster analysis, we can get the classification and ranking results of various commercial banks.

3. Results

The findings obtained from the study can be divided into two subsections: the comprehensive score and ranking of the competitiveness of each commercial bank using factor analysis, and the classification and ranking of commercial banks using K-means clustering analysis.

3.1 Results of Factor Analysis

In factor analysis, we first need to extract the common factor. The principle of factor extraction is: the initial eigenvalue should be greater than 1, and the cumulative variance contribution rate should be above 70%. Table 2

is the total variance interpretation of the data after SPSS processing. From this we can get that the eigenvalues of the first three factors after rotation are 2.453, 2.360, and 1.328 respectively, and the cumulative contribution rate is 87.730%. Therefore, we can basically use the first three factors to represent most of the data, and the data information they reflect is sufficient to describe the entire data level.

Table 2. Total variance explanation

	Initial eigenvalue			Extract load sum of squares			Sum of rotation load squares		
	total	Variance percentage	Accumulation %	total	Variance percentage	Accumulation %	total	Variance percentage	Accumulation %
1	3.551	50.733	50.733	3.551	50.733	50.733	2.453	35.042	35.042
2	1.599	22.840	73.574	1.599	22.840	73.574	2.360	33.717	68.758
3	.991	14.156	87.730	.991	14.156	87.730	1.328	18.972	87.730
4	.454	6.489	94.219						
5	.298	4.257	98.476						
6	.070	1.002	99.478						
7	.037	.522	100.000						

Extraction method: principal component analysis.

After extracting the common factors, we need to establish a factor loading matrix. In the factor loading matrix, it is likely that a variable requires multiple factors to explain together or a factor can explain multiple variables at the same time. In order to highlight the typical representative variables of each factor, we need to orthogonally rotate the factors using the maximum variance method, and output the rotated factor matrix in descending order of the first factor load. Table 3 is the rotated component matrix obtained by applying the SPSS tool (where the non-performing loan is the data after the non-performing loan rate is normalized).

From Table 3, we can see that the load of asset adequacy ratio and non-performing loan ratio is higher in the first factor, and these two indicators are variables describing asset security, so we can name the first factor as asset safety factor. In the second indicator, the load on average return on assets, return on net assets and provision coverage is higher. Because average return on assets and return on net assets are variables that describe profitability, the second factor can be described as a profitability factor. Among the three factors we can see that only the deposit growth rate load is higher than 0.7 is 0.898, and the deposit growth rate is a variable describing the bank's growth capacity, so the third factor is named the growth capacity factor.

Table 3. Rotated component matrix [a]

	ingredient		
	1	2	3
RROA	.562	.758	-.017
ROE	.017	.967	.119
Provision coverage	.049	.736	.455
CAR	.854	.449	.121
Deposit growth rate	.085	.269	.898
Loan growth rate	-.931	-.060	.011
Positive NPL ratio	.730	-.174	.535

Extraction method: principal component analysis.

Rotation method: Caesar's normalized maximum variance method[a]

a. The rotation has converged after 7 iterations.

After that, we can get the scoring expressions for each factor according to the component score coefficient matrix in Table 4 (note the variables as x_1, x_2, x_3, x_4, x_5, x_6, x_7 in the order presented in the table).

Table 4. Component scoring coefficient matrix

	ingredient		
	1	2	3
RROA	.179	.326	-.247
ROE	-.132	.478	-.083
Provision coverage	-.137	.288	.263
CAR	.339	.102	-.104
Deposit growth rate	-.126	-.046	.753
Loan growth rate	-.445	.084	.160
Positive NPL ratio	.296	-.288	.413

Extraction method: principal component analysis.

Rotation method: Caesar's normalized maximum variance method: Component score.

The factor score expression is:

$$F1=0.179*X_1-0.132*X_2-0.137*X_3+0.339*X_4-0.126*X_5-0.445*X_6+0.296*X_7$$

$$F2=0.326*X_1+0.478*X_2+0.288*X_3+0.102*X_4-0.046*X_5+0.084*X_6-0.288*X_7$$

$$F3=-0.247*X_1-0.083*X_2+0.263*X_3-0.104*X_4+0.753*X_5+0.160*X_6+0.413*X_7$$

We can get the score of each factor of each commercial bank according to the formula. After sorting the results, we can get the ranking of commercial banks under each factor. The score and ranking structure are shown in Table 5.

Table 5. Score and ranking of each factor

Bank name	F1	F1 Ranking	F2	F2 Ranking	F3	F3 Ranking
ICBC	1.27466	2	0.41485	5	-0.21989	11
ABC	-0.15658	7	0.90249	2	-0.01485	9
BANK OF CHINA	1.27650	1	-0.78547	10	0.17311	5
CCB	1.23311	3	0.58072	4	0.23250	4
BCM	1.13861	4	-1.37472	13	0.04968	8
China Merchants Bank	0.61853	5	2.15402	1	0.11201	6
CITIC Bank	-0.34888	8	-1.07792	12	0.44734	3
CHINA EVERBRIGHT BANK	-0.10672	6	-0.74351	9	0.60053	2
CMBC	-0.47851	9	0.04565	7	-1.71933	12
SPDB	-1.20626	12	0.33776	6	-1.81378	13
Industrial Bank	-1.42974	13	0.73625	3	2.23539	1
Ping An Bank	-0.99042	11	-1.06858	11	0.10922	7
Hua Xia Bank	-0.82430	10	-0.12154	8	-0.19194	10

According to the variance percentage and cumulative of the rotation load in Table 2, we can get the comprehensive score.

The comprehensive score formula is:

$$F=F1*35.042/87.73+F2*33.717/87.73+F3*18.972/87.73$$

We can get the comprehensive score of each commercial bank according to the formula. After sorting from large to small, we can get the comprehensive score of each commercial bank. The score and ranking structure are shown in Table 6.

Table 6. Comprehensive score and ranking

Bank name	Comprehensive score	Comprehensive ranking
China Merchants Bank	1.10	1
CCB	0.77	2
ICBC	0.62	3
ABC	0.28	4
BANK OF CHINA	0.25	5
Industrial Bank	0.20	6
BCM	-0.06	7
CHINA EVERBRIGHT BANK	-0.20	8
Hua Xia Bank	-0.42	9
CITIC Bank	-0.46	10
CMBC	-0.55	11
SPDB	-0.74	12
Ping An Bank	-0.78	13

Table 6 shows the comprehensive scores and rankings of various banks, some of which are negative, but do not mean that the overall competitiveness of the bank is negative. This is related to the standardization of the data and the selected indicators, indicating the bank's competitiveness is lower than average.

By performing factor analysis on the data, the results shown in Table 6 indicate that the top five are China Merchants Bank, China Construction Bank, Industrial and Commercial Bank, Agricultural Bank of China, and Bank of China. Their overall competitiveness is above average. Four of them are state-owned enterprises. Other joint-stock banks are ranked lower.

In addition, from the results in Table 5, it can be analyzed that among the three factors of asset security, profitability and growth ability, state-owned banks rank high in asset security and in the ranking of the other two influencing factors, joint-stock banks is more prominent.

3.2 Results of Cluster Analysis

After the previous factor analysis, we got three common factors. We use these three common factors for a K-means clustering method. The purpose of this is to make similar objects fall into the same cluster for further comparative analysis. Table 7 shows the results after k-means clustering.

Table 7. k-means clustering results

Bank name	Cluster	distance
China Merchants Bank	1	1.15082
ABC	1	0.90676
CCB	1	0.68534
ICBC	1	0.83800
CHINA EVERBRIGHT BANK	2	0.51643
BANK OF CHINA	2	1.11050
Ping An Bank	2	1.19735
CITIC BANK	2	0.57315
BCM	2	1.03770
INDUSTRIAL BANK	3	0.00000
SPDB	4	0.72585
CMBC	4	0.59828
Hua Xia Bank	4	1.07038

From Table 7, we can see that these 13 banks are divided into 4 categories. In the first category, there are three state-owned banks: China Construction Bank, Industrial and Commercial Bank, and Agricultural Bank of China. It is characterized by strong competitiveness. The second category includes Bank of China, Bank of Communications, China Everbright Bank, CITIC Bank and Ping An Bank. The second type is characterized by weak profitability. There is only one Industrial Bank in the third category. In terms of overall development, Industrial Bank is very similar to other joint-stock commercial banks. However, as can be seen from Table 5, among the 13 banks, the banks' profitability and growth ability are more prominent. This also makes it stand out from other joint-stock commercial banks and stands out. The fourth category includes SPD Bank, Minsheng Bank and Huaxia Bank. The development of these three banks is in line with the development characteristics of joint-stock commercial banks, but their profitability and growth capabilities are in a low ranking, and the overall comprehensive score is not high.

4. Discussion

In this study, I evaluated the competitiveness of 13 businesses through factor analysis and cluster analysis. In general, this study can draw the following conclusions: First, the competitiveness of state-owned banks is generally stronger than that of joint-stock banks. This conclusion is basically consistent with the research conclusions of domestic scholars such as Fang Xianming, Su Xiaozhang and Sun Li (2014). The second conclusion is that among asset security, profitability and growth ability, asset security has a greater impact on bank competitiveness. This is inconsistent with Zhao Biying (2019)'s conclusion that profitability is the most important influencing factor. But it is consistent with the research conclusions of other scholars such as Liu Chunyu and Zhang Han (2018). Third, the development of joint-stock banks in various aspects is uneven. Most joint-stock banks do not have strong competitiveness in development.

State-owned banks make full use of the advantages of state-owned holding, have sufficient funds and large scale, so the security of their assets is guaranteed to a certain extent (Xing Guan, 2016). In terms of profitability and growth ability, although the performance of state-owned banks has improved compared with the statistical analysis data of previous years, there is still room for continued improvement.

Two joint-stock commercial banks: China Merchants Bank and Industrial Bank, although their systems are the same, their development situation is not the same. China Merchants Bank, as the first joint-stock commercial bank in China wholly owned by a corporate legal person, has matured its system (Lu Yurong, & Tu Chunqiu, 2013). Judging from the separate scores of the three common factors, whether it is asset safety, profitability or growth ability, its scores are above the average level, so it is natural that the comprehensive competitiveness ranking is high. Industrial Bank was established relatively late, and it also lacks sufficient capital resources

compared with other state-owned banks. This can be seen from the factor score of asset security, which ranks last. But it ranks high on two other factor scores. This shows that Industrial Bank has strong profitability and growth ability, which has greatly enhanced its comprehensive strength.

In addition, most of the lower-ranked banks score below average in terms of asset security. This is a relatively weak part of joint-stock commercial banks (He Liang, & Cao Qingyu, 2018). In terms of profitability and growth ability, these banks have not shown strong advantages, which makes their comprehensive competitiveness weak. From this perspective, there are still many shortcomings in the development of joint-stock commercial banks.

Based on the above analysis, I can give three suggestions: First, state-owned banks need to continuously improve profitability and their own growth capabilities while ensuring the security of funds. Improve own management efficiency, optimize management system, make rational and scientific decision-making investments, and increase net profit. Introduce better wealth management products and continuously improve the ability to attract deposits. And continue to reduce the number of non-performing loans. Second, joint-stock commercial banks need to compensate for capital and increase the capital adequacy ratio. Having a higher capital reserve can effectively improve banks' own risk response capabilities and improve asset security. Third, joint-stock commercial banks need to continue to flourish and promote the overall growth of China's banking industry. Continuously enhance our profitability and improve our comprehensive strength. Carry out development and improvement of the bank's operating system.

Although there are many shortcomings in this research, we hope to help other scholars and companies. The development of China's banking industry depends on the improvement of the comprehensive strength of banks in various systems. Banks need to constantly find out their own shortcomings, improve all aspects of construction, and improve their capabilities.

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