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Research on Investment Value of Bank Stocks Based on Factor Analysis Model

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Research Article

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Abstract

Banks are directly affected by macroeconomic factors in China, with changes in these factors significantly impacting bank stock prices and the banks' operations and management. Due to differences in capital attributes, state-owned banks and non-state-owned banks exhibit various micro-level differences, leading to different reactions in their stock prices to macroeconomic changes. Consequently, the investment value analysis for banks with different attributes also differs. This paper conducts an empirical analysis of the investment value of bank stocks, primarily following these steps: first, conducting factor analysis on cross-sectional data to calculate the total variance explained by the factor analysis and the factor scores; second, calculating the common factors and composite scores for each quarter; and finally, using panel data and the improved TOPSIS-based factor analysis model to evaluate the stock investment value of 16 banks for the first, second, and third quarters of 2022. The results indicate a disparity in investment value between state-owned and non-state-owned banks, with an overall imbalance in investment value among these banks.

Keywords: Commercial Banks; Macroeconomics; Investment Value; TOPSIS; Factor Analysis

Abbreviations: KMO: Kaiser Meyer Olkin; CM: Commercial Banks; CSDF: Cross Sectional Data Factor Analysis.

Introduction

Macroeconomic factors refer to the various elements at the entire economic level that impact stock prices. From the perspective of the capital market, the macroeconomic factors influencing stock prices include macroeconomic policy factors, macro market factors, and other macro-level factors. According to regression analysis results by Sun Jingyu [1], there is a long-term equilibrium relationship between long-term stock price fluctuations and macroeconomic factors [1]. Schwert GW [2] proposed that macroeconomic factors affect stock returns by influencing the discount rate, companies' expected cash flows, and stock dividends [2]. By affecting the operating performance and profitability of listed companies, these factors, in turn, impact people's psychological expectations of stocks, thereby influencing stock prices. Abbas G, et al. [3] suggested that there is no significant difference in the correlation between returns and volatility of the Chinese stock market and macroeconomic variables. However, the stock market exhibits relatively strong directional return and volatility spill over effects on macroeconomic variables [3]. Kangxing Y and Xiaoyun L [4] noted that China's stock market is among the most volatile in the world. Conducting volatility analysis on it is crucial for the long-term stable and healthy development of China's stock market [4].

Jin Fang [5] suggested that Chinese stock prices, as typical representatives of financial assets, function as a barometer reflecting China's economic conditions. The trends and development of the stock market can reflect the state of the country's economic development, indicating that stock price fluctuations mirror the operations of the macroeconomy in China [5]. Zhang Xin [6] proposed that after more than twenty years of development, the Chinese stock market has become the core of modern finance [6]. Liu Jingyu [7] found that banks are the main components of China's financial system and the direct subjects of macroeconomic influences. Chinese commercial banks act as crucial bridges between the central bank and the resident enterprise sector, and changes in macroeconomic factors significantly impact the liquidity, safety, and profitability of banks [7]. According to Liu Jingyu [7] and Ben S, et al. [8] as of March 2022, the market value of Chinese bank stocks accounted for 20.26% of the market value of A-shares on the Shanghai and Shenzhen stock exchanges, making it the largest sector in terms of market value. Its fluctuations have a significant impact on the entire stock market. Additionally, within the banking industry, there are many micro-level differences between state-owned and non-state-owned banks due to differences in capital attributes.

Lin Wei [9] suggested that the rapid development of China's stock market has continuously updated social investment concepts and gradually become an important driving force for economic development [9]. Lu Wanfeng [10] proposed that the activity and volatility of the stock market also constitute potential factors that cause economic fluctuations [10]. Zhang Xingwang [9] indicated that an increasing number of investors are becoming more rational in their investment decisions and are paying more attention to the investment value analysis of enterprises [11]. Therefore, studying stock market volatility and exploring the causes of stock price changes hold significant theoretical and practical importance today.

Theoretically, China's banking sector is a market with Chinese characteristics, adapted to the country's economic conditions. Jianli W, et al. [12] proposed that the valuation system with Chinese characteristics emphasizes a deep understanding of the unique features of China's industries, institutional characteristics, and the sustainable development capabilities of enterprises. Therefore, China's state-owned commercial banks are more suitable for long-term value investment rather than short-term investment [12]. Zhong D, et al. [13] found a significant positive correlation between the effectiveness of monetary policy and the stock returns of real enterprises, a significant negative correlation between the level of financialization and the stock returns of real enterprises, and that the level of financialization significantly weakens the positive impact of monetary policy effectiveness on stock returns [13]. Cao L, et al. [14] demonstrated that the inflation rate has a significant negative impact on stock returns [14]. Based on the current economic context, this paper examines the impact of macroeconomic factors on the investment value of bank stocks by studying time series of stock returns [15] and empirical research on influencing factors [16-18] building on previous studies to provide a theoretical reference for future research.

Practically, through factor analysis of bank stock investment value [19-21] multiple linear regression [22], DuPont analysis [23] and the PEST model [24] investors can more accurately understand the structure and operating characteristics of the banking stock market, thereby making scientific and reasonable investment decisions. This provides investors with a practical tool for stock research, significantly enhancing the quality and performance of listed companies, and promoting healthy growth of enterprises. It also holds substantial practical significance for further improving and regulating China's securities market, promoting the efficient development of the country's capital market, and responding to international financial crises.

Methods

Data

Considering the requirements for data length, sample size, and data stability, this paper selects 16 banks listed on the Shanghai A-shares before 2016. These 16 banks are further divided into 5 state-owned banks and 11 non-state-owned banks. The 5 state-owned banks are Agricultural Bank of China, Bank of Communications, Industrial and Commercial Bank of China, China Construction Bank, and Bank of China. The 11 non-state-owned banks are Ping an Bank, Bank of Ningbo, Shanghai Pudong Development Bank, Huaxia Bank, China Minsheng Bank, China Merchants Bank, Bank of Nanjing, Industrial Bank, Bank of Beijing, China Everbright Bank, and China CITIC Bank. By analysing data from the first three quarters of 2022, the relevant sample data mainly come from each bank's quarterly data available in the Tonghuashun database.

Based on the factors influencing bank stock investment value, this paper constructs an index system from four aspects reflecting the growth ability, expansion ability, operating ability, and solvency of banks. It selects 11 indicators, including net profit, year-on-year growth rate of net profit, total operating income, growth rate of total operating income, basic earnings per share, earnings per share, capital reserve per share, undistributed profit per share, return on equity, diluted return on equity, and asset-liability ratio, to form a comprehensive evaluation index system of bank investment value [21] as shown in Table 1.

Before conducting factor analysis on the data, pre-processing is necessary. Firstly, among the 11 indicators, the asset-liability ratio is a negatively oriented indicator, while the rest are positively oriented indicators. Therefore, the asset-liability ratio needs to be positively oriented. The formula for positive orientation is $1/|X-X^{-}|$. Secondly, standardization processing is performed on individual time cross-section data.

Symbols	Explanations for each Symbol
x1	Net profit growth rate %
x2	Operating income growth rate %
x3	Return on equity %
x4	Return on equity diluted %
x5	Basic earnings per share (RMB)
x6	Net assets per share (RMB)
x7	Capital reserve per share (RMB)
x8	Undistributed earnings per share (RMB)
x9	Net profit (RMB)
x10	Operating income (RMB)
x11	Asset-liability ratio %

Table 1: Evaluation Index System of Bank Investment Value.

The Model

The basic idea of factor analysis is dimensionality reduction. This involves studying the internal structure of the correlation matrix of variables to identify a few key variables that can describe the relationships among multiple variables. Variables are then grouped based on the size of their correlations, with higher correlations within the same group and lower correlations between different groups. The aim is to synthesize the complex relationships of the variables into a smaller number of factors that represent the original variables' relationships with the factors. The specific steps are as follows:

1. Suppose there are n samples and m observations, and the original data is represented as matrix $V = (V_1,\cdots,V_m)$.
2. Standardize the original data to eliminate differences in scale among variables.
3. Construct the correlation matrix R of variables and perform principal component analysis on R.
4. Perform the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test to determine whether factor analysis is appropriate for the data.
5. Calculate the eigenvalues $\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_p$ and corresponding unit eigenvectors of R. Generally, select the number of common factors based on eigenvalues greater than 1 and cumulative variance contribution rate greater than 80%. Extract the first P eigenvalues and their corresponding eigenvectors to form the loading factor matrix A, $A=[A]_{m\times p}$.
6. Apply varimax orthogonal rotation to matrix A.
7. Compute factor scores.

Standard factor analysis typically applies to cross-sectional data only. Based on panel data and an improved factor analysis model incorporating Topsis [21], the calculation steps are as follows:

1. Establish the indicator system, with the set of objects under study denoted as S_{ti} (i=1,2,⋯,n), the set of indicators denoted as U_{tj} (j=1,2,⋯,m), and n representing the number of evaluation objects, $t\in[t_1,t_2]$. If the evaluation period spans years, then $I=t_1-t_2+1$.
2. Conduct factor analysis on Sti using cross-sectional data, obtaining the factor composite score $y_{t1}, y_{t2},\cdots,y_{tn}$ for each object set, where represents the time point, thus obtaining the $(Y_{ti})_{n\times l}$ matrix.
3. Apply the Topsis method to evaluate the final factor composite score (y_{ti}) of object set S_{ti} (i=1,2,⋯,n). The specific steps are as follows:

The factor analysis scores of cross-sectional data for each quarter serve as an evaluation indicator system for bank investment value. This forms a new indicator system, consisting of l indicators, n evaluation objects, and (y_{ti}) data points.

First, normalize the l indicators as shown in Equation 1:

$$Z_{ti}=\frac{Y_{ti}}{\sqrt{\sum_{i=1}^{n}Y_{ti}^2}} \tag{1}$$

Second, normalize the matrix, where the optimal and worst vectors are composed of the maximum and minimum values of each column, respectively, as shown in Equations 2 and 3 below.

$$Z^{+}=\left(Z_{max1},Z_{max2},\cdots,Z_{maxi}\right) \tag{2}$$

$$Z^{-}=\left(Z_{min1},Z_{min2},\cdots,Z_{minl}\right) \tag{3}$$

Third, the distance between the i_{th} evaluation object and the optimal/worst solutions is calculated as shown in Equations 4 and 5 below.

$$D_i^{+}=\sqrt{\sum_{j=1}^{l}\left(Z_{max1}-Z_{ji}\right)^2} \tag{4}$$

$$D_i^- = \sqrt{\sum_{j=1}^{l} \left(Z_{min1} - Z_{ji} \right)^2} \quad (5)$$

Fourth, the proximity degree C between the i_{th} evaluation object and the optimal/worst solutions is determined as shown in Equation 6 below.

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad (6)$$

If C_i is larger, it indicates that the investment value of the i_{th} bank from the first quarter to the third quarter of 2022 is higher; conversely, it indicates that the value is lower.

Empirical Analysis

Cross-Sectional Data Factor Analysis

1. The KMO (Kaiser-Meyer-Olkin) and Bartlett tests were conducted on the standardized data using SPSS software, and the results are shown in Table 2 below.

	Kaiser-Meyer-Olkin Statistic		0.581
First Quarter	Bartlett's sphericity test	Approximate Chi-Square	247.26
		Degrees of Freedom	55
		Associated Probability	0
	Kaiser-Meyer-Olkin statistic		0.531
Second Quarter	Bartlett's sphericity test	Approximate Chi-Square	204.131
		Degrees of Freedom	55
		Associated Probability	0
	Kaiser-Meyer-Olkin statistic		0.563
Third Quarter	Bartlett's sphericity test	Approximate Chi-Square	201.101
		Degrees of Freedom	55
		Associated Probability	0

Table 2: KMO and Bartlett Tests.

Generally, the KMO statistic should not be less than 0.5. As shown in Table 2, the KMO statistics for all three quarters are greater than the minimum requirement of 0.5. The accompanying probabilities for Bartlett's test are all 0, indicating a small probability event. Therefore, the hypothesis that the correlation matrix is an identity matrix is rejected, leading to the conclusion that there are significant correlations among the 11 factors. It is thus considered appropriate to conduct dimensionality reduction using factor analysis.

2. With the assistance of SPSS, factor analysis was conducted separately on the cross-sectional data for the first, second, and third quarters of 2022. The principal factor eigenvalues, contribution rates, and cumulative contribution rates are presented in Table 3 below.

Quarterly	Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
		Total	Variance (%)	Accumulated	Total	Variance (%)	Accumulated	Total	Variance (%)	Accumulated
First Quarter	1	5.483	49.848	49.848	5.483	49.848	49.848	3.923	35.665	35.665
	2	2.359	21.442	71.29	2.359	21.442	71.29	2.708	24.618	60.283
	3	1.561	14.195	85.485	1.561	14.195	85.485	2.614	23.762	84.045
	4	0.87	7.908	93.394	0.87	7.908	93.394	1.028	9.349	93.394
Second Quarter	1	4.932	44.839	44.839	4.932	44.839	44.839	3.089	28.078	28.078
	2	2.683	24.387	69.226	2.683	24.387	69.226	2.99	27.184	55.262
	3	1.516	13.786	83.012	1.516	13.786	83.012	2.435	22.139	77.401
	4	0.872	7.931	90.942	0.872	7.931	90.942	1.49	13.541	90.942

Third Quarter	1	5.192	47.202	47.202	5.192	47.202	47.202	3.359	30.538	30.538
	2	2.292	20.838	68.04	2.292	20.838	68.04	2.946	26.784	57.322
	3	1.64	14.91	82.95	1.64	14.91	82.95	2.664	24.219	81.541
	4	0.887	8.062	91.012	0.887	8.062	91.012	1.042	9.471	91.012

Table 3: Total Variance Explained by Cross-Sectional Data Factor Analysis.

From Table 3, it can be observed that through factor analysis, 11 eigenvalues were obtained. For the first quarter, the first eigenvalue is 5.483, explaining a variance contribution rate of 35.665%; the second eigenvalue is 2.359, explaining a variance contribution rate of 24.618%; the third eigenvalue is 1.561, explaining a variance contribution rate of 23.762%; and the fourth eigenvalue explains a cumulative variance contribution rate of 9.349%. At this point, the cumulative variance contribution rate reaches 93.394%, so the first four common factors are selected.

For the second quarter, the first eigenvalue is 4.932, explaining a variance contribution rate of 28.078%; the second eigenvalue is 2.683, explaining a variance contribution rate of 27.184%; the third eigenvalue is 1.516, explaining a variance contribution rate of 22.139%; and the fourth eigenvalue explains a cumulative variance contribution rate of 13.541%. At this point, the cumulative variance contribution rate reaches 90.942%, so the first four common factors are selected.

For the third quarter, the first eigenvalue is 5.192, explaining a variance contribution rate of 30.538%; the second eigenvalue is 2.292, explaining a variance contribution rate of 26.784%; the third eigenvalue is 1.64, explaining a variance contribution rate of 24.219%; and the fourth eigenvalue explains a cumulative variance contribution rate of 9.471%. At this point, the cumulative variance contribution rate reaches 91.012%, so the first four common factors are selected.

Factor	Component (Quarter 1)				Component (Quarter 2)				Component (Quarter 3)			
	1	2	3	4	1	2	3	4	1	2	3	4
zx1	-0.134	0.4	-0.082	-0.014	-0.12	0.408	0.004	-0.246	-0.142	0.391	0.015	0.088
zx2	-0.19	0.487	0.013	0.095	-0.137	0.426	0.058	-0.207	-0.224	0.373	-0.135	0.086
zx3	0.141	0.143	0.11	0.014	-0.027	0.234	0.025	0.196	0.012	0.247	0.057	-0.078
zx4	0.109	0.198	0.111	0.042	0.038	0.288	0.009	0.131	0.056	0.276	0.172	-0.026
zx5	0.295	-0.102	0.025	-0.019	0.294	-0.012	0.045	0.102	0.309	-0.037	0.053	-0.079
zx6	0.284	-0.136	-0.033	0.044	0.37	-0.106	0.039	-0.059	0.347	-0.157	-0.038	0.001
zx7	0.009	0.095	-0.25	0.072	0.073	0.129	-0.215	-0.15	0.049	0.059	-0.231	0.219
zx8	0.351	-0.202	0.035	-0.154	0.412	-0.153	0.097	0.024	0.377	-0.141	0.055	-0.088
zx9	0.077	0.019	0.407	0.042	0.086	0.068	0.474	-0.118	0.041	0.062	0.393	0.048
zx10	0.049	0.035	0.395	0.04	0.083	0.084	0.493	-0.195	0.02	0.051	0.379	0.044
zx11	-0.062	0.093	0.029	0.999	0.021	0.178	0.137	-0.745	-0.079	0.061	-0.015	0.968

Table 4: Factor Loadings Based on Cross-Sectional Data Factor Analysis.

In factor analysis, the larger the absolute value of the coefficient between a variable and a factor, the closer the relationship between the variable and that factor.

Analysing the coefficient matrices of the first, second, and third quarters, as shown in Table 4, it can be observed that: The first component primarily explains factors zx5, zx6 and zx8, corresponding to variables such as return on equity, basic earnings per share, net asset per share, and undistributed profits per share, reflecting primarily the bank's expansion capability [25]. The second component mainly interprets factors zx1, zx2, zx3 and zx4, corresponding to variables such as year-on-year growth rates of net profit, operating income, return on equity, and diluted return on equity, predominantly reflecting the bank's growth capability [26]. The third component mainly explains factors zx7, zx9 and zx10, corresponding to variables such as capital reserves per share, net profit, and operating income, primarily reflecting the bank's profitability [27]. The fourth component mainly explains factor zx11, corresponding to the variable asset-liability ratio, primarily reflecting the bank's solvency [28].

3. Based on the factor score results, calculate the scores of each common factor for each quarter.

Let F_i represent the scores of each bank on the common factors, and zx1, zx2, ⋯, zx11 represent the standardized data of each original indicator. Then, the formula for the first quarter is as follows:

$$\begin{cases} F_1 = -0.134_{ZX_1} - 0.19_{ZX_2} + \ldots + 0.049_{ZX_{10}} - 0.062_{ZX_{11}} \\ F_2 = 0.4_{ZX_1} + 0.487_{ZX_2} + \ldots + 0.035_{ZX_{10}} + 0.093_{ZX_{11}} \\ F_3 = -0.082_{ZX_1} + 0.013_{ZX_2} + \ldots + 0.395_{ZX_{10}} + 0.029_{ZX_{11}} \\ F_4 = -0.104_{ZX_1} + 0.095_{ZX_2} + \ldots + 0.04_{ZX_{10}} + 0.099_{ZX_{11}} \end{cases} \quad (7)$$

The formula for the second quarter is as follows:

$$\begin{cases} F_1 = -0.12_{ZX_1} - 0.137_{ZX_2} + \ldots + 0.083_{ZX_{10}} + 0.021_{ZX_{11}} \\ F_2 = 0.408_{ZX_1} + 0.426_{ZX_2} + \ldots + 0.084_{ZX_{10}} + 0.178_{ZX_{11}} \\ F_3 = 0.004_{ZX_1} + 0.058_{ZX_2} + \ldots + 0.493_{ZX_{10}} + 0.137_{ZX_{11}} \\ F_4 = -0.246_{ZX_1} - 0.207_{ZX_2} + \ldots - 0.195_{ZX_{10}} - 0.745_{ZX_{11}} \end{cases} \quad (8)$$

The formula for the third quarter is as follows:

$$\begin{cases} F_1 = -0.12_{ZX_1} - 0.224_{ZX_2} + \ldots + 0.02_{ZX_{10}} - 0.079_{ZX_{11}} \\ F_2 = 0.391_{ZX_1} + 0.373_{ZX_2} + \ldots + 0.051_{ZX_{10}} + 0.061_{ZX_{11}} \\ F_3 = 0.015_{ZX_1} - 0.135_{ZX_2} + \ldots + 0.379_{ZX_{10}} - 0.015_{ZX_{11}} \\ F_4 = 0.088_{ZX_1} + 0.086_{ZX_2} + \ldots + 0.044_{ZX_{10}} + 0.968_{ZX_{11}} \end{cases} \quad (9)$$

The calculation results are shown in Tables 5-7.

Name	F_1	F_2	F_3	F_4
Agricultural Bank of China	-0.70037	0.28689	1.38608	0.29419
Bank of China	-0.68389	-0.22873	0.88332	-0.3017
Bank of Communications	-0.73127	-0.07612	-0.22184	-0.1658
Industrial and Commercial Bank of China	-0.39125	0.01108	1.83784	-0.20062
China Construction Bank	-0.03757	0.27601	1.87477	-0.05961
Bank of Nanjing	-0.53902	2.11975	-0.54211	-0.13235
Bank of Beijing	-0.48275	-0.38122	-0.74553	-0.43284
China Everbright Bank	-0.85302	-0.74115	-0.49238	-0.40048
China Minsheng Bank	0.1261	-2.2985	-0.42682	-0.46182
Huaxia Bank	-0.48128	-0.99544	-1.25364	-0.39448
Bank of Ningbo	0.47704	1.36363	-1.13111	-0.14274
Shanghai Pudong Development Bank	0.17632	-0.3744	-0.33698	3.67981
China Merchants Bank	2.44156	-0.02958	0.43537	-0.48272
Ping An Bank	-0.1976	1.14731	-0.92313	-0.21375
Industrial Bank	2.32293	-0.06515	-0.07917	-0.23875
China Citic Bank	-0.44592	-0.01437	-0.26466	-0.34631

Table 5: First Quarter Factor Scores.

According to Table 5, in the first quarter, from the expansion capability factor (F_1), it can be observed that the top three are China Merchants Bank, Industrial Bank, and Ningbo Bank, while the bottom three are Agricultural Bank of China, Bank of Communications, and China Everbright Bank. From the growth capability factor (F_2), it is evident that the top three are Nanjing Bank, Ningbo Bank, and Ping An Bank, whereas the bottom three are China Everbright Bank, Huaxia Bank, and Minsheng Bank. From the profitability factor (F_3), the top three are China Construction Bank, Industrial and Commercial Bank of China, and Agricultural Bank of China, while the bottom three are Ping An Bank, Ningbo

Bank, and Huaxia Bank. From the debt-paying ability factor (F_4), it is apparent that the top three are Shanghai Pudong Development Bank, Agricultural Bank of China, and China Construction Bank, whereas the bottom three are Bank of Beijing, Minsheng Bank, and China Merchants Bank.

Name	F_1	F_2	F_3	F_4
Agricultural Bank of China	-0.86366	0.05514	1.19506	0.01957
Bank of China	-0.77864	0.15093	1.06925	0.39965
Bank of Communications	-0.699	-0.24812	-0.27337	0.08424
Industrial and Commercial Bank of China	-0.31275	-0.12737	2.00467	0.05393
China Construction Bank	-0.08159	0.00127	1.763	-0.10395
Bank of Nanjing	-0.61336	1.60967	-0.89457	1.29178
Bank of Beijing	-0.67177	-0.34465	-1.01939	0.55878
China Everbright Bank	-0.98058	-0.01715	-0.62838	0.76202
China Minsheng Bank	-0.00427	-2.43352	-0.72899	0.34138
Huaxia Bank	-0.06499	-0.85315	-1.00666	-0.20171
Bank of Ningbo	0.64025	1.68432	-0.93138	0.30896
Shanghai Pudong Development Bank	0.37167	-0.63575	-0.28324	-1.71239
China Merchants Bank	2.46332	0.38314	0.50918	1.37854
Ping An Bank	0.08836	1.33496	-0.33326	-2.65179
Industrial Bank	2.07679	-0.60368	-0.09402	-0.27419
China Citic Bank	-0.56977	0.04396	-0.34788	-0.25484

Table 6: Second Quarter Factor Scores.

According to Table 6, in the second quarter, from the expansion capability factor (F_1), it can be observed that the top three are China Merchants Bank, Industrial Bank, and Ningbo Bank, while the bottom three are Bank of China, Agricultural Bank of China, and China Everbright Bank. From the growth capability factor (F_2), it is evident that the top three are Ningbo Bank, Nanjing Bank, and Ping An Bank, whereas the bottom three are Shanghai Pudong Development Bank, Huaxia Bank, and Minsheng Bank. From the profitability factor (F_3), the top three are Industrial and Commercial Bank of China, China Construction Bank, and Agricultural Bank of China, while the bottom three are Ningbo Bank, Huaxia Bank, and Bank of Beijing. From the debt-paying ability factor (F_4), it is apparent that the top three are China Merchants Bank, Nanjing Bank, and China Everbright Bank, whereas the bottoms three are Industrial Bank, Shanghai Pudong Development Bank, and Ping An Bank.

Name	F_1	F_2	F_3	F_4
Agricultural Bank of China	-0.76268	0.06951	1.25849	-0.53494
Bank of China	-0.75935	-0.15417	0.8295	-0.60468
Bank of Communications	-0.57179	-0.18992	-0.16427	-0.26539
Industrial and Commercial Bank of China	-0.2216	-0.1946	2.04216	-0.55505
China Construction Bank	-0.26981	0.16871	1.75123	2.14514
Bank of Nanjing	-0.81781	1.65295	-0.76139	-0.52113
Bank of Beijing	-0.57561	0.29223	-0.77787	-0.90601
China Everbright Bank	-0.77975	-0.40504	-0.40087	-0.22814
China Minsheng Bank	0.07846	-1.8895	-0.37755	-0.6107
Huaxia Bank	-0.0706	-0.63697	-1.02854	0.12121

Bank of Ningbo	0.57383	1.26606	-1.03067	-0.28167
Shanghai Pudong Development Bank	0.18109	-1.96986	-1.02945	1.44148
China Merchants Bank	2.37918	0.38691	0.57812	-1.12181
Ping An Bank	-0.0054	1.50398	-0.55169	2.04127
Industrial Bank	2.30018	-0.02596	0.05556	0.29117
China Citic Bank	-0.67834	0.12568	-0.39276	-0.41074

Table 7: Third Quarter Factor Scores.

According to Table 7, in the second quarter, from the expansion capability factor (F_1), it can be observed that the top three are China Merchants Bank, Industrial Bank, and Ningbo Bank, while the bottom three are Agricultural Bank of China, China Everbright Bank, and Nanjing Bank. From the growth capability factor (F_2), it is evident that the top three are Nanjing Bank, Ping An Bank, and Ningbo Bank, whereas the bottom three are Huaxia Bank, Minsheng Bank, and Shanghai Pudong Development Bank. From the profitability factor (F_3), the top three are Industrial and Commercial Bank of China, China Construction Bank, and Agricultural Bank of China, while the bottom three are Huaxia Bank, Shanghai Pudong Development Bank, and Ningbo Bank. From the debt-paying ability factor (F_4), it is apparent that the top three are China Construction Bank, Ping An Bank, and Shanghai Pudong Development Bank, whereas the bottom three are Minsheng Bank, Bank of Beijing, and China Merchants Bank.

1. The comprehensive evaluation score F can be obtained by weighting the contribution rates of each main factor's variance relative to the cumulative contribution rate of the four main factors and summing them up. The formula for the first quarter is as follows:

$$F = \frac{(35.665F_1 + 24.618F_2 + 23.762F_3 + 9.349F_4)}{93.349} \quad (10$$

The formula for the second quarter is as follows:

$$F = \frac{(28.078F_1 + 27.184F_2 + 22.139F_3 + 13.541F_4)}{90.942} \quad (11)$$

The formula for the third quarter is as follows:

$$F = \frac{(30.538F_1 + 26.784F_2 + 24.219 + 9.471F_4)}{91.012} \quad (12)$$

Finally, the comprehensive evaluation scores of cross-sectional factor analysis for the first quarter, second quarter, and third quarter are obtained, as shown in Table 8 below.

Sample Banks	First Quarter	Second Quarter	Third Quarter
Agricultural Bank of China	0.19027	0.04367	0.043773
Bank of China	-0.12692	0.124519	-0.14235
Bank of Communications	-0.37236	-0.34399	-0.31908
Industrial and Commercial Bank of China	0.301024	0.361415	0.354051
China Construction Bank	0.529431	0.388897	0.648366
Bank of Nanjing	0.201735	0.266351	-0.0448
Bank of Beijing	-0.51785	-0.47539	-0.40842
China Everbright Bank	-0.68648	-0.34739	-0.51125
China Minsheng Bank	-0.71254	-0.85537	-0.69376
Huaxia Bank	-0.80463	-0.55018	-0.47223
Bank of Ningbo	0.239538	0.520412	0.261549
Shanghai Pudong Development Bank	0.251266	-0.3992	-0.64289
China Merchants Bank	0.987026	1.204282	0.949274
Ping An Bank	-0.0293	-0.04965	0.506407
Industrial Bank	0.825856	0.397037	0.809242
China Citic Bank	-0.27608	-0.28541	-0.33788

Table 8: Comprehensive Scores of Cross-Sectional Factor Analysis for the First, Second, and Third.

According to Table 8, the top three banks in terms of composite factor scores for the first quarter are Industrial and Commercial Bank of China, Agricultural Bank of China, and China Construction Bank, while the bottom three are China Merchants Bank, Bank of Communications, and Bank of China; for the second quarter, the top three banks are Industrial and Commercial Bank of China, China Construction Bank, and Agricultural Bank of China, while the bottom three are China Merchants Bank, Bank of China, and Bank of Communications; and for the third quarter, the top three banks are Industrial and Commercial Bank of China, China Construction Bank, and Agricultural Bank of China, while the bottom three are China Merchants Bank, Bank of Communications, and Bank of China.

Based on Panel Data and Topsis-Improved Factor Analysis

Luo G, et al. [29] and Xiao Hongfei [30] calculated the evaluation results of stock investment value for 16 banks in the first, second, and third quarters of 2022 using a factor analysis model based on panel data and Topsis improvement, as shown in Table 9.

Sample Banks	C_i	Ranking	Attributes
China Merchants Bank	1	1	Non-state-owned bank
Industrial Bank	0.750794	2	Non-state-owned bank
China Construction Bank	0.69617	3	State-owned bank
Bank of Ningbo	0.617868	4	Non-state-owned bank
Industrial and Commercial Bank of China	0.611149	5	State-owned bank
Bank of Nanjing	0.510158	6	Non-state-owned bank
Ping An Bank	0.494165	7	Non-state-owned bank
Agricultural Bank of China	0.476763	8	State-owned bank
Bank of China	0.409926	9	State-owned bank
Shanghai Pudong Development Bank	0.324161	10	Non-state-owned bank
CITIC Bank	0.267623	11	Non-state-owned bank
Bank of Communications	0.240862	12	State-owned bank
Bank of Beijing	0.17432	13	Non-state-owned bank
Everbright Bank	0.170748	14	Non-state-owned bank
Huaxia Bank	0.1164	15	Non-state-owned bank
Minsheng Bank	0.028214	16	Non-state-owned bank

Table 9: Evaluation Results of Stock Investment Value for 16 Banks.

According to Table 9, among the 16 banks, the top three are Industrial and Commercial Bank of China, China Construction Bank, and Agricultural Bank of China, while the bottom three are Bank of Communications, Shanghai Pudong Development Bank, and China Merchants Bank. Among the top three banks, two are state-owned banks, while among the bottom three banks, all are non-state-owned banks. The ranking of state-owned banks among the 16 banks is 3rd, 5th, 8th, 9th, and 12th, corresponding to China Construction Bank, Industrial and Commercial Bank of China, Agricultural Bank of China, Bank of China, and Bank of Communications, respectively.

Conclusion

Firstly, the higher the score the stronger the bank's growth capability, expansion capability, profitability and debt-paying capability indicating a more robust operation and hence greater investment value. Based on the scores of the main factors in each quarter, it can be observed that, in terms of expansion capability, China Merchants Bank, Industrial Bank, and Bank of Ningbo have relatively high scores, indicating strong expansion capabilities for these three banks. Regarding growth capability, Bank of Ningbo, Bank of Nanjing, and Ping An Bank have relatively high scores, suggesting promising future development potential. In terms of profitability, Industrial and Commercial Bank of China, China Construction Bank and Agricultural Bank of China have high scores, indicating strong profitability. Regarding debt-paying capability, China Construction Bank, Shanghai Pudong Development Bank, and Agricultural Bank of China have high scores, indicating good capital turnover and strong debt-paying capability for these three banks.

Secondly, non-state-owned banks have higher scores in terms of expansion capability and growth capability, while state-owned banks have higher scores in terms of profitability and debt-paying capability. This indicates that non-state-owned banks have good development potential, while state-owned banks are more stable and secure in their development.

Thirdly, according to the evaluation of stock investment value, the stock investment value of the 16 banks in the first three quarters of 2022 is generally not high and varies greatly. China Merchants Bank, Industrial Bank, and China Construction Bank rank in the top three indicating that the overall operating capacity of banks is good and has high investment value. On the other hand, China Everbright Bank, Huaxia Bank and Minsheng Bank rank at the bottom three suggesting that their investment value needs improvement and requires cautious investment. Among the 16 banks, China Merchants Bank is the most investment-worthy, while Minsheng Bank is the least investment-worthy.

In conclusion, from an overall perspective, the stock investment value of state-owned banks and non-state-owned banks varies greatly, indicating an imbalance in the investment value between state-owned banks and non-state-owned banks.

Conflict of Interest

We have no conflict of interests to disclose and the manuscript has been read and approved by all named authors.

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