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Combining CRITIC and TOPSIS methods for studying on financial performance evaluation in China's banking industry

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ABSTRACT: Banks today, after centuries of evolution, hold a crucial position in the global economy, becoming indispensable players in economic operations. The banking sector faces escalating risks and challenges amid severe economic conditions domestically and internationally. Evaluating banks' financial performance using scientific methods is imperative for industry advancement. This study assesses banks' financial performance focusing on asset quality, profitability, and development capacity, employing CRITIC and TOPSIS techniques. Findings reveal asset quality as pivotal, followed by profitability and development capacity. Moreover, China Merchants Bank (CMB) demonstrates superior financial performance, with recommendations for enhancing its financial standing.

KEYWORDS: Bank industry; financial performance; CRITIC; TOPSIS; China Merchants Bank (CMB).

I. INTRODUCTION

In today's era of globalization, the banking sector stands as a crucial component of the economy. Its robust and steady growth is vital for fostering economic advancement and upholding financial stability [18]. Since 2023, the global energy crisis, rising inflation, geopolitical tensions, and complex economic conditions, both domestically and internationally, have brought significant shifts to the operational landscape of the global banking sector. The widespread availability of domestic financial services has spurred the rise of Internet finance and the marketization of interest rates. China's strategic economic adjustments, including a more cautious macro-assessment approach, stringent regulatory measures, and the intermittent entry of foreign banks into the Chinese financial market, have exposed banks to heightened risks and challenges amid escalating market competition and evolving financial conditions. Consequently, it is imperative to employ scientific methodologies to effectively assess the financial performance of banks [5].

As the domestic financial market gradually opens and improves, a variety of banks, including urban commercial banks, joint-stock banks, and large state-owned banks, coexist and play a crucial role in advancing local economic development, catering to small and medium-sized enterprises, and addressing the diverse financial requirements of the populace [1,3]. Nonetheless, these banks vary significantly in terms of capital scale. Therefore, it is imperative to choose suitable evaluation indicators and decision-making models based on the specific characteristics of each type of bank to assess their financial performance effectively.

Financial performance evaluation serves not only as a crucial tool for assessing bank operational outcomes but also as a vital instrument for enhancing bank management proficiency and refining resource allocation. Conventional methods of financial performance evaluation typically center on individual financial metrics or basic ratio analyses, which may fail to capture the holistic operations of banks [7]. Hence, the adept utilization of multi-criteria decision-making (MCDM) techniques can offer a fresh outlook and methodological approach to appraising the financial performance within the banking sector. Applying MCDM methods is particularly suitable and efficacious in enhancing decision-making quality when dealing with multiple indicators, thereby enabling a comprehensive assessment of the banking industry's financial performance. This study amalgamates the current research landscape on domestic banking financial performance, establishes a scientifically grounded comprehensive benefit evaluation index framework from a novel standpoint, and integrates its findings with bank financial performance for empirical exploration. This endeavor holds significant theoretical and practical implications for the application of this methodology.

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This study combines the CRITIC and TOPSIS methodologies to address the complex decision-making task of evaluating the financial performance of domestic banks. The CRITIC method leverages objective data to ascertain objective weights, while TOPSIS analysis evaluates the proximity of each alternative to the ideal solution based on the objective data, facilitating decision-making. The findings of this analysis can enhance investors' comprehension of banks' operations and offer valuable insights for regulatory authorities.

II. THE EVALUATIVE INDEX FRAMEWORK FOR FINANCIAL PERFORMANCE

Financial performance evaluation involves analyzing a company's financial situation and operational performance. To begin, it is essential to identify the industry and characteristics of the company being assessed. Subsequently, appropriate and representative financial indicators should be selected and analyzed methodically. The results should then be used to evaluate the company's performance. This process enables a comprehensive assessment of the company's financial performance and identification of key factors influencing it. Through this evaluation, a clear understanding of the company's financial standing at its current developmental stage can be achieved. This understanding equips managers with valuable insights to enhance company management and decision-making [2].

Based on scientific rigor, objectivity, rationality, and a blend of qualitative and quantitative analyses, the evaluation index system for assessing the financial performance of the banking industry has been developed. Drawing insights from the specific characteristics of the banking sector's financial operations and supported by pertinent literature [4,6,11,15-16], as well as expert consultations, a comprehensive evaluation framework has been established through a meticulous process of screening, synthesis, and literature review (refer to Table 1). Financial performance is assessed based on three main dimensions: profitability, asset quality, and development capability. In terms of profitability, the key metrics considered are Return on Equity (ROE) and the cost-to-income ratio, as identified in the literature. For asset quality evaluation, criteria such as the capital adequacy ratio, provision coverage ratio, and non-performing loan ratio are crucial factors. Similarly, the assessment of development capability focuses on indicators like the net asset growth rate and net profit growth rate. These dimensions and criteria are structured into a hierarchical system comprising three levels: the top level representing the overall target, the second level encompassing three dimensions, and the third level detailing seven specific attributes. These indicators are characterized by their clarity, analytical robustness, and representational significance.

Table 1: The evaluative index of financial performance for China's bank industry

Evaluative dimension	Evaluative criteria	Code
Profitability (A)	Return on equity (ROE)	A1
	Cost-to-income ratio	A1
	Capital adequacy ratio	B1
Asset quality (B)	Provision coverage	B2
	Bad loan ratio	B3
Develop capacity (C)	Net asset growth rate	C1
	Net profit growth rate	C2

Bank financial performance evaluation is a comprehensive system employing various indicators, models, and methods to assess the performance and risks of commercial banks [14]. This system offers crucial benchmarks for enhancing operations and performance, serving as an effective guide for shareholders, managers, and regulators.

III. RESEARCH METHODS

3.1 CRITIC Method

The CRITIC method, introduced by Diakoulaki, is an objective approach to distributing values [8]. This method involves objectively assigning weights to indicators based on correlation coefficients and standard deviations. By prioritizing indicators through correlation and weight comparisons, the CRITIC method offers a thorough evaluation technique. As a performance-based weighting method, it operates solely on empirical data, eliminating the need for subjective input from decision-makers. This objectivity minimizes potential biases in evaluation processes [13]. The procedural steps associated with the CRITIC method are outlined below.

Step 1. Construct the initial assessment matrix X, where X is a data matrix comprising n assessment objects and m assessment attributes.

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Here, x_{ij} represents the recorded value of the *i*th object for the *j*th attribute.

Step 2. Normalization of the decision matrix, which is carried out through the following formula.

$$x_{ij} = \frac{x_j - x_{\min}}{x_{\max} - x_{\min}} \quad (1)$$

Step 3. Calculate the standard deviation of each criterion. In this step, the standard deviation of each criterion, S_j, is calculated using Equation (2).

$$S_j = \sqrt{\frac{\sum_{i=1}^{n}(x_{ij} - \bar{x}_j)^2}{n-1}} \quad (2)$$

Step 4. Calculate the distance correlation of every pair of criteria. In this here, the conflicting relationships between criteria are captured with the help of the Pearson correlation. Therefore, the sum shown in formula (3) represents a measure of the conflict created by criterion j with respect to the decision situation defined by the rest of criteria.

$$R_j = \sum_{i=1}^{m}(1 - r_{ij}) \quad (3)$$

Step 5. Compute the information content (C_j). The amount of information contained in criterion *j* is calculated by applying Equation (4).

$$C_j = S_j \sum_{i=1}^{m}(1 - r_{ij}) = S_j \times R_j \quad (4)$$

Step 6. Determine the objective weights (W_j). The objective weight of criterion *j* is determined using Equation (5).

$$W_j = C_j / \sum_{j=1}^{m} C_j \quad (5)$$

where W_j is the objective weights of C_j.

Hence, the CRITIC method is a suitable approach for determining indicator weights as it considers the impact of variation within indicators on the weights and the conflicts between them [13]. When conflicts between indicators are minimal, it indicates a higher similarity in the information they reflect. With a larger number of evaluation indicators, some indicators with stronger positive correlations can be reduced to streamline computations without significantly affecting evaluation outcomes. Likewise, indicators with low variability can be omitted from the process.

3.2 TOPSIS Method

TOPSIS (Technique for order preference by similarity to ideal solution) is based upon the concept of choosing an alternative that have a shortest distance from positive ideal solution (PIS) and the farthest from negative ideal solution (NIS). The criteria are classified into two categories which include the benefit and cost. The benefit criterion means it has the characteristics that the performance of the alternative is better when the value of the alternative versus a benefit criterion is larger. Cost criterion has the characteristics that the performance of the alternative is better when the value of alternative versus a cost criterion is smaller [12]. Once the weights of criteria are obtained, the TOPSIS method can be proposed for conducting the ranking process.

Its relevant steps are shown as the following [9]:

Step 1. Normalize the original evaluation matrix.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, \quad i = 1,2,...,m; \quad j = 1,2,...,n \quad (6)$$

Step 2. Calculate the weighted normalized decision matrix.

$$v_{ij} = w_j \times r_{ij} \quad (7)$$

Step 3. Determine the PIS and NIS.

$$\begin{aligned} A^+ &= (\max_i r_{i1}, \max_i r_{i2}, \ldots, \max_i r_{in}) \\ &= (A_1^+, A_2^+, \ldots, A_n^+) \\ A^- &= (\max_i r_{i1}, \max_i r_{i2}, \ldots, \max_i r_{in}) \\ &= (A_1^-, A_2^-, \ldots, A_n^-) \end{aligned} \quad (8)$$

Step 4. Calculate the separation measure for each bank.

$$\begin{aligned} S_i^+ &= \left[\sum_{j=1}^{n}(v_{ij} - A_j^+)\right]^{1/2}, \quad i = 1,2,...,m \\ S_i^- &= \left[\sum_{j=1}^{n}(v_{ij} - A_j^-)\right]^{1/2}, \quad i = 1,2,...,m \end{aligned} \quad (9)$$

Step 5. Calculate the relative closeness for the ideal solution.

$$C_i = \frac{S_i^-}{(S_i^+ + S_i^-)}, \quad 0 \le C_i \le 1 \quad i = 1,2,...,m \quad (10)$$

Select the option with C_i close to 1 since it means the distance is closer to the positive ideal solution.

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Step 6. Rank the preference order. The best (optimal) alternative can be decided according to the preference rank order of C_i.

IV. EMPIRICAL ANALYSIS

The study focuses on the domestic banking industry, specifically analyzing China Construction Bank (CCB), Bank of China (BOC), China Merchants Bank (CMB), Agricultural Bank of China (ABC), Ping An Bank (PAB), and Industrial and Commercial Bank of China (ICBC). The research period spans from 2020 to 2022, encompassing three years of financial data extracted from the stock market listings, as presented in Table 2. The data was obtained and analyzed using the RESSET database. The selection of these six banks was based on the following criteria:

(1) The Bank's system is comprehensive and well-organized, ensuring the credibility of its information.

(2) The financial data of the bank has been audited by a certified accountant and is under the supervision of the China Securities Regulatory Commission and the stock exchange, further enhancing the reliability of the disclosed information.

(3) The selection of listed companies on the Shanghai and Shenzhen stock exchanges guarantees the sample's representativeness and credibility.

(4) By choosing financial statements from the past three years, the continuity and stability of the information are maintained, providing a better reflection of the enterprise's changes and development trends during this period.

Table 2: Raw data for six banks, 2020-2022

	A1	A2	B1	B2	B3	C1	C2	Years
CCB	11.4618	1.6184	6.7028	213.59	17.06	25.12	1.56	2020
BOC	9.4617	1.5875	10.0836	177.84	16.22	26.73	1.46	2020
CMB	13.4497	4.8553	18.3950	437.68	16.54	33.30	1.07	2020
ABC	9.7935	1.6325	13.1616	260.64	16.59	29.23	1.57	2020
PAB	7.9444	2.5998	16.3421	201.40	13.29	29.11	1.18	2020
ICBC	10.9178	1.3799	8.1204	180.68	16.88	22.30	1.58	2020
CCB	11.688	11.0933	9.4478	239.96	17.85	27.43	1.42	2021
BOC	9.7323	10.8452	9.1607	187.05	16.53	28.17	1.33	2021
CMB	13.9648	23.3516	18.6522	483.87	17.48	33.12	0.91	2021
ABC	9.9885	11.8004	9.5164	299.73	17.13	30.46	1.43	2021
PAB	9.1886	25.6084	8.6005	288.42	13.34	28.30	1.02	2021
ICBC	10.6926	10.24	12.5887	205.84	18.02	25.97	1.42	2021
CCB	11.3368	6.3298	10.374	241.53	18.42	28.12	1.38	2022
BOC	9.3689	4.4713	9.0976	188.73	17.52	27.88	1.32	2022
CMB	14.5967	15.2772	10.1029	450.79	17.77	32.88	0.96	2022
ABC	9.7114	6.9241	10.5113	302.6	17.20	31.63	1.37	2022
PAB	10.4712	25.2642	9.9209	290.28	13.01	27.45	1.05	2022
ICBC	10.3137	3.0901	7.2877	209.47	19.26	25.01	1.38	2022

4.1 CRITIC method to determine weights

Step 1. The data is normalized and the processed data is shown in Table 3.

Step 2. Calculate the variability of the criterion for S.D. of the S_j, then the results of the variability of the criterion is shown in Table 4.

Table 4: The variability of criterion

	2020	2021	2022
A1	0.3438	0.3648	0.3641
A2	0.3535	0.4567	0.3836
B1	0.3971	0.3832	0.3766
B2	0.3806	0.3532	0.3603
B3	0.3728	0.3722	0.3485
C1	0.3460	0.4427	0.3689
C2	0.4365	0.3618	0.4479

Step 3. Calculate the conflict of the criterion, the results are shown in Table 5.

Table 5: The conflict of criterion

	2020	2021	2022
A1	3.9228	3.4236	4.5427
A2	3.9520	5.8226	6.2383

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B1	4.9230	3.4949	4.7685
B2	3.3223	3.9613	4.2407
B3	5.5423	5.1531	6.7732
C1	4.2891	8.8081	4.1479
C2	8.8473	3.6397	8.5141

Step 4. Calculate the information content, the results are shown in Table 6.

Step 5. Calculate the weight value of each criterion, and the weight value of the criterion is shown in Table 7.

Table 3: Post-Normalization data for six banks, 2020-2022

	A1	A2	B1	B2	B3	C1	C2	Years
CCB	0.6389	0.0686	0.0000	0.1376	1.0000	0.2564	0.9608	2020
BOC	0.2756	0.0597	0.2892	0.0000	0.7772	0.4027	0.7641	2020
CMB	1.0000	1.0000	1.0000	1.0000	0.8621	1.0000	0.0000	2020
ABC	0.3359	0.0727	0.5524	0.3187	0.8753	0.6300	0.9804	2020
PAB	0.0000	0.3510	0.8244	0.0907	0.0000	0.6191	0.2157	2020
ICBC	0.5401	0.0000	0.1212	0.0109	0.9523	0.0000	1.0000	2020
CCB	0.5233	0.0555	0.0843	0.2042	0.9637	0.9808	0.1783	2021
BOC	0.1138	0.0394	0.0557	0.3077	0.6816	0.8077	0.0000	2021
CMB	1.0000	0.8532	1.0000	1.0000	0.8846	0.0000	1.0000	2021
ABC	0.1675	0.1015	0.0911	0.6280	0.8098	1.0000	0.3796	2021
PAB	0.0000	1.0000	0.0000	0.3259	0.0000	0.2115	0.3415	2021
ICBC	0.3149	0.0000	0.3968	0.0000	1.0000	0.9808	0.0633	2021
CCB	0.3764	0.1461	0.9574	0.2015	0.8656	0.3952	1.0000	2022
BOC	0.0000	0.0623	0.5615	0.0000	0.7216	0.3647	0.8571	2022
CMB	1.0000	0.5496	0.8733	1.0000	0.7616	1.0000	0.0000	2022
ABC	0.0655	0.1729	1.0000	0.4345	0.6704	0.8412	0.9762	2022
PAB	0.2109	1.0000	0.8169	0.3875	0.0000	0.3100	0.2143	2022
ICBC	0.1807	0.0000	0.0000	0.0791	1.0000	0.0000	1.0000	2022

Table 6: The information content

	2020	2021	2022
A1	1.3485	1.2488	1.6539
A2	1.5155	2.6589	2.3931
B1	1.9548	1.3393	1.7958
B2	1.2645	1.3390	1.5278
B3	2.0659	1.9181	2.3602
C1	1.4839	3.8992	1.5302
C2	3.8614	1.3168	3.8134

Table 7: The weight for criterion

	2020	2021	2022
A1	9.99%	9.06%	10.97%
A2	11.00%	28.30%	10.15%
B1	14.49%	9.72%	11.91%
B2	11.23%	19.30%	15.88%
B3	15.31%	13.92%	15.66%
C1	9.37%	10.15%	10.14%
C2	28.61%	9.56%	25.30%

4.2 Ranking with TOPSIS method

Step 1. Multiply the normalized data in Table 3 by the weight values in Table 7 to obtain the weight moments v_{ij}.

Step 2. Calculate the positive ideal solution (A^+) and negative ideal solution (A^-) of the data.

Step 3. Calculate the distances between the ith evaluative bank and the positive ideal solution (A^+) and the negative ideal solution (A^-), S_i^+ and S_i^- the results are shown in Table 8.

Table 8. Distance between evaluative bank and PIS and NIS

2020	S_i^+	S_i^-
CCB	0.3408	0.1859
BOC	0.2946	0.1599
CMB	0.1120	0.3894
ABC	0.3277	0.1677
PAB	0.2347	0.2608
ICBC	0.3485	0.1912
2021	S_i^+	S_i^-
CCB	0.3562	0.1645
BOC	0.3292	0.1492

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CMB	0.1010	0.3877
ABC	0.3565	0.1448
PAB	0.2153	0.3034
ICBC	0.3632	0.1724
2022	S_i^+	S_i^-
CCB	0.3093	0.1944
BOC	0.3122	0.1510
CMB	0.1305	0.3449
ABC	0.3193	0.1681
PAB	0.2007	0.2849
ICBC	0.3467	0.1878

Step 4: Calculate the relative closeness (C_i) of the data, and rank the schemes according to the relative closeness value. The results are shown in Table 9.

Table 9: Ranking results under TOPSIS

2020	Relative closeness	Ranking
CCB	0.3529	4
BOC	0.3518	5
CMB	0.7767	1
ABC	0.3385	6
PAB	0.5263	2
ICBC	0.3543	3
2021	Relative closeness	Ranking
CCB	0.3159	4
BOC	0.3119	5
CMB	0.7934	1
ABC	0.2889	6
PAB	0.5849	2
ICBC	0.3219	3
2022	Relative closeness	Ranking
CCB	0.3860	3
BOC	0.3260	6
CMB	0.7255	1
ABC	0.3448	5
PAB	0.5867	2
ICBC	0.3514	4

4.3 The analysis results

Table 7 reveals that in evaluating the financial performance of the domestic banking industry in 202, the non-performing loan ratio, capital adequacy ratio, and net asset growth rate are the most influential indicators, with the non-performing loan ratio carrying the highest weight at 28.61%. In 2021, the cost-income ratio, net profit growth rate, and capital adequacy ratio are the primary indicators. For 2022, the key indicators are the non-performing loan ratio, net profit growth rate, and capital adequacy ratio. Consequently, from 202 to 2022, the capital adequacy ratio, non-performing loan ratio, and net profit growth rate consistently emerge as the most impactful indicators in assessing the financial performance of the domestic banking sector. The capital adequacy ratio is a key metric that reflects a bank's capacity to absorb potential losses from non-performing loans. A higher ratio indicates the bank is better positioned to withstand risks, providing greater protection for creditors and depositors [10]. The non-performing loan ratio, on the other hand, can be used to assess the borrower's ability to avoid default risk and the likelihood of timely repayment of principal and interest. Elevated non-performing loan ratios increase credit risk, reduce liquidity and return on assets, thereby negatively impacting the bank's asset quality. Additionally, return on equity serves as an indicator of the bank's profitability.

The asset quality of banks has emerged as the primary driver of financial performance in the banking industry over the 2020-2022 period, as evidenced by the CRITIC method analysis. This finding underscores the importance for banks to prioritize the maintenance of stable asset quality to sustain their capacity to effectively serve the real economy. The development ability of banks was identified as the second most influential factor, while profitability exhibited the smallest contribution to overall financial performance during this timeframe.

The TOPSIS method was employed to aggregate the proximity indices calculated for each bank across all analysis years, providing a comprehensive understanding of the overall ranking of domestic banks, as shown in Table 10. The results indicate that, based on the financial performance indicators examined, CMB exhibited the strongest financial performance during the observation period, followed by PAB and CCB. In contrast, ABC ranked last in financial performance from 2020 to 2022, with ICBC and BOC ranking fourth and fifth, respectively. These findings suggest that the financial performance of the latter banks requires further strengthening. Additional investigation into the operations of CMB would be warranted to corroborate the results obtained through the multi-criteria decision-making approach.

Table 10: TOPSIS comprehensive score

Bank	The sum of relative closeness	Ranking
CCB	1.0548	3
BOC	0.9897	5
CMB	2.2956	1

ABC	0.9722	6
PAB	1.6979	2
ICBC	1.0276	4

V. CONCLUSION

With escalating market competition and evolving financial landscapes, factors such as financial services, online lending, interest rate liberalization, China's economic restructuring measures, meticulous macroeconomic evaluations, enhanced regulatory oversight, and the participation of foreign banks in China's financial sector have heightened risks and challenges for banks [17]. Consequently, there is a pressing need for a thorough and efficient assessment of bank financial performance. Accurate evaluation of bank financial performance is crucial in furnishing pertinent insights for bank executives.

This study applies the CRITIC-TOPSIS method to conduct a comprehensive analysis of the financial performance of Chinese banks. This method offers a distinct financial performance index that integrates multiple financial indicators, addressing limitations associated with individual indicators. The empirical analysis demonstrates the practical utility and fundamental importance of the evaluation model. The assessment outcomes are deemed to be scientifically sound, reliable, and effective. Consequently, this model can be utilized to assess the financial performance of banks accurately and objectively, thereby contributing to the advancement of research on financial performance within the Chinese banking sector.

The CRITIC-TOPSIS assessment methodology proves highly beneficial for various stakeholders. It allows for a straightforward representation of business performance through a single indicator, facilitating comprehension by both management and customers. Additionally, the results serve regulatory purposes by highlighting operational challenges faced by banks. Asset quality indicators play a crucial role in assessing financial performance due to their significant weight. This study offers valuable insights for bank managers and government authorities, enabling bank managers to enhance financial performance through effective risk management, particularly via risk control.

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