Research on Computer Intelligent Evaluation Model of the Impact of Green Credit on the Operating Performance Using Principal Component Analysis

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Abstract. Under the background of "carbon peaking and carbon neutrality goals", green credit has become an important financial strategy to support green development, and commercial banks play a core role as the main force of implementing green credit policy. Based on the data of 10 commercial banks with relatively early and complete disclosure of green credit scale from 2016 to 2020, this paper establishes the operating performance evaluation system of commercial banks by using the principal component analysis(PCA)method, and establishes a fixed-effect model to empirically analyze the impact of green credit scale on the operating performance of commercial banks. The results show that there is a significant positive correlation between the scale *of* green credit and the operating performance of commercial banks. The implementation of green credit policy will improve the operating performance of commercial banks, and the promoting role of state-owned commercial banks is more prominent than that of small and medium-sized joint-stock commercial banks.

Keywords: green credit scale, commercial banks, operating performance, principal component analysis method.

1. Introduction

In recent years, China's economy has developed rapidly. However, increasing environmental pollution not only restricts sustainable development, but also threatens people's well-being. The year 2021 is the first year of "carbon neutrality". Under the background of "double-carbon", green finance is an important link.As the core of green finance, green credit is the key to optimize resource allocation and promote economic transformation.

In 2003, with the announcement and implementation of the international "Equatorial Principles", green credit emerged at the historic moment to guide funds in environment-friendly industries and enterprises and promote sustainable development, Green credit has gradually become an important social responsibility for commercial banks to fulfill [1]. The promulgation of the Opinions on Implementing Environmental Protection Policies and Regulations to Preventing Credit Risk in 2007 marks that green credit has become an important economic means for energy conservation and emission reduction in China.

In this context, the green credit scale of China's commercial banks is growing. According to the central bank's report, by the end of 2020, China's balance of green loans was nearly 12 trillion yuan, ranking first in the world for many years, and the overall quality of green financial assets was good. In the process of promoting the development of green credit, commercial banks are the main force. Therefore, it is particularly important to study how the green credit scale affects the performance of commercial banks. By studying the relationship between green credit scale and the operating performance of commercial banks, this paper provides a reference for the challenges and opportunities brought by green financial policy.

There has been extensive research on the impact of the implementation of green credit on the operating performance of commercial banks at home and abroad, but scholars at home and abroad have different views, and a unified conclusion has not been reached yet.

Cilliers (2010) and others believe that the implementation of green credit policies can improve the operating performance of commercial banks [2]. Miles et al. (2000) and Richardson (2015) also

believe that green credit, as an effective tool [3], helps commercial banks to improve economic benefits and promote sustainable development [4]. Scholtens and Dam (2007) believe that although the reputation of banks has improved by fulfilling social responsibilities, banks' profits and performance are still the core of their attention, so commercial banks should pay the price in performance [5]. Ning Ding and others (2020) studied the data of 73 banks and found that the implementation of green credit policy could promote the performance of commercial banks by improving credit risk management and improving the reputation of banks [6]. Dexu He et al. (2007) [7] and Xuehong Zhi et al. (2018) also believe that the implementation of green credit can significantly improve the operating performance of commercial banks [8]. However, some scholars believe that the implementation of green credit in the short term will reduce the operating performance of commercial banks, and it will take some time to promote the performance of commercial banks. Fengxia Han et al (2017) believe that the implementation of green credit will lose "two remaining" customers, thus reducing the bank interest income and operating performance [9]. Cheng Li et al. (2016) analyzed the data of 16 listed banks, and empirically concluded that the green credit policy is significantly and negatively related to the performance of commercial banks, indicating that the practical implementation of the green credit policy is still obstacles, but with the development of green credit, the existing difficulties are being gradually solved [10].

According to the above discussion, although the research on green credit and commercial banks has achieved some results, there are still some limitations. In the past, most scholars used qualitative analysis methods for green credit, but less quantitative analysis methods, and relatively few studies on in-depth comparison and analysis of how green credit scale affects the operating performance of state-owned commercial banks and small and medium-sized joint-stock commercial banks.

The contribution of this paper is to select 5 state-owned commercial banks with early and relatively complete green credit information disclosure and 5 small and medium-sized joint-stock commercial banks for comparative research, On the basis of previous research, multiple representative indicators were selected to establish a relatively comprehensive operating performance evaluation system of commercial banks, and use the fixed effect model to explore the relationship between green credit scale and the operating performance of commercial banks, and further analyze the action mechanism, and conducted relevant tests.

2. Analysis of the influence mechanism and the research hypothesis

2.1. Concept definition of the operating performance of commercial banks

Nowadays, there is no unified definition and explanation of the term "operating performance" in academia. After comprehensive various literature studies, this paper defines the operating performance of commercial banks based on the three principles, namely "safety, liquidity and profitability".

2.2. The impact of green credit on the operating performance of commercial banks

This paper summarizes the previous literature, and believes that the impact mechanism of green credit on the operating performance of commercial banks can be analyzed from three aspects: external economic environment, bank brand reputation and cost effect. The specific impact mechanism is shown in Fig. 1.

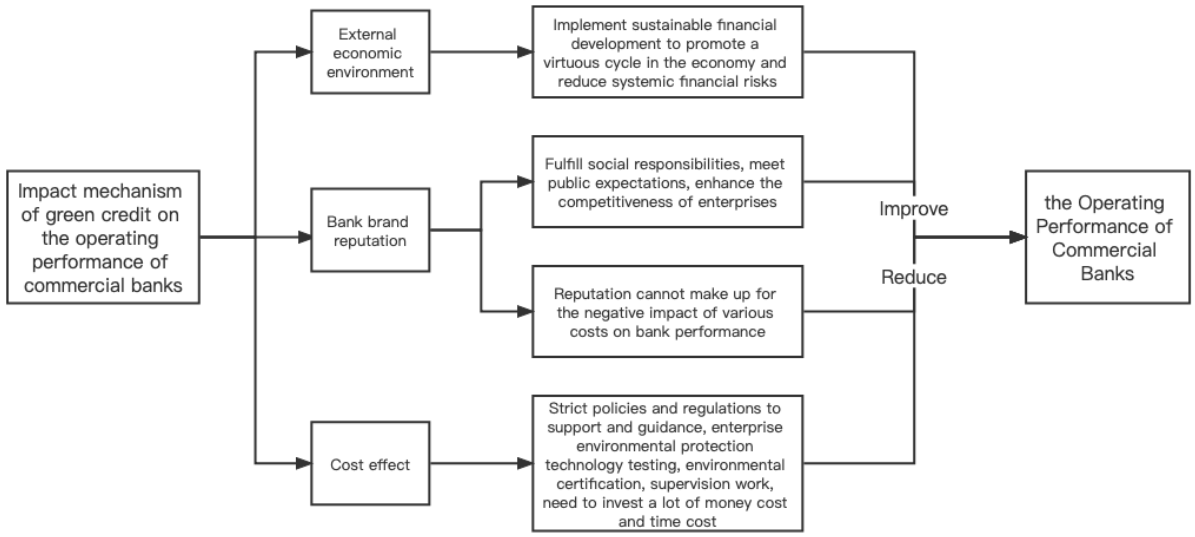

Fig. 1 Impact mechanism

Based on the above analysis, commercial banks will actively implement green credit policies, which may cause the improvement of the operating performance of commercial banks and may also lead to their decline. Accordingly, this paper presents two opposing hypotheses, H 1 and H 2.

H 1: The scale of green credit will have a positive effect on the operating performance of commercial banks.

H 2: Green credit scale will have a negative effect on the operating performance of commercial banks.

3. Research design

3.1. Sample data sources

China's green credit policy was officially released in July 2007, As the major banks have only successively disclosed the relevant green credit data since 2009, and have not yet released the complete financial statement data. Therefore, while ensuring the authenticity of the data, In this paper, 10 state-owned commercial banks and small and medium-sized joint-stock commercial banks that had published the green credit data between 2016 and 2020 were selected for analysis. There are 10 effective samples, including Industrial and Commercial Bank of China, Agricultural Bank of China, Bank of China, China Construction Bank, Bank of Communications, China Minsheng Bank, China Everbright Bank, Shanghai Pudong Development Bank, Industrial Bank, and Bank of Beijing, Fifteen metrics were used as the balance panel data. Financial statement data and green credit data are obtained from the WIND database and the annual report and social responsibility report of the official websites of each bank.

3.2. Selection and definition of the variables

3.2.1. The explained variable

Referring to the research of Ning Ding (2020), Cheng Li (2016) and other scholars, and comprehensively considering the three principles of commercial banks, the explanatory variables were selected as the performance scores obtained by using the principal component analysis method of 10 commercial banks below, and the evaluation indicators used are shown in TABLE I.

Table 1. Operating performance evaluation indicators of commercial banks

Indicator type	Specific variable
PI	net interest income
	Return on equity
	The proportion of non-interest income
	Cost-revenue ratio
Safety indicators	capital adequacy ratio
	Maximum 10 customer loan ratio
	provision coverage
	Non-performing loan ratio
Liquidity indicators	Proportion of deposit and loan
	asset-liability ratio
	liquidity ratio
scale merit	accept money deposits
	tax payable
	Net profit share

3.2.2. Core explanatory variables

The core explanatory variable is the bank's green credit scale, as measured by the green credit balance disclosed by the bank every year in the statement.

3.2.3. Control variable

The control variables selected in this paper are deposit absorption and capital adequacy ratio. The amount of the deposits absorbed is the main source of the bank capital and an important factor determining the scale of the loan. The more deposits the bank absorbs, the more profitable the profitability. The capital adequacy ratio is the proportion of the total bank capital in the total weighted risk assets, which reflects the risk resistance and solvency ability of the bank, the more the lower the default probability under pressure. Specific variable definitions are shown in TABLE II.

Table 2. Description of the Variables

type of variable	Variable name	meaning
explained variable	Bank performance score	Based on the comprehensive score derived from the principal component analysis method
explanatory variable	Green Credit (one trillion)	Green credit balance issued by the bank
controlled variable	Deposit absorption (one trillion yuan)	Total deposits absorbed by the banks
	capital adequacy ratio (%)	The ratio of total bank capital to total weighted risk assets

3.3. Operating performance evaluation of state-owned commercial banks

3.3.1. Establish sequential stereo data

The data of 10 commercial banks ranked 14 indicators in chronological order to establish two timing data tables:

$$X = (X_{ij})\ nT \times p$$

3.3.2. Standardized processing of the data

To ensure the standardization of the study data, all the data are standardized in order to eliminate the dimensional effects and retain the standardized index data for the global principal component analysis.

3.3.3. Effectiveness test of the data

SPSS is used for KMO (Kaiser-Meyer-Olkin) sampling appropriateness and Bartlett spherical. The test results of state-owned commercial banks and small and medium-sized joint-stock commercial banks are shown in TABLE III and TABLE IV.

Table 3. KMO test results of state-owned commercial banks

Number of KMO sampling suitability quantities		0.641
Bartlett's spherical degree test	Approximate card square	515.859
	free degree	91
	conspicuousness	0.000

Table 4. KMO test results of small and medium-sized joint-stock commercial banks

Number of KMO sampling suitability quantities		0.670
Bartlett's spherical degree test	Approximate card square	730.180
	free degree	91
	conspicuousness	0.000

The value range of KMO test is 0 ~ 1, and the larger the value, the more suitable for decision component analysis. We can see from the above table that the KMO test value is 0.641 and 0.670, greater than 0.5 indicates a strong correlation between the indicators. The data of both models are suitable for decision component analysis.

3.3.4. principal component analysis

Global principal component analysis of the normalized data using SPSS, extracting common factors for the sample data following the principle of eigenvalues greater than 1, and the results are shown in Fig. 2 and Fig. 3. According to Fig. 2, the operating performance of state-owned commercial banks can be comprehensively evaluated by three factors, with the cumulative contribution rate of 84.470%. According to Fig. 3, the operating performance of small and medium-sized joint-stock commercial banks can be comprehensively evaluated by four factors, with the cumulative contribution rate reaching 78.334%.

ing red ient	Initial eigenvalue			Extract sum of square			Sum of square of the rotating load		
	amount to	variance percentage	accumulate%	amount to	variance percentage	accumulate %	amount to	variance percentage	accumulate %
1	5.630	40.217	40.217	5.630	40.217	40.217	5.340	38.139	38.139
2	2.310	16.500	56.718	2.310	16.500	56.718	2.328	16.628	54.767
3	1.867	13.335	70.053	1.867	13.335	70.053	1.828	13.057	67.824
4	1.159	8.282	78.334	1.159	8.282	78.334	1.472	10.511	78.334
5	0.885	6.320	84.654						
6	0.743	5.310	89.964						
7	0.431	3.081	93.046						
8	0.327	2.336	95.382						
9	0.268	1.913	97.295						
10	0.161	1.148	98.444						
11	0.132	0.943	99.386						
12	0.048	0.345	99.731						
13	0.036	0.255	99.986						
14	0.002	0.014	100.000						

Fig. 2 Explanation of the total variance of state-owned commercial banks

ingredient	Initial eigenvalue			Extract sum of square			Sum of square of the rotating load		
	amount to	variance percentage	accumulate%	amount to	variance percentage	accumulate%	amount to	variance percentage	accumulate%
1	6.825	48.747	48.747	6.825	48.747	48.747	6.171	44.077	44.077
2	3.589	25.636	74.382	3.589	25.636	74.382	3.132	22.373	66.451
3	1.412	10.087	84.470	1.412	10.087	84.470	2.523	18.019	84.470
4	0.740	5.286	89.755						
5	0.563	4.025	93.780						
6	0.338	2.411	96.191						
7	0.258	1.841	98.032						
8	0.108	0.768	98.800						
9	0.078	0.559	99.360						
10	0.042	0.300	99.659						
11	0.028	0.203	99.862						
12	0.011	0.080	99.942						
13	0.007	0.053	99.995						
14	0.001	0.005	100.000						

Fig. 3 Explanation of the total variance between small and medium-sized joint-stock commercial banks

Generally, the large absolute value of the correlation coefficient is selected as the comprehensive index representing the extraction factor system of the global principal component analysis. According to TABLE V, the three main components of the operating performance of commercial banks are as follows: The first component mainly includes six indicators: deposit absorption, tax payable, net profit share, loan ratio of 10 customers, non-interest income ratio and liquidity ratio, which can be named as scale factor. The second component mainly includes five indicators: return on equity, deposit and loan ratio, capital adequacy ratio, non-performing loan ratio and asset-liability ratio, which can be named as safety factor. The third component mainly includes three indicators: net interest income, provision coverage, and cost-income ratio, which can be named as a for-profit factor.

Table 5. Explanation of the total variance of state-owned commercial banks

metric	ingredient		
	1	2	3
Net interest income (one million)	0.402	0.140	0.527
Return on equity, (%)	0.506	-0.739	0.206
Cost and revenue ratio of (%)	0.541	0.391	0.643
capital adequacy ratio (%)	0.581	0.745	0.030
asset-liability ratio (%)	0.355	0.761	0.475
accept money deposits	0.987	0.014	0.064
tax payable	0.946	0.160	0.188
Net profit share	0.956	0.001	0.245
Non-performing loan ratio is (%)	-0.064	0.718	0.339
Maximum 10 customer loan ratio is (%)	-0.866	0.100	-0.060
provision coverage (%)	0.088	-0.210	-0.944
Non-interest income for (%)	-0.851	0.137	-0.226
Deposit and loan ratio is (%)	0.611	-0.670	-0.240
liquidity ratio (%)	-0.595	0.464	-0.586

According to TABLE VI, the four main components of the operating performance of commercial banks are as follows: The first component mainly includes four indicators of the loan ratio of the

largest ten customers, deposit absorption, tax payable, and net profit share, which can be named as the scale factor. The second component mainly includes four indicators: return on equity, capital adequacy ratio, deposit and loan ratio and asset-liability ratio, which can be named as the asset correlation factor. The third component mainly includes four indicators: non-interest income ratio, provision coverage, non-performing loan ratio and liquidity ratio ratio, which can be named as liquidity factor. The fourth component mainly includes two indicators of net interest income and cost-income ratio, which can be named as the income correlation factor.

Table 6. Composition matrix of small and medium-sized joint-stock commercial banks

metric	ingredient			
	1	2	3	4
Net interest income (one million)	0.555	0.057	0.018	0.646
Return on equity, (%)	0.128	-0.871	-0.034	0.118
Non-interest income for (%)	-0.017	0.229	-0.733	-0.559
Cost and revenue ratio of (%)	-0.126	0.171	-0.007	0.797
capital adequacy ratio (%)	0.404	0.712	0.069	0.282
Maximum 10 customer loan ratio is (%)	0.781	0.363	-0.174	0.199
provision coverage (%)	0.011	0.097	-0.853	0.160
Non-performing loan ratio is (%)	-0.498	0.068	0.660	-0.040
Deposit and loan ratio is (%)	-0.278	-0.704	0.457	-0.133
asset-liability ratio (%)	0.020	0.949	0.144	0.119
liquidity ratio (%)	0.118	0.264	0.685	0.112
accept money deposits	0.966	0.160	-0.071	0.019
tax payable	0.809	0.039	0.173	-0.308
Net profit share	0.939	-0.134	-0.066	0.098

The operating performance scores of commercial banks are calculated as shown in Fig. 4 and Fig. 5.

Bank name	a particular year	Comprehensive score
Bank Of China	2016	-0.17
	2017	-0.1
	2018	-0.01
	2019	0.28
	2020	0.42
Agricultural Bank of China	2016	-0.85
	2017	-0.62
	2018	-0.22
	2019	0.22
	2020	0.33
Industrial & Commercial Bank of China	2016	0.24
	2017	0.43
	2018	0.59
	2019	0.9
	2020	0.88
China Construction Bank	2016	0.04
	2017	0.28
	2018	0.62
	2019	0.61
	2020	0.67
bank of communications	2016	-1.05
	2017	-1.06
	2018	-1.01
	2019	-0.71
	2020	-0.7

Fig. 4 Operating performance scores of state-owned commercial banks

Bank name	a particular year	Comprehensive score
Bank of Beijing	2016	-0.82
	2017	-0.73
	2018	-0.45
	2019	-0.17
	2020	-0.3
Shanghai Pudong Development Bank	2016	-0.64
	2017	-0.22
	2018	0.14
	2019	0.48
	2020	0.64
Industrial Bank	2016	0.08
	2017	0.08
	2018	0.43
	2019	0.83
	2020	0.96
China Everbright Bank	2016	-0.58
	2017	-0.04
	2018	-0.16
	2019	0.37
	2020	0.71
CMBC	2016	-0.56
	2017	-0.39
	2018	-0.48
	2019	0.31
	2020	0.52

Fig. 5 Operating performance scores of small and medium-sized joint-stock commercial banks

4. Empirical analysis

4.1. Model selection and estimation

4.1.2. Descriptive statistical analysis

TABLE VII presents the results of the descriptive statistics for each variable. From the perspective of the explained variables, the standard deviation of the performance score of state-owned commercial banks is larger than that of small and medium-sized joint-stock commercial banks, indicating that the fluctuation range of the operating performance of state-owned commercial banks is wider.

In terms of the core explanatory variables, the average green credit balance of the small and medium-sized joint-stock commercial banks is 0.255 trillion yuan, while the average green credit balance of the state-owned commercial banks is 0.876 trillion yuan, significantly higher than the small and medium-sized joint-stock commercial banks, indicating that the state-owned commercial banks occupy a more important position in the national green credit issuance.

From the perspective of the time trend, the scale of both green credit is growing in 2016-2020.In terms of control variables, the average deposits is higher than small and medium-sized joint-stock commercial banks, indicating that depositors have more trust in large commercial banks and have wider channels of funding. Both state-owned commercial banks and small and medium-sized joint-stock commercial banks have capital adequacy ratio higher than 8% requirement in Basel, indicating that the banks have strong risk resistance to timely discharge debts and better protect the interests of depositors.

Table 7. Descriptive statistics

The type of bank	Variable name	mean	standard deviation	minimum	median	maximum
Small and medium-sized joint-stock commercial banks	Bank performance	0.000	0.521	-0.820	-0.040	0.960
	Green credit amount	0.255	0.341	0.000	0.090	1.156
	accept money deposits	0.283	0.088	0.115	0.304	0.408
	capital adequacy ratio	12.630	0.938	10.800	12.280	14.640
State-owned commercial bank	Bank performance	0.000	0.623	-1.060	0.220	0.900
	Green credit amount	0.876	0.425	0.241	0.897	1.846
	accept money deposits	1.438	0.649	0.0148	1.6194	2.513
	capital adequacy ratio	15.334	1.200	13.040	15.140	17.520

4.2. Regression results analysis

Through Hausman test, this paper chose to use fixed effect model for regression analysis of state and small and medium-sized shareholding commercial banks, and the results are shown in TABLE VIII.

It can be seen that in both state-owned commercial banks and small and medium-sized joint-stock commercial banks, the scale of green credit has a significant positive impact on the performance score of banks, indicating that commercial banks' issuance of green credit can effectively improve their operating performance. Assuming that H1 is established.

Column (2) and (4) are the regression results of state-owned commercial banks and small and medium-sized joint-stock commercial banks when adding the control variables, respectively, and it can be seen that the scale of green credit has a greater positive impact on the operating performance of state-owned commercial banks. The reason is that compared with small and medium-sized joint-stock commercial banks, state-owned commercial banks have a better policy system, a more orderly corporate governance structure, and a better asset quality. Therefore, state-owned commercial banks can implement green credit policies more effectively.

From the regression results of the control variables, the bank deposit amount has no significant impact on the operating performance score, indicating that the increase in deposits will not significantly improve the bank operating performance. And the capital adequacy ratio has a significant positive impact on the bank performance score, meaning that the more sufficient the commercial bank, the better the buffer effect under pressure, the stronger the resistance to risk.

Table 8. Results of the fixed-effect regression

variable	State-owned commercial bank		Small and medium-sized joint-stock commercial banks	
	(1)	(2)	(3)	(4)
green-credit policy	1.258***	0.844*	0.746***	0.597***
	(0.18)	(0.46)	(0.16)	(0.11)
accept money deposits		-0.036		0.751
		(0.23)		(0.62)
capital adequacy ratio		0.316***		0.215***
		(0.11)		(0.05)
_cons	-1.102***	-5.530***	-0.122*	-3.029***
	(0.18)	(1.50)	(0.07)	(0.60)

Note: * * *, * * and * are significant at 1%, 5%, and 10%, respectively; standard errors in parentheses.similarly hereinafter.

4.3. Robustness test

To ensure the stability and reliability of the regression results, heteroscedastic stability criteria were introduced here to misestimate the impact of green credit scale on the operating performance of state-owned banks and small and medium-sized joint-stock commercial banks, and the results are shown in TABLE IX. It can be seen that the scale of green credit still shows a significant positive correlation with the operating performance of commercial banks, and the regression results have not changed substantially, indicating that the previous regression results are stable and reliable.

Table 9. Mixed-panel data regression results

variable	State-owned commercial bank		Small and medium-sized joint-stock commercial banks	
	(1)	(2)	(3)	(4)
green-credit policy	1.258***	0.844*	0.746***	0.597**
	(0.16)	(0.34)	(0.09)	(0.17)
accept money deposits		-0.036		0.751
		(0.29)		(0.62)
capital adequacy ratio		0.316***		0.215***
		(0.04)		(0.02)
_cons	-1.102***	-5.530***	-0.122***	-3.029***
	(0.14)	(0.64)	(0.02)	(0.11)

5. Conclusion and policy suggestions

This paper takes 10 commercial banks carrying out green credit business in China as a sample, by analyzing the relevant financial data from 2016-2020, compared the impact of green credit policy on 5 state-owned commercial banks and 5 small and medium-sized joint-stock commercial banks, the empirical results show that the green credit policy will improve the operating performance of commercial banks, and the positive impact on state-owned commercial banks is more prominent.
Based on the conclusion of empirical analysis, this paper puts forward the following two policy suggestions for the development of green credit in Chinese commercial banks.

First, due to the positive effect of green credit policy on commercial banks, China's commercial banks in China should implement strategic transformation and incorporate green credit into their sustainable development strategy. At the same time, commercial banks need to improve the credit system, improve the operation efficiency of the banking system, strengthen the legal system and system management, and improve the stability and effectiveness of the operation.

Second, state-owned commercial banks should take the initiative to assume social responsibility, and vigorously promote the implementation of green credit policy; small and medium-sized shareholding commercial banks should also improve their green credit policy implementation system, establish a perfect green credit audit and supervision system and innovative incentive mechanism, so as to better promote the development of green credit.

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