

The Impact of Green Credit on the Operating Performance of Commercial Banks in China: Based on Multiple Linear Regression and Principal Component Analysis

Yina Zhu

School of Finance, Anhui University of Finance and Economics, Bengbu 233000, China

Abstract

With the practical promotion of the "dual carbon" goal, green development has become the trend, and various industries are actively carrying out green innovation. Finance plays an important role in implementing the "dual carbon" goals, and green finance has become the research focus of the financial industry. Developing green finance has become a top priority for financial institutions in China. Green credit, as the earliest developed financial product in China's green finance, plays a crucial role in the process of green innovation in the financial industry. This article selects panel data from state-owned commercial banks in China from 1997 to 2021, constructs a performance indicator system for commercial banks, uses principal component analysis to obtain comprehensive scores, and establishes a multiple linear regression model to study whether the development of green credit business in China has a promoting effect on the operational performance of commercial banks.

Keywords

Green Credit; Commercial Banks; Business Performance; Principal Component Analysis; Multiple Linear Regression.

1. Introduction

With the continuous occurrence of severe weather, the concept of "sustainable development" has been increasingly popularized worldwide, and energy conservation and emission reduction have become an urgent problem that needs to be solved in human society. In 2006, China became the world's largest carbon emitter and the largest energy consumer in 2009. This is a solemn commitment made by China as a major and powerful country to the world, and it is also an important measure calling on all humanity to attach importance to natural environment protection and achieve "sustainable development". Against the backdrop of the "dual carbon" goal, green innovative technologies are constantly emerging in various industries, and finance plays a crucial role in carbon neutrality transformation, with green finance gradually becoming the focus. Among them, green credit is the earliest traced, largest in scale, and most mature product in China's green financial products. It occupies an important strategic position in China's economic development and it has received high attention from government departments, financial circles, and academia [1].

In recent years, China's green finance has developed rapidly. The banking industry in China began to establish green credit business in 2007. Currently, China has formed a relatively complete credit evaluation system, and the scale of green credit is constantly expanding. As of the end of March 2021, the balance of green credit has increased from 5.2 trillion in 2013 to 13 trillion, increasing at a rate of over 12%. Under the guidance of the new development concept of "dual carbon", developing green finance and promoting healthy economic development is the main work direction of various financial institutions at present and in the future.

Financial institutions not only need to face the risks of climate change, but also the credit risk, liquidity risk, development strategy risk, operational process risk, compliance risk, reputation risk and other risks caused by climate change [2]. So, many banks consider climate change when dealing with financial risks, but to some extent, traditional risk assessment methods are unpredictable, which means that countries must proactively respond with the help of central banks. In addition, we need to rely on large commercial banks to continue promoting the development of green economy. At the same time, the government should also fully play its leadership role, encourage commercial banks and financial institutions to carry out low-carbon technological innovation, promote reform and development in fields such as bioenergy, and form a scientific and reasonable constraint mechanism to fully reflect the functions of various financing methods.

Based on the above analysis, whether commercial banks can develop green credit for green innovation has sparked my thinking. Through exploring this issue, I aim to propose effective policy recommendations to improve the operational performance of commercial banks and effectively solve the "dual carbon" problem by utilizing green credit business.

2. Literature Review and Mechanism Analysis.

As this article collects data from China's top five commercial banks, it mainly reviews relevant domestic literature and theoretically explores the impact mechanism of green credit on the performance of commercial banks. There are three main views among domestic scholars on this issue:

2.1. Green Credit Can Improve the Operational Performance of Commercial Banks.

He Dexu (2007) and others believe that the risks of non-performing loans and non-performing loans of "two highs and one surplus" companies can also be effectively controlled. At the same time, commercial banks will also shift from traditional business models based on loan interest rates, and through innovation in intermediary and off balance sheet businesses, increase non interest income, thereby improving their business performance. From the perspective of corporate competitiveness, Gao Xiaoyan et al. (2018) conducted empirical research on 26 commercial banks and concluded that in the face of financing difficulties, credit support for green enterprises and green projects by commercial banks can effectively improve the financing difficulties of enterprises, shape their social image to a certain extent, and form a unique resource [3]. This will lay a solid foundation for taking the lead in environmental development in the future, while also increasing the possibility of new profit growth points. Zhang Hui et al. (2021) used the double difference partial score matching method to test it from the perspective of long-term development, and believed that green credit will improve the operational performance of commercial banks. The implementation approach is to recover loans from high energy consuming and high emission enterprises [4]. Tang Yalan (2021) conducted a credit evaluation model test on 13 banks, and the results showed that credit rating agencies have certain potential benefits. These industries often have characteristics such as small scale, difficulty in financing, difficulty in financing, and difficulty in financing [5], which support the environmental protection industry. By issuing green credit, it can promote the balance of market supply and demand, and ensure the healthy development of China's low-carbon economy.

2.2. Green Credit Will Reduce the Operational Performance of Commercial Banks.

Zhang Yu (2020) evaluated the operational performance of commercial banks from the perspective of corporate social responsibility based on principal component analysis, and

believed that green credit loans have a downward impact on the operational performance of some commercial banks [6].

Commercial banks conducting green credit business not only does not improve their operational performance, but may also increase costs. The increase in loan costs is mainly reflected in four aspects: firstly, the assessment fees before the loan. When determining the loan plan, banks must hire specialized environmental auditors to strictly review environmental requirements and screen out potential environmental risks. Jia Siqu et al. (2021) pointed out that this will indirectly increase bank labor costs, audit qualification fees, and the cost of collecting information from loan companies [7]. The second is the cost of post supervision. Environmental protection projects have the characteristic of long recovery cycles, and it is necessary to evaluate their additional environmental risk factors and predict their emission reduction indicators, in order to increase the lending costs of banks; The third is the loss of interest income. For some companies engaged in environmental protection projects, they will enjoy preferential policies such as lower interest rates, which to some extent reduces their interest income and thus suffers losses; The fourth is opportunity cost. For certain high pollution, high energy consumption, and overcapacity high carbon projects, banks often increase loan interest rates to limit their loan limits, leading to a large number of companies choosing to exit the banking industry, and banks will lose customers, resulting in opportunity cost. The operational performance of commercial banks has been affected to a certain extent.

2.3. Green Credit has No Significant Impact on the Operational Performance of Commercial Banks.

The research group of Shizuishan Central Branch of the People's Bank of China (2022) conducted an analysis on the correlation between green credit, green reputation, and bank performance using 15 listed banks from 2008 to 2020 as samples. Research has found that implementing green credit in Chinese commercial banks can enhance the green reputation of enterprises, but it has not significantly improved their performance [1].

Based on the above research, this article proposes three hypotheses:

H1: Green credit business will improve the operational performance of commercial banks.

H2: Green credit business will reduce the operational performance of commercial banks.

H3: Green credit business has no significant impact on the operational performance of commercial banks.

3. Model Construction and Data

3.1. Variable Description

3.1.1. Explained Variable

According to most scholars' research methods, when constructing an evaluation system for the operational performance of commercial banks, the basic emphasis is on starting from the safety, liquidity, and profitability of the bank. This article is modified based on the "three characteristics" and ultimately selects six indicators from the profitability, liquidity, and growth of commercial banks to jointly construct an evaluation index system in Figure1. Using principal component analysis, calculate the comprehensive score as the explained variable.

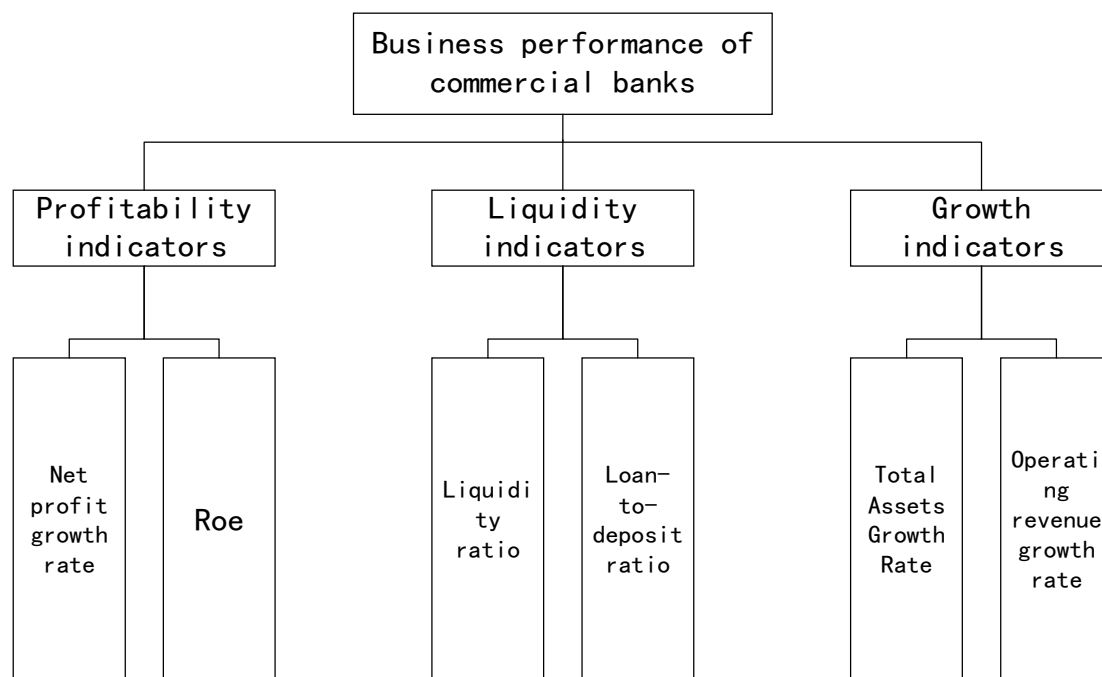


Figure 1. Construction Chart of Business Performance Indicators for Commercial Banks

3.1.2. Explanatory Variable

At present, when studying the impact of green credit on the operational performance of commercial banks, there are two types of indicators for measuring green credit: the first is the balance of green credit; The second type is the proportion of green credit. This article selects a total indicator to reflect the investment level of various commercial banks in green credit business, namely the balance of green credit.

3.1.3. Control Variable

According to a review of existing literature on control variables, there are many indicators that affect the operational performance of commercial banks, except for green credit. After considering the availability and effectiveness of data, this article selected two indicators: non-interest income and total asset size of banks as the control variables for the study.

3.2. Data Selection

This article selects Bank of China 2017-2021, China Construction Bank 2017-2021, Industrial and Commercial Bank of China 2017-2021, Agricultural Bank of China 2017-2021, Bank of Communications 2017-2021 net profit growth rate (f1), return on equity (f2), liquidity ratio (f3), deposit loan ratio (f4), total asset growth rate (f5), operating income growth rate (f6), green credit balance (GI), non-interest income (NII) Principal component analysis was conducted on the total asset size (TAA) and non-performing loan ratio (NPL) of banks. Multiple linear regression analysis was conducted using the above-mentioned indicator data of Bank of China from 1997 to 2021. The data mainly came from the annual report of Bank of China, NetEase Finance, and Sina Finance. (This only shows the data used by Bank of China for the multiple linear regression model, while the data used by the other four banks for principal component analysis is too complex to be displayed here).

Table 1. Data Collection Table

Chinese Abbreviation of Bank	Time	Liquidity Ratio(%)	Net Profit Growth Rate	Roe	Loan to Asset Ratio	Operating Revenue Growth Rate	Asset Size (logarithms of total assets) X3	Deposit Asset Ratio	Non Performing Loan Ratio X4	Deposit Loan Ratio	Total Assets Growth Rate	Non Interest Income X2 (100 million yuan)	Green Credit Balance X1 (100 million yuan)	Comprehensive Score Y
Bank of China	1997	47.1	-0.10063	0.107023	0.681547	-0.15369	30.40286	0.854262	1.45	0.797819	0.081243	1448.89	5388.07	-1.107
Bank of China	1998	58.7	0.10658	0.111587	0.688533	0.084404	30.47395	0.867045	1.42	0.794114	0.073674	1444.01	6326.67	0.7
Bank of China	1999	54.6	0.052736	0.110396	0.704781	0.561802	30.55112	0.853018	1.37	0.826221	0.080226	1749.32	7375.7	0.737
Bank of China	2000	54.5	0.039533	0.100227	0.718954	0.069897	30.61538	0.853611	1.46	0.84225	0.066376	1517.29	8967.98	0.598
Bank of China	2001	49.6	0.06899	0.096368	0.735487	0.061975	30.6927	0.849248	1.33	0.866046	0.080391	1804.17	14086	0.582
Bank of China	2002	43.53	-0.00465	0.144483	0.633099	-0.02501	30.64564	0.802877	1.49	0.788538	0.139216	5140.5	10025.21	-1.881
Bank of China	2003	47.69	0.033695	0.13238	0.622651	-0.00575	30.69746	0.797037	1.46	0.781208	0.053183	4957.8	10400	-0.4
Bank of China	2004	51.87	0.062604	0.127116	0.646443	0.574508	30.74424	0.816521	1.42	0.791704	0.047891	576.65	11758.02	0.626
Bank of China	2005	55.66	0.053952	0.119698	0.65983	0.065581	30.83374	0.83803	1.56	0.787358	0.093627	653.67	13400	-0.105
Bank of China	2006	59.32	0.033561	0.115666	0.665729	0.101574	30.93769	0.819913	1.42	0.811951	0.109548	973.34	19600	-0.061
Bank of China	2007	41.7	-0.00376	0.137903	0.624821	-0.00984	30.75691	0.844	1.55	0.740309	0.083005	2044.24	10991.99	-1.394
Bank of China	2008	43.8	0.031707	0.1318	0.625839	0.007111	30.83534	0.868913	1.52	0.720256	0.081594	2012.71	12377.58	-1.049
Bank of China	2009	43	0.046517	0.126441	0.643086	0.941238	30.89157	0.881589	1.43	0.729462	0.057841	2482.38	13508.38	0.221
Bank of China	2010	43.2	0.049954	0.115925	0.655674	0.073793	30.97758	0.884874	1.58	0.740979	0.089816	2359	18457.19	-0.641
Bank of China	2011	41.5	0.024105	0.109498	0.653573	0.062725	31.08487	0.836184	1.42	0.781613	0.113259	2520.82	24800	-0.85
Bank of China	2012	50.95	0.011981	0.139034	0.551454	-0.04011	30.59839	0.833012	1.81	0.662	0.099196	222.08	7476.25	-1.457
Bank of China	2013	55.17	0.047932	0.134677	0.57096	0.046043	30.67141	0.829437	1.59	0.688371	0.075753	426.87	10504	-0.602
Bank of China	2014	57.74	0.036294	0.119439	0.59474	0.639891	30.74293	0.825451	1.4	0.720503	0.074143	534.71	11910	0.36
Bank of China	2015	59.15	0.038053	0.106559	0.589014	0.035802	30.83809	0.824599	1.57	0.714303	0.099828	383.37	15149	-0.185
Bank of China	2016	62.01	0.020215	0.096215	0.634639	0.065548	30.92689	0.811351	1.43	0.7822	0.092865	615.9	19778	0.343
Bank of China	2017	58.66	0.000362	0.103272	0.542831	-0.01302	29.73643	0.600493	1.5	0.903976	0.170508	711.38	2771.08	-0.473
Bank of China	2018	67.28	0.04115	0.101251	0.549912	-0.04122	29.80887	0.648499	1.49	0.847976	0.075122	817.46	2830.54	0.893
Bank of China	2019	72.92	0.031866	0.101248	0.579842	0.584379	29.84453	0.65645	1.47	0.883299	0.036309	883.89	3283.52	2.145
Bank of China	2020	69.24	0.035537	0.09288	0.618759	0.061553	29.87723	0.691848	1.67	0.894356	0.03324	928.64	3872.8	1.778
Bank of China	2021	67.11	-0.0252	0.083221	0.64758	0.026166	29.94659	0.694899	1.48	0.931905	0.071814	1076.97	4767.63	1.221

3.3. Model Construction

Assuming n samples, represented by X1, X2,... Xp, the vector X=(X1, X2,... Xp), the matrix form of which is:

$$\begin{pmatrix} X_{11} & \dots & X_{1p} \\ \vdots & \ddots & \vdots \\ X_{p1} & \dots & X_{pp} \end{pmatrix}$$

By linearly transforming X, a new variable can be obtained, represented by Y:

$$\begin{cases} Y_1 = u_{11}X_1 + u_{12}X_2 + \dots + u_{1p}X_p \\ Y_2 = u_{21}X_1 + u_{22}X_2 + \dots + u_{2p}X_p \\ \vdots \\ Y_p = u_{p1}X_1 + u_{p2}X_2 + \dots + u_{pp}X_p \end{cases}$$

$$u_{k1}^2 + u_{k2}^2 + \dots + u_{kp}^2 = 1, k = 1, 2 \dots p \tag{1}$$

Among them, Y1, Y2, and Yp are respectively referred to as the first, second, and p-th principal components, and their proportion in the total variance decreases.

Using the comprehensive score calculated by principal component analysis as the dependent variable, green credit (GL) as the core explanatory variable, and non interest income (NII), total asset size (TA), and non-performing loan ratio (NPL) as the control variables, a regression model was constructed as follows [8].

$$f_{it} = \beta_0 + \beta_1GL_i + \beta_2NII_i + \beta_3TA_i + \beta_4NPL_i + \varepsilon_i \tag{2}$$

In the above equation, f represents the comprehensive score of the commercial bank's operational performance indicator system and is the dependent variable; GL represents the balance of green credit, which is the core explanatory variable; NII, TA, and NPL represent non interest income, total bank asset size, and non-performing loan ratio, respectively, as control variables. β_0 is the intercept term, ε_i is a random disturbance term, and i represents the i-th year.

4. Empirical Analysis

4.1. Principal Component Analysis Results

4.1.1. KMO and Bartlett's Test

Table 2. KMO and Bartlett test results

KMO	0.674
Bartlett Sphericity Test Approximate Chi Square	39.466
Freedom	15
Significance	0.001

KMO and Bartlett analysis were conducted on the data using SPSS software. The results showed that the significance values of KMO and Bartlett were 0.674 and 0.001, respectively in Table 2. The test results all indicate that the data can be analyzed using principal component analysis.

4.1.2. Extracting Principal Components

Table 3. Principal Component Extraction Analysis Table

Component	Total	Variance Percentage	Accumulated%
Principal Component 1	2.364	49.403	49.403
Principal Component 2	1.708	40.467	89.870

Using SPSS software, principal component analysis was conducted on six indicators in the indicator system and evaluated. In this result, we selected two main components, among which the variance contribution rate is above 80% in Table 3. Basically, it can be said that the first two main components have basically covered the content that all indicator variables need to reflect, which fully demonstrates the operational efficiency of commercial banks in China.

Table 4. Factor Load Table

Index	Principal Component 1	Principal Component 2
Zscore(f_1)	0.058	0.710
Zscore(f_2)	-0.897	0.187
Zscore(f_3)	0.075	0.795
Zscore(f_4)	0.846	-0.261
Zscore(f_5)	-0.339	-0.681
Zscore(f_6)	0.848	0.067

If F_1 and F_2 are used to represent the scores of the two principal components, then:

$$F_1 = 0.038Zscore(f_1) - 0.583Zscore(f_2) + 0.049Zscore(f_3) + 0.550Zscore(f_4) - 0.220Zscore(f_5) + 0.552Zscore(f_6)$$

$$F_2 = 0.462Zscore(f_1) + 0.122Zscore(f_2) + 0.517Zscore(f_3) - 0.170Zscore(f_4) - 0.443Zscore(f_5) + 0.044Zscore(f_6)$$

4.1.3. Calculate Comprehensive Score

Calculate the scores of two principal components based on the component score matrix, and then use their respective variance ratios as weights to calculate the comprehensive score of commercial bank operating performance.

The comprehensive evaluation model is as follows:

$$F = 0.5806 \times F_1 + 0.4194 \times F_2 \tag{3}$$

Table 5. Comprehensive Score Table

Bank Time	Bank of China	China Construction Bank	Industrial and Commercial Bank of China	Agricultural Bank of China	Bank of Communications
2017	-1.107	-1.881	-1.394	-1.457	-0.473
2018	0.700	-0.400	-1.049	-0.602	0.893
2019	0.737	0.626	0.221	0.360	2.145
2020	0.598	-0.105	-0.641	-0.185	1.778
2021	0.582	-0.061	-0.850	0.343	1.221

According to the scores in Table 5 can be obtained, where negative values are only due to the results of data standardization and do not represent negative business performance.

4.2. Multiple Linear Regression Model Results

The results of the multiple linear regression model are shown in Figure 2:

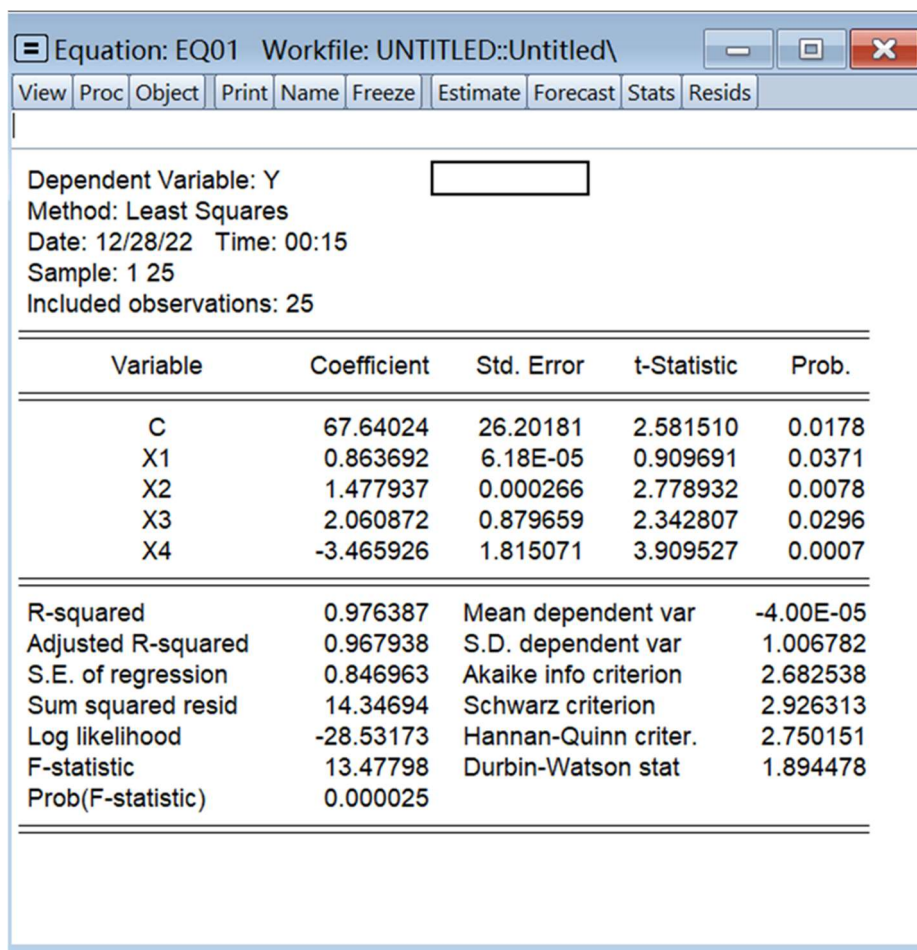


Figure 2. Results of Multiple Linear Regression Model

From the regression results in Figure 2, it can be seen that in model (1.2), there is a positive correlation between green credit and the overall operational performance of commercial banks, assuming H1 holds. However, the regression coefficient of the proportion of green credit is relatively small, indicating that the promoting effect of green credit on the operational performance of commercial banks still needs to be improved, laying the foundation for providing relevant policy recommendations in the future.

4.3. Model Test

4.3.1. Economic Test

In the process of economic test, the main judgment is the sign and numerical value of the estimated values of each parameter. From the results, it can be seen that the coefficients of green credit (GL), non-interest income (GII), and total asset size (TA) of banks are positive, while the coefficient of non-performing loan ratio (NPL) is negative, which is in line with the relationship between commercial bank performance and the four variables, and the economic significance is reasonable.

4.3.2. Statistical Inference Test

- ① Goodness of fit test: From Figure 2, it can be seen that the decision coefficient of the model is about 0.9764, and the corrected decision coefficient is about 0.9679, indicating a better fitting effect.
- ② Equation significance test (F-test): Given a significance level of 0.05, the value of the F-statistic from Figure 2 is approximately $13.4780 > F(4, 20) = 2.97$, and the equation significance test passes.
- ③ Variable significance test (t-test): Given a significance level of 0.05, the p-values corresponding to the t-statistics of each explanatory variable in Figure 2 are all < 0.05 , and the variable significance test is passed.

4.3.3. Econometrics Test

- ① Autocorrelation test (DW value)

From Figure 1, it can be concluded that the DW value of the model is approximately 1.8945, and the value of du is 1.767. Therefore, the DW value is in the range without autocorrelation, and the model has no autocorrelation. The autocorrelation test is passed.

- ② Multicollinearity test (variance inflation factor method)

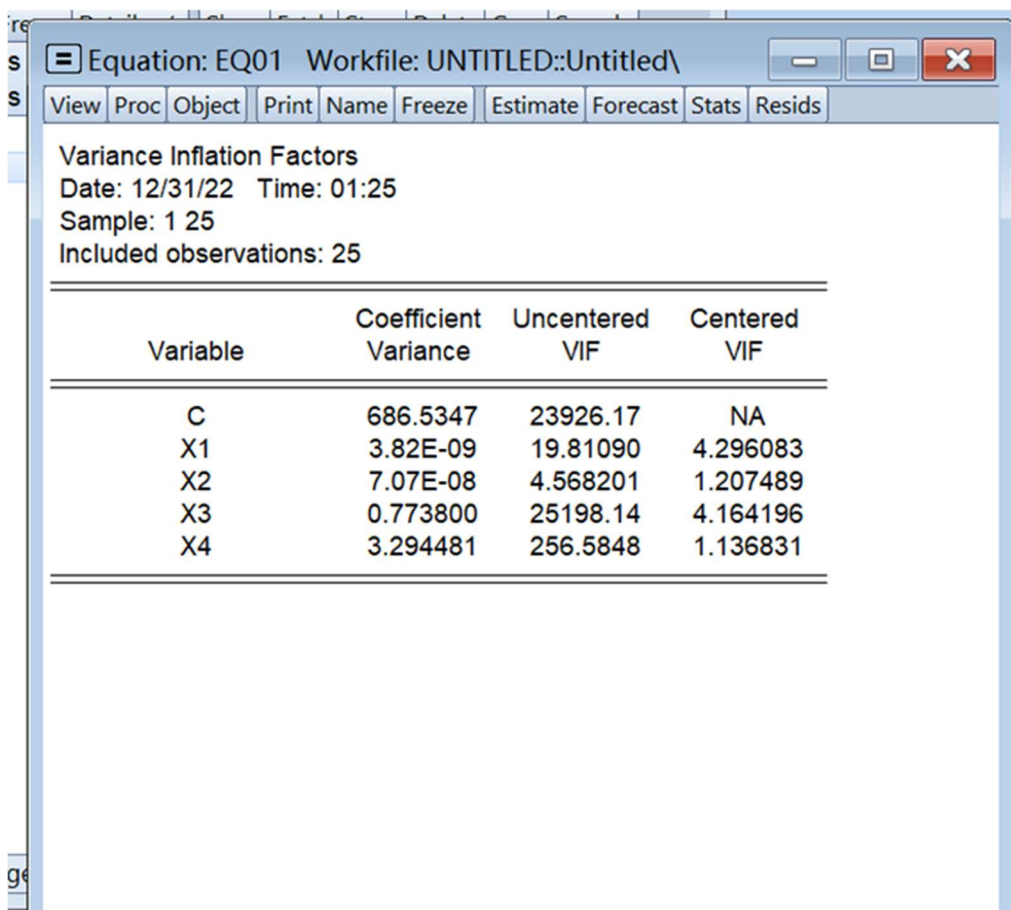


Figure 3. Test Results of Variance Expansion Factor Method

In Figure 3, it can be seen that the VIF values of the four explanatory variables are all less than 10, so the model does not have severe multicollinearity, and the multicollinearity test is passed.

- ③ Heteroscedasticity test (White test)

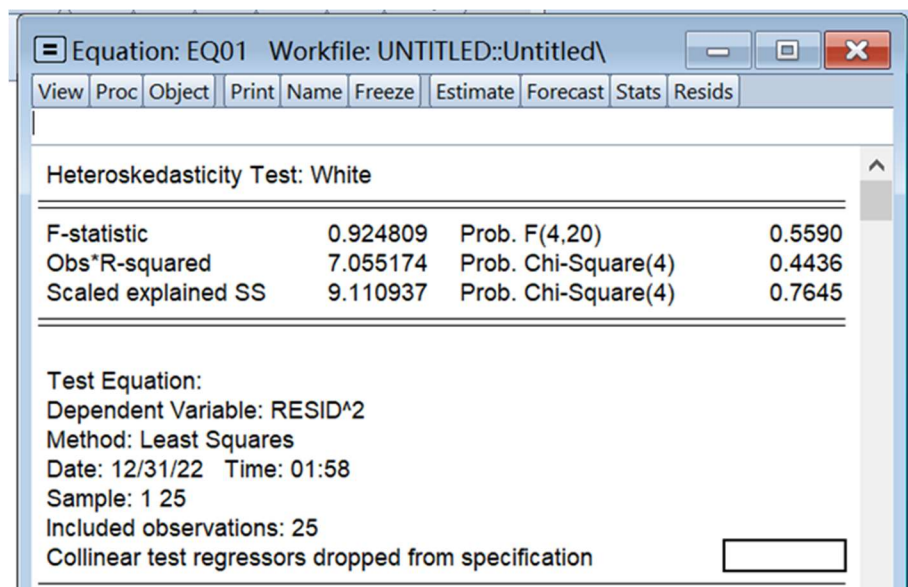


Figure 4. White Inspection Results

According to the White test results in Figure 4, at a significance level of 0.05, the value of nR^2 is less than the chi square critical value of 9.488 obtained from the table, with a p-value of >0.05 . Therefore, there is no heteroscedasticity in this model, and the heteroscedasticity test is passed. In summary, the results of the multiple linear regression equation are as follows:

$$f_{it} = 67.6402 + 0.8637GL_{it} + 1.4779NII_{it} + 2.0609TA_{it} - 3.4659NPL_{it} + \varepsilon_{it}$$

5. Conclusion and Suggestions

This article takes the green credit balance as the research object and empirically analyzes the relationship between the green credit balance of state-owned commercial banks - Bank of China and their operating performance. Research has found that:

5.1. Green Credit Business of Commercial Banks has a Positive Promoting Effect on Their Business Performance.

According to the multiple linear regression model constructed earlier (1.2), the coefficient before green credit balance (GL) is positive, indicating that commercial banks' green credit business has a positive promoting effect on business performance.

5.2. The Promotion Effect of Green Credit on the Operational Performance of Commercial Banks is Relatively Weak.

Although green credit has a promoting effect on the operational performance of commercial banks, its coefficient is very small and its impact is weak. Therefore, significant reforms are needed to promote green technology innovation in commercial banks.

This article believes that, on the premise of laying the foundation for this conclusion and vigorously developing green finance, the banking industry should actively participate in the process of green credit. Recognizing this is not only beneficial for improving the financial operation of banks, but also for promoting the healthy development of the banking industry, financial institutions, financial markets, and even society. In response to this, this article proposes the following suggestions:

5.2.1. On the Government Side

Firstly, establish a green financial regulatory framework that is compatible with China's financial system [9], implement strict regulatory mechanisms for the banking, insurance, and securities industries, and improve the phenomenon of unreasonable allocation of credit resources. Secondly, a set of evaluation mechanisms should be established to evaluate the effectiveness of green fiscal policies, in order to alleviate the asymmetry and lag in policy implementation [10].

5.2.2. In the Banking Industry

Firstly, commercial banks should closely follow the pace of advanced national policies, actively carry out green innovation and develop green financial services with the support and leadership of the central bank. Secondly, banks should effectively fulfill their responsibilities, strictly control credit access, increase resistance to "non green projects" and "non green enterprises", and prevent the mismatch of "credit targets".

5.2.3. Enterprise Aspect

Under policy guidance, enterprises should actively follow up with the national green innovation pace, promote the implementation of the "dual carbon" goal as their corporate goal, develop green projects to participate in commercial bank green credit business, and promote the green innovation development of commercial banks.

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