**An Empirical Study on the Impact of Green Credit on Financial Performance of Chinese Listed Banks**

**Abstract:** With the concept of green environmental protection and sustainability in China has been deeply rooted in the hearts of the people, green credit has become a hot topic in the society in recent years. Chinese financial institutions, especially banks, are also increasingly actively participating and investing in this field. In order to study the correlation between banks' participation in green credit business and banks' financial performance, this paper collects and collates the green credit balance, green credit ratio, return on total assets, non-performing loan ratio and other data of 16 major listed commercial banks in China from 2011 to 2019, builds an econometric model, selects the System GMM regression analysis method, and focuses on the impact of commercial banks’ green credit business on their profitability. The final research results show that banks' increasing investment in the field of green credit has a positive role in promoting their profitability, and the two show a positive correlation. Therefore, this paper suggests that banks should actively develop green credit business, which is beneficial to both the financial performance of banks and the construction of a green and environmentally sustainable society.

**Keywords:** green credit; green credit; bank financial performance

# I Introduction

## 1.1 Background of the study

From the end of February to the beginning of March 2022, the Financial Times, a leading Chinese economic newspaper, launched a social poll called “Hot Topics of the Two Sessions” on its news website, app client, official microblog and its WeChat public website, including traditional and new media channels, to select the topics and content that netizens cared most about. content. During the survey period, nearly 130,000 netizens participated in the poll through various channels. The final results of the survey showed that the option of “green credit” received a turnout of 15.66%, which was the fifth highest in the entire voting list, showing the high level of public concern for the hot topic of "green credit" in economics.

The so-called green credit refers to that the financial sector, such as banks, takes certain measures to give priority support to investment projects in areas such as clean energy, green buildings, green transportation to reduce consumption, energy conservation and emission reduction. Specifically, the financial sector will better support the development of the above projects by combining green credit, green bonds, green insurance, green funds and other financial products and services in many varieties and fields in terms of loan policies, objects and methods. Green credit requires the financial sector to take the harmonious coexistence of man and nature as the basic principle, implement green innovation, sustainable development, industrial transformation, supply side structural reform and other requirements, adhere to the concept of system, and finally form a green credit system with coordinated economic and environmental development.

In terms of the current state of development of green credit, as society attaches more and more importance to environmental protection, the concept of green credit is also receiving more and more attention from the financial sector at home and abroad. At present, the financial institutions that are most concerned about green credit are the banks, as reflected in the various credit businesses related to the environmental protection industry launched by the banking industry, collectively known as "green credit" business. The development of green credit business in China can be traced back to 2007, when the three departments of the CBRC, PBoC and SEPA jointly proposed the Opinions on Implementing Environmental Protection Policies and Regulations to Prevent Credit Risks. Since then, the CBRC issued a further

The Green Credit Guidelines, which more explicitly calls for financial institutions, especially banking institutions, to step up their efforts in green credit operations.

On 22 September 2021, China announced the “Opinions of the State Council of the Central Committee of the Communist Party of China on the Complete and Accurate Implementation of the New Development Concept and the Good Work of Carbon Peaking and Carbon Neutral”, which mainly elaborated on the basic attitude and main policies of the Chinese government towards carbon peaking and carbon neutral, and also indicated that supporting green and low-carbon development would become the focus of the financial sector in China in the coming period. In 2021, the People's Bank of China issued the Green Financial Evaluation Program for Banking Financial Institutions, and the central bank's improvement of the incentive and restraint mechanism has further enhanced the initiative and enthusiasm of Chinese financial institutions in developing green financial services and increased the financial sector's support for them.

The development of green credit business in China has gained momentum, and by the end of 2021, the green credit of Chinese banking institutions reached RMB15.9 trillion, an increase of RMB 3.86 trillion for the year, with a growth rate of 33%, ranking first in the world in terms of worldwide comparison. And the asset non-performing rate of green credit in China is much lower than the overall non-performing level of various loans in the same period, and the overall quality of green credit assets shows good characteristics.

## 1.2 Research Methodology and Research Ideas

This thesis takes green credit, Chinese listed commercial banks, as the main object of study. In recent years, green credit has received more and more attention from the public, and the development of green credit has been strongly supported by relevant government departments. Moreover, green credit is significantly different from traditional finance in terms of loan assets. Green credit is an innovative business area for banks, and the banking industry in China is also enthusiastic about this business area. The thesis starts with a theoretical analysis, in which the green credit business and financial performance of banks are firstly explained in the theoretical analysis chapter, and then further analyses how green credit affects the profitability of banks in both positive and negative ways. Secondly, in the research design chapter, this paper constructs an econometric model by collecting data related to green credit and financial performance of commercial banks, selecting the variables in the econometric model and choosing the regression method of systematic GMM in three segments. Afterwards, in the empirical analysis chapter, the paper regresses the designed econometric model, analyses the results obtained, and performs robustness tests on the model. Finally, in the Conclusions and Recommendations section, the thesis draws conclusions and makes recommendations based on the theoretical and empirical analysis.

## 1.3 Review of the literature

Wu Lianghai, Hu Yue and Yang Lu (2022) used the financial data of 20 commercial banks in China from 2008 to 2019 as the basis of their study, and used the DID model to study the impact of green credit on the financial performance of commercial banks, and the results of the study indicated that commercial banks could improve their financial performance by increasing their investment in green credit. Zhang Hui, Zhu Wanwan, Xu Yusuan et al. (2021) used a double-difference propensity score matching method to study the impact of green credit on the financial performance of 35 listed commercial banks in China from 2005 to 2018, and the results of the study showed that the increase in green credit investment had a boosting effect on the financial performance of state-owned banks in China, but had a negative effect on the joint-stock banks in China. The results show that the increase in green credit has a positive effect on the financial performance of state-owned banks in China, but a negative effect on joint-stock banks in China. Chen Kun, Sun Xiubing and Yu Huilin (2021) studied the relationship between green credit and banks' financial performance based on the data of 14 commercial banks in China from 2011 to 2019, and found that green credit had a positive impact on the operating conditions and financial performance of commercial banks. Zhang Lin and Lian Yonghui (2020) used the relevant data of 29 major commercial banks in China from 2007 to 2017 as the analysis data, and used the ordinary least squares method to construct an OLS model to test the impact of commercial banks' green credit business on their financial performance indicators such as net interest margin, and the empirical results showed that the increase of banks' green credit balance as a percentage of their issued loans had a positive effect on their net interest margin level The empirical results show that the increase in the percentage of banks' green credit balance to their loans issued has a catalytic effect on the improvement of their net interest margin level. Wang Jianqiong and Dong Ke (2019) construct a random effects variable intercept regression model based on relevant panel data of 12 commercial banks in China from 2010 to 2017, and the results of the empirical analysis show that the development of green credit business has a negative impact on the financial performance of large state-owned banks in China, while the impact on the operating performance of small and medium-sized joint-stock commercial banks in China is not significant.

A comprehensive analysis comparing the existing research papers shows that scholars have different views on whether the impact of green credit on the financial performance of commercial banks is positive or negative, and the specific empirical analysis methods used by different scholars also differ, as do the conclusions drawn.

# II Theoretical Analysis

## 2.1 A description of green credit operations and financial performance

Green financial services include green credit, green bonds and green funds, etc. This paper decides to focus on green credit as the focus of the empirical study, based on the scale of each of these services and the availability of relevant data. This is followed by a description of financial performance. In conducting their business operations, commercial banks are generally guided by the so-called “three principles”, i.e. “safety, liquidity and profitability” of commercial banks. Profitability is central to the business activities of commercial banks, as it is a requirement for commercial banks to maximise their profitability, in other words, to maximise their business results at minimal cost. Therefore, this paper, with reference to the existing literature and the availability of data, decides to focus on the profitability of listed commercial banks in China as the focus of the empirical study of their financial performance, that is, to quantify the financial performance of commercial banks into the relevant financial indicators that can indicate the profitability of the banks. In the following, this paper will explore, from a theoretical perspective, what impact green credit can have on the profitability of banks and the mechanism of action that causes the impact.

## 2.2 Impact of green credit on the profitability of commercial banks

Studies have been conducted to show that the development of green credit business may affect the profitability of banks in several ways.

### 2.2.1 Expanding new business models

Nowadays, the homogeneity of the operating models of commercial banks in China is more serious, so the competition among banks in traditional business sectors is becoming increasingly fierce. The green credit business, as an emerging business area, still has a lot of room for development. In addition, in recent years, Chinese government has put the concept of green protection in a more important position in its development philosophy, and banks are gradually reducing the amount of loans to traditional "two high and one leftover" enterprises, i.e. resource-based industries with high pollution and energy consumption, and industries with excess capacity. The banks have to face the general environment of a depressed real estate market. It is imperative for market commercial banks to do business differently and to find and build new profit growth areas, and green credit business is certainly a good area to do so. Foreign scholars Siegel and Vitaliano (2007) have concluded that differentiation is one of the most important competitive strategies. By entering the green credit field and launching lending business for green and environmental protection enterprises, commercial banks can seize the first opportunity to develop in this field, occupy a favourable position, obtain a first-mover advantage, further obtain more high-quality green credit projects, form a differentiated competitive advantage, improve the bank's competitiveness and ultimately enhance the bank's profitability and revenue level.

### 2.2.2 Improving asset quality

Commercial banks can generally obtain high returns in the short term by granting loans to traditional “two high and one surplus” enterprises, but in an environment where the concept of green environmental protection is gradually gaining popularity and the government is becoming stricter and more concerned about environmental evaluation and supervision and enforcement, "two high and one surplus" enterprises, due to their production nature, may not meet the standards in the relevant environmental evaluation and may violate the relevant policies and regulations. Due to the nature of their production, "two high and one leftover" enterprises often cause serious pollution to their surroundings and may fail to meet the relevant environmental assessment and violate the relevant policies and regulations, which may lead to the enterprises being forced to pay certain fines, which may bring additional pressure on their operations, and in more serious cases, these enterprises may even be ordered to cease operation and rectification. In more serious cases, these companies may even be ordered to cease operations. These possibilities are becoming more and more likely as the concept of green development becomes more mainstream. If commercial banks grant loans to these enterprises, the default rate of these "two high and one surplus" enterprises will increase, and the possibility of their loans being converted into non-performing assets will also increase, which will undoubtedly have a negative impact on the banks' business conditions. This will undoubtedly have a negative impact on the banks' business conditions.

In addition, banks may be held jointly and severally liable by the relevant regulatory authorities for granting loans and providing financial services to these polluting enterprises, which may place a burden on the financial performance of the bank and even affect the image of the penalised bank in the eyes of the public, further increasing the bank's losses. In contrast to the "two high and one leftover" enterprises, green credit business and related policies are required to be monitored by the public, and banks and the government are required to disclose information about the environmental and social impact of their business, and to make the detection of the environmental impact of enterprises, their pollution control and their ecological protection an important reference rule for banks in granting loans. This will undoubtedly raise the threshold for enterprises to apply for loans. The above-mentioned green credit policy formulation and operations have raised the level of commercial banks' ability to control operational risks. In addition, it will also help to solve the problem of loans issued that have long been difficult for banks to deal with in the past being transformed into non-performing assets such as doubtful and dead loans, reducing the risks faced by banks and ultimately effectively improving the financial performance of commercial banks. Finally, commercial banks' support for green enterprises helps to achieve sustainable development, creating a development environment in which people and nature live in harmony and more healthy and sustainable industries, which can also bring positive externalities to banks.

### 2.2.3 Developing new types of intermediary business

Green credit business carried out by commercial banks can not only bring new credit business directly to the banks, but also generate some new intermediate business. For example, commercial banks can provide some green financial consulting services, play the role of financial consultant related to green finance, and provide financial leasing services related to green finance. As an emerging business field, with the rapid development of green finance, the intermediate business will gradually become rich, and commercial banks can also gain profits from these intermediate businesses. Moreover, the activity of these intermediary businesses will also enhance the diversification of banks' income methods. According to the research of Yin Kaingrui and Zhu Jianlin (2017) on the impact of commercial banks' income structure on their profitability, the diversification of commercial banks' income can significantly improve their financial performance, especially their revenue level.

### 2.2.4 Improving the social evaluation of commercial banks

The widespread and increased efforts of commercial banks to develop green credit business can be seen as a manifestation of commercial banks' proactive social responsibility, and this will bring benefits to banks in several ways. Firstly, the initiative of commercial banks to take up social responsibility helps them to establish good cooperation with the government and other social organisations, and according to the results of a study by Chinese scholars Zhang Zhaoguo, Jin Xiaocui and Li Gengtai (2013) on the relationship between corporate social responsibility and financial performance, the increase in awareness of social responsibility and the assumption of social responsibility by enterprises has a positive impact on their financial performance. Commercial banks' green credit business strongly supports the country's green and sustainable development strategy, and therefore may enable them to obtain various subsidies as well as preferential measures granted by the government and the central bank, for example, the People's Bank of China has extended the scope of quantitative evaluation of financial institutions to green credit and green bonds in the green credit Evaluation Programme for Banking Financial Institutions released in 2021, in addition, the programme also reserves space in advance for other businesses in green credit such as green insurance, green wealth management, green funds and green trusts. In addition, the People's Bank of China has also developed policies and products to support the reduction of carbon emissions and the refinancing of loans specifically for the efficient and clean use of coal. Secondly, green credit is a way for banks to gain the support of customers who value the environment. In today's society, the concept of green and sustainable living is gaining popularity, and commercial banks taking the initiative to assume social responsibility for environmental protection will gain the favour of customers who are more environmentally conscious and establish an advantageous position for the bank to gain customers. Finally, in addition to customers, commercial banks can also gain the favour of green investors in the capital market by conducting green credit business. The act of doing green credit can send a message to the capital markets that banks value green-related financial services. Further, the focus and expansion of resources in the green credit business by commercial banks can also demonstrate to the outside world that they have strong green financial capabilities, which can help them attract investment from green investors in the capital markets.

### 2.2.5 Negative effects

Commercial banks undertaking green credit projects can likewise have a negative impact on their profitability. In the following, this paper will examine what negative effects green credit has on commercial banks and the mechanisms of its effects from several different theoretical perspectives.

The development of green credit may increase the operating costs of commercial banks, which can be analysed from two aspects: direct costs and indirect costs. In terms of direct costs, as green credit is an emerging field, there is still a certain talent gap in Chinese banking industry and financial institutions in this field, and as Chinese green credit business has been launched relatively late, there is still room for improvement in the degree of specialisation. This will result in certain trial and error costs, which will impose an additional burden on the banks' operations. In addition, as the threshold for green credit is high for enterprises applying for loans, banks need to test and evaluate the environmental standards and pollution control effects of the applicant enterprises, which will cost the banks extra manpower, material and time costs. In addition, green enterprises are mostly projects with long production cycles and high marginal costs in the production process. In order to give green enterprises preferential treatment in order to support their better development, commercial banks may also grant loans at lower interest rates to enterprises that meet green standards. In addition to direct costs, there are indirect costs associated with the development of green credit. As banks have limited funds and resources, increased investment in green credit by commercial banks will inevitably squeeze out the resources invested in traditional credit operations. Despite the rapid development of green credit over the past period, traditional financial services still account for the majority of the total loans granted by commercial banks and are their core business, and the reduction of resources invested in their core business may weaken their core competitiveness. In addition, the reduction of commercial banks' credit to the "two high and one leftover" enterprises will also add some additional costs. The reduction in bank lending to these enterprises will have a negative impact on the short-term financial performance of banks, which generally earn higher returns in the short term. The reduction of loans to these enterprises will increase the chances of their production and operation difficulties, which will increase the risk of default of the bank's initial investment in these enterprises and make it easier to turn them into non-performing assets, which is detrimental to the bank's risk management. Finally, some of the customers of the "two high and one leftover" enterprises reduced by commercial banks may turn to rival banks in the same industry, making the banks face increased competition in the market in the short term, which will have a negative impact on the profitability of banks.

In summary, the green credit business can have a positive and negative impact on the profitability of commercial banks in two different directions, and the final effect of green credit on the financial performance of banks needs to take into account the neutralisation of the two forces of different nature, which requires the use of more precise data for analysis. In the following, a statistical model will be constructed to carry out the empirical analysis.

# III Study Design

## 3.1 Collecting and collating data

Chinese green credit policy was first proposed on 12 July 2007, and the disclosure of green credit-related data, such as green credit balance and green credit ratio, by commercial banks in China generally started in 2007. The disclosure of green credit data by most of the listed commercial banks in China was not common in the first few years after 2007, but after 2010, more and more banks published their green credit business development and the data was gradually improved. In this paper, from the perspective of data availability and completeness, we decided to select the development of green credit business of some listed commercial banks in China in the nine years starting from 2011 to 2019. Taking the completeness of the data related to green credit disclosed by listed commercial banks in China as the selection criterion, 16 banks that published complete data on green credit during the period from 2011 to 2019 were selected as the subjects of the empirical study. These listed commercial banks are Ping An Bank (PAB), Bank of Ningbo (BON), Shanghai Pudong Development Bank (SPDB), Hua Xia Bank (HXB), China Minsheng Banking Co. (CMB), Bank of Jangsu (BOJ), Industrial Bank Co. Industrial and Commercial Bank of China (ICBC), China Everbright Bank (CEB), China Construction Bank (CCB), Bank Of China (BOC), and China Citic Bank (CITIC). In this paper, by collecting relevant data disclosed in the financial annual reports and social responsibility reports published on the respective official websites of the above listed commercial banks from 2011 to 2019, we collated and plotted the tables to summarise the balanced panel data with 16 valid observation samples, 9 years and a total of 144 observations.

## 3.2 Building the econometric model

### 3.2.1 Selection of explanatory and explained variables

Explained variable: return on total assets. This paper studies the impact of conducting green credit business on the financial performance of listed commercial banks in China, where the financial performance of banks is again mainly related to the indicators of profitability. By referring to the empirical study on the impact of green credit and internal and external policies on the competitiveness of commercial banks done by Chinese scholars He Lingyun and Wu Chen et al. (2018), this thesis decides to use the return on total assets as an indicator of the profitability of horizontal commercial banks, which is also used as the explanatory variable in this empirical analysis. Return on Total Assets (ROA), abbreviated as ROA, is calculated as the net profit generated by a commercial bank per unit of assets, and its specific formula is

Return on total assets (ROA) = Net Profit ÷ Total Assets x 100% (3.1)

Core explanatory variable: green credit balance. The focus of this paper is on the impact of green credit on banks' financial performance in green credit business. Referring to the existing literature on the measurement of commercial banks' investment in green credit, this paper decides to use the green credit balance, which is the sum of loans invested by commercial banks in various energy-saving and environmental protection projects and related service businesses, as a quantitative indicator to reflect the development of commercial banks' green credit business. In addition, considering that the development of green credit business has a certain lag effect on the profitability of commercial banks, and referring to the study of He Lingyun et al. (2018), this paper decides to use the lagged period of green credit balance as the core explanatory variable in the empirical study in the model. Green Credit Balance (GCB), abbreviated as GCB, measures the total amount of credit invested by commercial banks in green economic projects.

Control variables: NPL ratio, total assets of commercial banks, capital adequacy ratio of commercial banks. One-period lagged return on total assets. From the above analysis, it is clear that there are a number of different paths and ways in which the development of green credit by commercial banks can impact their financial performance, and this paper will introduce control variables to improve the econometric model. Firstly, the quality of assets is an important factor that affects the return on total assets as the explanatory variable selected in this paper. Therefore, for the sake of theoretical soundness and completeness, this paper decides to introduce an indicator to quantify the quality of assets in the econometric model. By referring to the study on the impact of green credit on bank operating performance by Wang Jianqiong and Dong Ke (2019), this paper selects the non-performing loan ratio as a measure of asset quality and introduces it into the model as a control variable. The non-performing loan ratio (NLR), abbreviated as NL, is calculated as the proportion of non-performing loans to the total loan balance of commercial banks, and is calculated by the following formula.

Non-performing loan ratio (NL) = (subordinated loans + doubtful loans + loss loans)

÷ loss loans x 100% (3.2)

Secondly, the 16 banks selected as the research sample in this paper include both large state-owned banks, such as the four major state-owned banks, and some small and medium-sized local joint-stock commercial banks, and there are certain differences between the different research subjects. Therefore, based on the rigour of the empirical research, this paper decides to introduce the differences in the internal factors of the research subjects as influencing factors in the construction of the econometric model. By analysing the existence of significant and deterministically different financial performance indicators for commercial banks of different sizes, plus drawing reference from the study of Wang Jianqiong et al. (2019), this paper decides to select the total assets of commercial banks and the capital adequacy ratio of commercial banks as the data indicators for quantifying the internal factors of commercial banks. Finally, in order to make the mathematical model more rigorous and complete, this paper decides to select the one-period lag of the return on total assets as the explanatory variable to be introduced into the econometric model used in the study, considering that the financial performance of commercial banks in previous periods will have certain influence on the financial performance in the current period. Total Assets (TA) of a commercial bank, abbreviated as TA, quantifies all the assets owned or controlled by the commercial bank. The one-period lagged return on total assets, abbreviated as ROAi,t-1 , is calculated as the ratio of a bank's total capital to its risk-weighted assets, calculated as

Capital adequacy ratio (CA) = Capital ÷ Risk Assets x 100% (3.3)

The core explanatory variable used for robustness testing: the green credit ratio. In addition to using green credit balance as a measure of green credit size in green credit-related studies, some scholars also use green credit ratio as an indicator to quantify the intensity of commercial banks' investment in green credit business, such as referring to the practice of using green credit ratio as the core explanatory variable in the study on the impact of green credit on the heterogeneity of banks' financial performance conducted by Zhang Lin and Lian Yonghui et al. (2020). Unlike the aggregate indicator of green credit balance, the green credit ratio is a relative indicator. On balance, this paper decides to introduce the green credit ratio as an alternative variable to the original core explanatory variable of green credit balance in the robustness analysis of the econometric model, in order to make the whole process of empirical analysis more complete and rigorous. The Green Credit Ratio (GCR), abbreviated as GCR, is calculated as the proportion of green credit balances to total loans issued by banks, and is calculated as follows.

Green credit ratio (GCR) = Green credit balance (Green credit balance) ÷ Total bank

loans (Total loan) x 100% (3.4)

### 3.2.2 Setting up the model

Through the analysis and selection of the explanatory and explanatory variables above, the final empirical analysis model constructed in this paper is shown below.

ROAi,t =(model 1)

Considering that the green credit balance is an aggregate indicator while the return on total assets is a relative indicator, in order to eliminate the undesirable consequences of possible heteroskedasticity in the regression analysis (Hou Jingya, Lu Xiaoyu, 2022), this paper decided to take the natural logarithm of the data for the green credit balance variable to eliminate heteroskedasticity.

In Model 1, different values of the subscript i for each variable indicate different commercial banks and different values of the subscript t for each variable indicate different years of the commercial bank. ROAi,t indicates the return on total assets of commercial banks, indicates the one-period lagged return on total assets of commercial banks, indicates the green credit balance of commercial banks after taking the natural logarithm, indicates the non-performing loan ratio of commercial banks, indicates the total assets of commercial banks, indicates the capital adequacy of commercial banks, indicates the unobservable fixed effects in Model 1, indicates the random disturbance term in Model 1.  denotes total assets of commercial banks, denotes capital adequacy ratio of commercial banks, denotes unobservable fixed effects in Model 1 and denotes random disturbance terms in Model 1.

## 3.3 Choice of measurement method

Firstly, based on the general econometric model constructed in this paper and the type and characteristics of the data selected, it can be determined that the data used in this study is panel data. Based on the analysis and selection of the explanatory and explanatory variables chosen in the model above, it can be seen that this paper introduces a one-period lag of the explanatory variable total return on assets in the explanatory variables of the econometric model, and therefore the econometric model that should be built in this paper should be that of a dynamic panel. For the dynamic panel, the

In a regression analysis, it is not possible to use methods such as simple difference and within-group deviation as in a static panel in order to eliminate fixed effects, and ultimately it is not possible to obtain consistent estimates of the coefficients before the explanatory variables, which is also referred to as dynamic panel bias (Nguyen Van-Thep, Liu Day-Yang, 2019). Secondly, from the perspective of the research subjects selected for this paper, there are significant differences in the nature and size of the different commercial banks that are the subject of the study, for example, there are large state-owned banks such as the Big Four, but also some local small and medium-sized joint-stock commercial banks, so there are considerable individual differences in the research sample selected for this paper, which means that when considering the measurement method, we must take into account the possible In other words, when considering the measurement method, this paper must take into account the possible existence of individual fixed effects. By fixed effects, we mean that even though the intercept term of the model may differ between the different samples (in this paper, the 16 commercial banks selected), the intercept does not change over time across the different samples.

In addition, this paper needs to discuss the problem of endogeneity variables that may exist in the setting of the model. The problem of endogeneity refers to the correlation between one or more explanatory variables in the mathematical model and the random disturbance term of the model (Raza Kashif et al, 2019). Although this paper will study the impact of the development of green credit business on the financial performance of commercial banks, the theoretical analysis shows that the financial performance of commercial banks may also counteract the development of green credit business of banks, which is also known as the phenomenon of mutual causality, and this will lead to This can lead to endogeneity problems in the model. Therefore, an endogeneity test is needed to check whether the model has endogenous variables.

This paper uses the Hausman test for endogeneity testing of the constructed models, for model 1 constructed above and for the robustness tests to be constructed below

model (Model 2), i.e. the core explanatory variable green credit balance in Model 1 is replaced with a robustness test model (Model 2) for the green credit ratio and a Hausman test is conducted. The results of the Hausman test are presented in Table 3.1 below.

Table 3.1 Hausmann test results

|  |  |  |
| --- | --- | --- |
| Name of measurement model | Hausmann test value | P-value |
| Model 1 | 89.45 | 0.0000 |
| Model 2 | 74.47 | 0.0000 |

The original hypothesis can be seen by looking at the results of the Hausman test in Table 3.1. That is, the model does not have endogenous variables and is rejected at the 1% level, then it can be assumed that there are endogenous variables in either model 1 or model 2.

In summary, in order to effectively control as well as overcome the individual fixed effects and endogeneity problems of the model, this paper decided to select the system generalised moment estimation model, also known as the system GMM model, as the econometric analysis method used for the study. The method uses an instrumental variable (tentatively set as Zit ), uncorrelated with the random disturbance term , i.e. . of the generalised moment condition to estimate generalised moments for the parameters before the explanatory variables. In addition, the panel data used in this study is a short panel of 16 commercial banks and 9 years of large N and small T data, which is consistent with the applicable prerequisites for dynamic panel generalised moment estimation. The systematic GMM model uses the difference values of the lagged variables of the explanatory variables as instrumental variables for the endogenous explanatory variables in the level equation and the level values of the lagged explanatory variables as instrumental variables for the endogenous explanatory variables in the difference equation, which helps to control for endogeneity problems and individual fixed effects in the econometric model.

# IV Estimation of the econometric model and analysis of the regression results

With the mathematical model set up above, the selection of variables in the model and the choice of measures, the following paper will formally begin the regression analysis. The econometric software used to estimate the model in this paper is STATA.

## 4.1 Model estimation

### 4.1.1 Descriptive statistics and analysis of statistical results

Firstly, the sample collected by the author was firstly defined for the panel data, as well as the cross-sectional and temporal variables. Secondly, descriptive statistics were conducted and the results of the statistics are shown in Table 4.1 below.

Table 4.1 Descriptive statistics for panel data

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable name | Variable abbreviations | Average | Standard deviation | Minimum value | Maximum  value |
| Return on total assets | ROA | 1.057356 | 0.195199 | 0.7134 | 1.4748 |
| Green Credit Balance | GCB | 2344.152 | 3234.665 | 5.34 | 12377.58 |
| Non-Performing Loan Ratio | NL | 1.265694 | 0.406027 | 0.38 | 2.39 |
| Total assets | TA | 74618.51 | 73644.47 | 2604.98 | 301094.4 |
| Capital Adequacy Ratio | CA | 12.86278 | 1.573643 | 9.88 | 17.52 |
| Green Credit Ratio | GCR | 4.808348 | 5.099686 | 0.09013369 | 29.37424 |

As can be seen from Table 4.1 above, the standard deviation of the return on total assets of the 16 different commercial banks selected for this paper is about 0.20%, and the standard deviation of total assets is about 73,644.5, which indicates that there are large differences in the return on total assets and the scale of the banks among the different commercial banks as the subject of the study, which is also consistent with the theoretical prediction before the analysis. the green credit balance of the 16 commercial banks The average value of green credit balance of the 16 commercial banks is about RMB234.415 billion and the average value of green credit ratio is about 4.81%, thus it can be seen that the scale of green credit business carried out by commercial banks in China is not large enough and there is still room for improvement. In addition, the standard deviation of green credit balance is about 3234.67, and the standard deviation of green credit ratio is about 5.10, which indicates that there is also a certain difference in the scale of green credit business carried out by these 16 listed commercial banks in China. In addition, the maximum non-performing loan ratio of the 16 commercial banks in the sample over the nine years from 2011 to 2019 is 2.39%, which is less than 5%, meaning that the likelihood of serious credit risk for the 16 banks during the nine years is low, the asset quality of each bank is relatively healthy, and the banks' control of their business risks is within a reasonable range. The minimum capital adequacy ratio of the 16 banks in the sample over the 9-year period was 9.88%. According to the Basel III Accord issued on 21 September 2010, the capital adequacy ratio of commercial banks should not be less than 4%. In summary, it can be seen that the banks selected for this study have performed well in terms of resisting possible credit risks.

### 4.1.2 Systematic GMM model estimation and analysis of regression results

After entering a series of program commands for the regression of the OS-specific GMM model in the econometric software STATA, the econometric software regresses the previously constructed mathematical model 1.

ROAi,t =(model 1)

A systematic GMM regression analysis was carried out and the regression results were summarised and collated and the significant information is shown in Table 4.2 below.

Table 4.2 Model 1 system GMM model estimation results

|  |  |  |  |
| --- | --- | --- | --- |
| Variable name | Parameters to be estimated | Parameter estimates | P-value |
| ROAi ,t-1 |  | 0. 743374 | 0. 000 |
| lnGCBi,t-1 |  | 0. 0526519 | 0.001 |
| NLit |  | -0.2205349 | 0.000 |
| TAit |  | -8.11e-07 | 0. 000 |
| CAit |  | 0. 0172943 | 0. 023 |

Systematic GMM models require over-identification tests and autocorrelation tests in the process of use.

By autocorrelation test, it is meant that one of the applicable conditions for a systematic GMM model is that the random disturbance terms of the model be free from serial correlation. The test for autocorrelation will use the AR(2) test as well as the AR(3) test, which tests whether there is second-order autocorrelation or third-order autocorrelation in the differences of the random disturbance terms, and the results of the AR(2) as well as the AR(3) tests are shown in Table 4 below.

Table 4.3 AR(2) test for Model 1 and AR(3) results

|  |  |  |
| --- | --- | --- |
| Name of measurement model | AR(2) test p-value | AR(3) test p-value |
| Model 1 | 0.088 | 0.630 |

As can be seen from Table 4.3 above, the p-value of the AR(2) test is greater than 5%, which indicates that Model 1 is insignificant at the 5% significance level, i.e. the original hypothesis of the AR(2) test "no autocorrelation of the random disturbance term" is accepted, while the p-value of the AR(3) test is greater than 0.10, which indicates that Model 1 is insignificant at the 10% significance level, i.e. the original hypothesis of the AR(3) test “no autocorrelation of the random disturbance term” is not rejected. This means that model 1 is not significant at the 10% significance level, i.e. the original hypothesis of the AR(3) test "no autocorrelation of the random disturbance term" is not rejected. In summary, the model is generally consistent with the applicable assumptions of the systematic GMM model and ensures the consistency of the estimation of the parameters of the systematic GMM model.

The so-called over-identification test refers to the use of a systematic GMM model to perform an over-identification test on the appropriateness of the instrumental variables used in the model, i.e. whether the setting of the instrumental variables in the econometric model is reasonable. In this paper, the Sargan test and the Hansen J test will be used for the over-identification test, and the results of the test for Model 1 are shown in Table 4.4 below.

Table 4.4 Sargan test for model 1 and Hansen J test results

|  |  |  |
| --- | --- | --- |
| Name of measurement model | Sargan test p-value | Hansen J test p-value |
| Model 1 | 0.212 | 0.933 |

As can be seen from Table 4.4 above, the p-value of the Sargan test is greater than 0.10, indicating that Model 1 is not significant at the 10% significance level, i.e. the original hypothesis of the Sargan test "instrumental variables are reasonably used and there is no over-identification" is accepted, while the p-value of the Hansen J test is also greater than 0.10. This indicates that Model 1 is not significant at the 10% level of significance, i.e. the original hypothesis of the Hansen J test is accepted as "the instrumental variables are used reasonably and there is no over-identification". In summary, it can be judged that the instrumental variables chosen for model 1 are valid.

In the following, the results of the regression of the system GMM model in Table 3 above will be analysed. From Table 3 it can be seen that the estimated results of the coefficient before the variable has a p-value of less than 0.01, indicating that the coefficient is significant at the 1% level of significance. The estimated value of the coefficient is approximately 0.0527, which indicates that for every 1% increase in the amount of green credit balances invested by listed commercial banks in China in the previous period, the return on total assets of these commercial banks increases by 0.0527%, with other control variables held constant. At the same time, the value of this coefficient is greater than zero, indicating that commercial banks' development of green credit business still has a positive impact on their profitability level, which is the core issue of this paper's research. The estimated p-value of the coefficient of the variable before is less than 0.01, which indicates that this coefficient shows significant at the 1% level of significance. The estimated value of this parameter is approximately -0.221, which indicates that for every 1% increase in the NPL ratio of a commercial bank, the bank's total return on assets decreases by 0.221%, holding all other explanatory variables constant. The estimated p-value of the parameter preceding the variable is 0.023, which is less than 0.05, indicating that the parameter behaves significantly at the 5% level of significance. The estimated value of is approximately 0.017, which implies that for every 1% increase in the capital adequacy ratio of a commercial bank, the capital adequacy ratio of the bank will increase by 0.017% under the assumption that the other independent variables remain constant. The regression results for the above two parameters also indicate that an increase in the asset quality of commercial banks has a positive effect on their profitability, and this result is consistent with the theoretical analysis as well as common sense logic, further demonstrating that the model does not contradict economic theory and justifying the model previously constructed. The p-value of the regression results for the coefficient of before the explanatory variable is less than 0.01, which can be explained by the fact that the coefficient behaves significantly at the 1% significance level criterion. The estimated value of the coefficient is less than 0. This indicates that as the total assets of commercial banks rise, the return on total assets of banks will fall, reflecting a negative correlation between the scale of operations and profitability of commercial banks. The explanation for this regression result is that the sample selected in this paper includes the four state-owned banks and some other listed commercial banks with large asset size, and as the asset size of banks expands, the marginal return of total assets to commercial banks will diminish. In the regression model, there is a negative correlation between the two, i.e. the value of is less than 0.

## 4.2 Robustness tests

In order to make the econometric model constructed in the previous section more convincing, robustness tests are conducted below. By robustness tests I mean to go through the robustness of the constructed econometric model methodology and the explanatory power of the explanatory variables selected by the model. In this paper, we will start with the selection of variables and look for alternative variables to replace the core explanatory variable of green credit balance in model 1 . Based on the previous analysis when conducting the selection of the explanatory variables, this paper will use the green credit ratio in place of the green credit balance and ultimately construct model 2 as follows.

ROAi,t = (model 2)

A systematic GMM regression analysis was conducted for Model 2 and the regression results are shown in Table 4.5 below. In addition, the AR(2) test and AR(3) test were performed on Model 2 and the results are shown in Table 4.6 below. In addition, the Sargan test as well as the Hansen J test were conducted for Model 2 and the results are shown in Table 4.7 below.

Table 4.5 Model 2 system GMM model estimation results

|  |  |  |  |
| --- | --- | --- | --- |
| Variable name | Parameters to be estimated | Parameter estimates | P-value |
|  |  | 0.6923059 | 0.000 |
|  |  | 0.0000385 | 0.021 |
| NLit |  | -0.1146441 | 0.034 |
| TAit |  | -8.72e-07 | 0.075 |
| CAit |  | 0.0368838 | 0.000 |

Table 4.6 AR(2) test for model 2 and AR(3) results

|  |  |  |
| --- | --- | --- |
| Name of measurement model | AR(2) test p-value | AR(3) test p-value |
| Model 2 | 0.062 | 0.319 |

Table 4.7 Sargan test for model 2 and Hansen J test results

|  |  |  |
| --- | --- | --- |
| Name of measurement model | Sargan test p-value | Hansen J test p-value |
| Model 2 | 0.997 | 0.980 |

The results of the above series of manipulations show that the coefficient before the green credit ratio variable in model 2 is greater than zero at the 5% significance level, indicating that an increase in the green credit ratio of commercial banks has a positive impact on the return on total assets of banks, confirming the findings in model 1 above. In addition, the significance of the remaining explanatory variables did not change significantly from positive to negative. is less than 0 at the 5% significance level and is less than 0 at the 0.1 significance level, indicating that the regression results for NPL ratio and total assets show a negative relationship between the two and return on total assets. In contrast, is greater than 0 at the 1% significance level, indicating a positive relationship between capital adequacy ratio and return on total assets. The results of the regression analysis of model 1 are generally consistent with the above analysis. The results of AR(2) test for model 2 indicated that model 2 accepted the original hypothesis of no autocorrelation of the random disturbance term at the 5% significance level, and the results of AR(3) test indicated that model 2 accepted the original hypothesis of no autocorrelation of the random disturbance term at the 0.1 significance level. The Sargan test for model 2 indicates that model 2 accepts the hypothesis that "the instrumental variables are used reasonably and there is no over-identification" at the 10% level of significance, and the Hansen J test for model 2 indicates that model 2 accepts the hypothesis that "the instrumental variables are used reasonably and there is no over-identification" at the 10% level of significance. The Hansen J test for Model 2 indicates that Model 2 accepts the original hypothesis of "reasonable use of instrumental variables and no over-identification" at the 10% significance level. The above tests indicate that the use of Model 2 meets the prerequisites and the reasonableness of the instrumental variables used.

In summary, the good performance of the robustness test results indicates that the econometric model constructed in this paper and the selection of the systematic generalised moment estimation method as the measure is relatively robust.

# V Conclusions and recommendations

## 5.1 Research findings

In Part 1, this paper describes the general context in which green credit is now attracting attention and outlines the current research dynamics of domestic scholars on the correlation between green credit and the financial performance of commercial banks. In Section 2, the mechanism of the impact of green credit on the profitability of commercial banks is analysed, and it is concluded that the former can have both positive and negative effects on the latter. In Part 3 and Part 4, the paper collects and collates data, constructs an econometric model, and selects a measurement method. The empirical study concludes that there is a positive relationship between commercial banks' increasing efforts in green credit business and their profitability.

## 5.2 Recommendations for green credit

Based on the findings of the study, this paper gives the following suggestions on how to increase the investment of commercial banks in green credit in China, both from the banks and the government.

### 5.2.1 Recommendations to the Government

In recent years, the People's Bank of China, the China Banking Regulatory Commission, the Environmental Protection Bureau and other government departments have issued many policies and measures to stimulate the development of green credit, but most of these measures are some recommendation-based and initiative-based policies and some guidance documents of moral persuasion, and their legal binding force is weak. Therefore, there is still some room for the government to promote commercial banks to fulfil their responsibilities and obligations in terms of green sustainability and to encourage them to invest more in green credit. For example, the CBRC should strengthen its supervision of commercial banks' credit activities, introduce binding laws and regulations in the field of green credit, improve the legal system and policy system in the field of green credit, and strictly restrict banks from granting credit to enterprises that are contrary to the concept of sustainable development, such as the so-called "two highs and one surplus". The government should also strengthen its efforts to ensure that the green financial system is not compromised. Secondly, the Environmental Protection Bureau and other government departments should strengthen their efforts to conduct strict environmental assessments and environmental reviews of corporate and enterprise credit operations carried out by banks, establish environmental access thresholds for credit projects, and elevate the environmental impact of corporate production practices to a more important position in credit policies. In addition, the government should also improve or introduce more incentives and compensation policies for banks to carry out green credit business. For example, banks should be given certain subsidies, the government should provide guarantees for green and sustainable projects, and the development of green credit should be included in the evaluation programme for commercial banks. All government departments should coordinate and work together to improve the enthusiasm and initiative of commercial banks to carry out green credit business, so that they will invest more in green credit projects.

### 5.2.2 Recommendations to banks

At present, China is accelerating the construction of a resource-saving and environment-friendly society, vigorously promoting the comprehensive green transformation of Chinese economic and social development, and green and low-carbon development has become the general trend. Commercial banks in China should also strengthen their own sense of social responsibility, so as to contribute to the early realization of ecological priority, green and low-carbon high-quality development path in China, and the completion of carbon peaking and carbon neutrality as scheduled. In addition, according to the findings of this paper, there is a positive correlation between commercial banks' increased efforts in green credit and their profitability, and the fact that banks invest more resources in green projects has a positive impact on their operating conditions, business performance and even social evaluation. Therefore, banks should take the initiative to increase their support for green and sustainable projects, provide more credit and financial resources to enterprises in this field, and discourage the granting of credit to obsolete and highly polluting industries.

To better develop their green credit business, commercial banks can develop more innovative and redundant quality green credit-related products and services to meet society's demand for green credit in various aspects and attract more quality customers through differentiated competition. In addition, banks should also improve their internal evaluation and audit systems, strengthen the verification of green credit applicants, train and reserve professional talents who are proficient in green credit business, and reduce their own trial and error costs in the emerging field of green credit.

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