Financial Economics Research; Vol.3, No.3; 2026
E-ISSN: 3006-3663 P-ISSN: 3006-3655
DOI: https://doi.org/10.70267/fer.250303.3546
Published by: Zeus Press

The Impact of Structural Monetary Policy on Commercial Banks' Credit Risk: A Quasi-Natural Experiment Based on the Central Bank's Carbon Emission Reduction Facility

Chenlin Cai*

School of Finance, Dongbei University of Finance and Economics, Dalian 116025, China

**Corresponding author: Chenlin Cai.*

Abstract

Against the backdrop of China's "Dual Carbon" strategy, structural monetary policy has increasingly been used to support green transition while maintaining financial stability. Taking the Carbon Emission Reduction Facility (CERF), introduced by the People's Bank of China in November 2021, as a policy shock, this study examines its effect on commercial banks' credit risk. Using balanced panel data for Chinese commercial banks from 2014 to 2024, a Difference-in-Differences (DID) framework is employed, with the first group of national financial institutions participating in the CERF serving as the treatment group and local city commercial banks and rural commercial banks as the control group. The results suggest that the implementation of the CERF is associated with a decline in credit risk, but the estimated effect on the non-performing loan ratio does not reach conventional levels of statistical significance. This indicates that the policy's risk-reduction effect had not yet become fully evident during the initial stage of implementation. A possible explanation is that the benefits of lower-cost funding were offset, at least in the short run, by adjustment costs arising from green transformation, including long investment horizons and still-developing risk assessment systems. The main findings remain unchanged after controlling for bank-level characteristics and macroeconomic growth conditions. Overall, the evidence suggests that the influence of the CERF on bank risk is more gradual than immediate. The findings contribute to ongoing discussions of the transmission effects of structural monetary policy and offer insights into how commercial banks manage the balance between green credit expansion and risk control under the "Dual Carbon" agenda.

Keywords

carbon emission reduction facility, commercial banks, credit risk, difference-in-differences method, structural monetary policy

1. Introduction

China's commitment to achieving carbon peaking and carbon neutrality, announced in 2020, has placed the green transformation of the economy at the centre of national development strategy. In this process, the financial system is expected to play a crucial role by directing capital towards low-carbon activities and supporting the development of green industries.

Yet the expansion of green finance is not without challenges. Compared with conventional investment projects, many green projects are characterised by long payback periods, relatively uncertain returns, and substantial positive externalities. These features do not always fit comfortably within the traditional lending framework of commercial banks, which tends to emphasise short-term risk–return considerations. As a result, although policy support for green development has continued to strengthen, commercial banks may still face insufficient incentives to expand green lending on a large scale.

Against this backdrop, the People's Bank of China launched the Carbon Emission Reduction Facility (CERF) in November 2021. As a targeted structural monetary policy tool, the CERF adopts a "lend first, then refinance" mechanism, under which financial institutions can obtain low-cost funding support for eligible carbon-reduction loans. By lowering funding costs and providing additional liquidity, the policy was intended to encourage banks to increase credit supply to sectors such as clean energy, energy conservation, environmental protection, and carbon-reduction technologies.

The rapid growth of green credit following the introduction of the CERF has also raised a question that deserves closer examination. On the one hand, policy support may improve asset quality by directing credit towards industries with stronger long-term growth prospects. On the other hand, the accelerated expansion of green lending may expose banks to new risks if project evaluation standards, risk identification systems, and management experience remain underdeveloped. Whether the policy ultimately improves or weakens banks' credit quality therefore remains an empirical issue.

Existing studies have examined the relationship between green finance and bank risk from a variety of perspectives. At the enterprise level, Yao et al. find that green credit policies increase financing constraints and reduce operating performance among heavily polluting firms [1]. Focusing on commercial banks, Cui et al. show that a higher proportion of green loans is associated with lower non-performing loan ratios [2]. Building on this line of research, Huang et al. argue that the risk-reducing effect of green credit is influenced by the monetary policy environment, becoming stronger under accommodative conditions and weaker during periods of monetary tightening [3]. Cao et al. further suggest that the impact of green credit on bank risk may follow an inverted U-shaped pattern and exhibit a lagged effect [4]. Using green credit policy as a quasi-natural experiment, Gao and Guo find that green lending contributes to lower non-performing loan ratios and improved profitability over the longer term through adjustments in asset structure [5]. From a market perspective, Gong et al. report that the Carbon Emission Reduction Facility enhances the market valuation of commercial banks through signalling and reputational channels [6].

Although the literature has generated important insights into the relationship between green finance and bank performance, relatively little attention has been paid to the Carbon Emission Reduction Facility itself. In particular, evidence on whether this structural monetary policy affects banks' credit risk remains limited. Existing studies tend to focus either on green credit in general or on market responses to policy announcements, while the direct impact of the CERF on banks' asset quality has received less empirical scrutiny.

To address this gap, this paper uses balanced panel data for Chinese commercial banks covering the period from 2014 to 2024. Treating the introduction of the Carbon Emission Reduction Facility as a quasi-natural experiment, a Difference-in-Differences (DID) framework is employed to examine its impact on banks' non-performing loan ratios (NPLs). Banks included in the first batch of institutions eligible for CERF support are defined as the treatment group, while city commercial banks and rural commercial banks outside the programme serve as the control group. By focusing on the credit-risk consequences of a targeted structural monetary policy, this study adds to the growing literature on green finance and provides evidence on the micro-level effects of China's carbon-transition policies.

2. Literature Review and Theoretical Hypotheses

Existing research has reached no clear consensus on how green finance policies influence the risk profile of commercial banks.

One strand of the literature suggests that green finance contributes to risk reduction. According to this view, loans directed towards clean energy, environmental protection, and other green sectors are generally less exposed to environmental regulation risks and policy-related uncertainty. As a result, the probability of default may be lower than that associated with traditional high-pollution industries. Drawing on Chinese banking data,

Cui et al. find that a higher share of green lending is associated with lower non-performing loan ratios [2]. Di Tommaso et al. examine market reactions to green loan announcements using global banking data and find that such announcements are followed by a decline in banks' CDS spreads, suggesting that investors view green lending as a favourable signal of future stability and lower risk [7].

A different view emphasises the costs and uncertainties associated with the transition towards a low-carbon economy. Cao et al. and Zhou et al. argue that stricter environmental policies may place considerable pressure on carbon-intensive firms [4, 8]. Adjustments in lending strategies, including reductions in credit supply to traditional industries, can worsen financing conditions for affected firms and increase repayment pressure. Yao et al. find that green credit policies can tighten external financing channels for heavily polluting enterprises and weaken their operating performance [1]. These developments may, at least in the short run, increase the likelihood of loan deterioration. At the same time, evaluating green projects often requires specialised expertise and information that many banks are still developing. Limited experience in environmental risk assessment may create additional uncertainty during the early stages of green credit expansion.

Compared with general green finance policies, the Carbon Emission Reduction Facility (CERF) may influence bank risk through a somewhat different mechanism. Introduced by the People's Bank of China in 2021, the CERF provides financial institutions with access to low-cost funding for eligible carbon-reduction loans. By lowering funding costs and supporting credit expansion in targeted sectors, the policy may strengthen banks' ability to absorb potential losses and improve balance-sheet resilience. Gong et al. also note that the policy generates positive market signals and may improve investors' expectations regarding participating banks [6].

Another notable feature of the CERF is its disclosure and verification framework. Participating institutions are required to disclose the carbon-reduction performance of supported loans and undergo third-party verification. These arrangements may help improve information transparency and reduce concerns about greenwashing. In practice, compliance with such requirements often requires banks to refine internal review procedures and strengthen project evaluation standards. To the extent that these adjustments improve loan screening and monitoring, they may contribute to better asset quality over time.

At the same time, the expansion of green lending under the CERF may involve adjustment costs. Many green projects are characterised by long investment horizons and uncertain cash-flow patterns, while risk assessment standards continue to evolve. Consequently, any benefits associated with lower funding costs may not be immediately reflected in asset quality indicators.

Given these competing considerations, the direction of the CERF's effect on commercial bank credit risk remains an empirical question. Accordingly, the following hypotheses are proposed:

H1a (Risk Mitigation Hypothesis): The implementation of the Carbon Emission Reduction Facility reduces the credit risk of commercial banks in the treatment group.

H1b (Transition Pain Hypothesis): The implementation of the Carbon Emission Reduction Facility increases the credit risk of commercial banks in the treatment group in the short run.

H1c (Dynamic Hedging Hypothesis): In the early stage of policy implementation, the benefits associated with lower funding costs and the adjustment costs arising from the green transition offset one another, resulting in no statistically significant change in the credit risk of commercial banks.

3. Research Design

3.1 Sample Selection and Data Sources

The sample consists of Chinese commercial banks observed between 2014 and 2024. This period covers both the years before the introduction of the Carbon Emission Reduction Facility (CERF) and the years following its implementation, allowing a comparison of changes in credit risk before and after the policy. As the CERF was launched in November 2021, 2022 is treated as the first post-policy year.

The treatment group is identified according to the list of institutions included in the first batch of CERF-supported financial institutions announced by the People's Bank of China. Policy banks are excluded because

their operating objectives differ from those of commercial banks. In addition, Guangfa Bank, Bohai Bank, and Hengfeng Bank are removed due to data unavailability. The treatment group therefore consists of 15 large state-owned and joint-stock commercial banks included in the initial support programme (Treat = 1). City commercial banks and rural commercial banks outside the programme are used as the control group (Treat = 0).

Financial indicators and credit-risk data are obtained from the Wind Financial Terminal. To reduce the influence of extreme observations, all continuous variables are winsorized at the 1st and 99th percentiles.

3.2 Variable Definitions

(1) Dependent Variable: Credit Risk (NPL). Following Cui et al., credit risk is measured by the annual non-performing loan ratio, calculated as non-performing loans divided by total loans [2]. Higher values indicate greater credit risk.

(2) Core Explanatory Variable: Treat × Post. The key explanatory variable is the interaction between the treatment-group indicator and the post-policy indicator. It equals 1 for banks included in the first batch of CERF-supported institutions during the period from 2022 onward, and 0 otherwise. The coefficient on this interaction term captures the average policy effect.

(3) Control Variables. Following previous studies on commercial bank risk, several bank-level characteristics are included as controls: bank size (LogAsset, the natural logarithm of total assets), profitability (ROA, return on assets), capital adequacy ratio (CAR, net capital divided by risk-weighted assets), liquidity ratio (Liquidity, liquid assets divided by liquid liabilities), and financial leverage (Leverage, total liabilities divided by total assets).

(4) Macroeconomic Control Variable: GDP_Growth. The annual growth rate of China's real GDP is included to account for changes in the broader macroeconomic environment that may affect banks' credit quality.

3.3 Model Specification

To accurately identify the policy effects of the CERF, this paper constructs a classical two-way fixed effects Difference-in-Differences model:

$$NPL_{i,t+1} = \alpha_0 + \alpha_1 (Treat_i \times Post_t) + \Sigma \beta_j Controls_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (1)$$

where i represents commercial banks and t represents years. μi denotes bank fixed effects, δt denotes time fixed effects, and εi,t is the random disturbance term. The parameter α1 is the core coefficient of greatest interest in this paper, reflecting the net impact of the Carbon Emission Reduction Facility on banks' non-performing loan ratio. If α1 is significantly negative, it supports the risk mitigation hypothesis.

4. Empirical Results and Analysis

4.1 Descriptive Statistical Analysis

Prior to conducting the benchmark regression and formal tests, this paper first performs descriptive statistics on the main variables involved in the empirical model. The relevant data distributions are presented in Table 1.

Table 1: Descriptive Statistics of Main Variables

Variable	Observations	Mean	Std. Dev.	Min	Max	Median
GDP Growth Rate (%)	462	5.945	1.775	2.340	8.570	6.758
Non-Performing Loan Ratio (%)	462	1.350	0.371	0.640	2.710	1.340
ROA (%)	462	0.876	0.205	0.285	1.757	0.867
Log of Total Assets	462	9.449	1.704	6.429	13.098	9.242
Capital Adequacy Ratio (%)	462	13.757	1.697	9.560	19.690	13.530
Liquidity Ratio (%)	462	62.796	20.976	28.770	202.210	58.495
Financial Leverage Ratio (%)	462	6.756	1.045	2.983	10.333	6.650

As reported in Table 1, the mean non-performing loan ratio (NPL) of commercial banks during the sample period is 1.350%, with a standard deviation of 0.371. The minimum and maximum values are 0.640% and 2.710%, respectively. Although the overall level of credit risk remains relatively low, noticeable differences in asset quality can still be observed across banks.

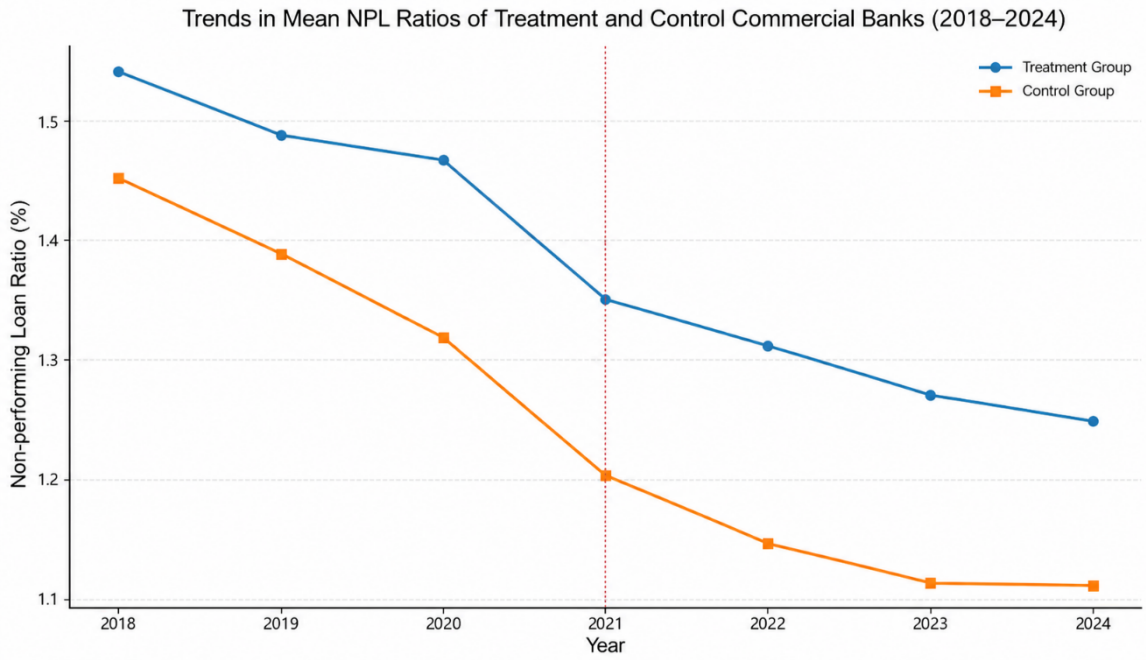
Among the control variables, the average capital adequacy ratio (CAR) is 13.757%, well above the regulatory requirements under both Basel III and China's banking supervision framework. The highest observed value reaches 19.690%, suggesting that most sample banks maintain sufficient capital buffers against potential losses. The mean return on assets (ROA) is 0.876%, with a standard deviation of 0.205, indicating some variation in profitability across banks during the sample period. These differences across institutions justify the inclusion of bank-level controls and fixed effects in the subsequent regression analysis.

4.2 Parallel Trends Test and Dynamic Effects

The validity of the Difference-in-Differences (DID) approach depends on the parallel trends assumption. In other words, absent the policy intervention, the treatment and control groups should exhibit similar trends in credit risk over time. To examine this assumption, the period from 2018 to 2024 is used as the event-study window. A visual comparison of group means is conducted first, followed by a formal econometric test.

Figure 1 plots the average NPL ratios for the treatment and control groups based on panel data obtained from the Wind database. Before the introduction of the Carbon Emission Reduction Facility in 2021, the two groups differ in their NPL levels, but their overall trajectories move in a broadly similar direction. The gap between the groups remains relatively stable, providing preliminary support for the parallel trends assumption. After 2021, NPL ratios continue to decline for both groups. At the same time, fluctuations in the difference between the two series become more apparent, suggesting that simple trend comparisons alone are insufficient to identify the policy effect and that further econometric analysis is required.

Figure 1: Evolution of Mean NPL for Treatment and Control Group Commercial Banks



This paper further reports the dynamic coefficients estimated from the event-study specification (Table 2, Table 3, and Figure 2). Prior to the introduction of the Carbon Emission Reduction Facility, the estimated interaction coefficients remain close to zero, and the corresponding 95% confidence intervals consistently cover zero. No statistically significant differences between the treatment and control groups are observed during the pre-policy period, lending support to the parallel trends assumption. Following policy implementation, the difference in non-performing loan ratios between the two groups does not exhibit a clear narrowing trend. In several post-policy periods, the gap even increases slightly. These patterns suggest that any potential impact of the policy on credit risk was limited during the initial years after implementation.

Table 2: Dynamic Effects of the Carbon Emission Reduction Facility on Commercial Banks' Credit Risk

Variable	Coefficient	Std. Err.	t-value	P-value
Treatment × 2018 (relative to 2021: -3)	-0.017	0.097	-0.174	0.862
Treatment × 2019 (relative to 2021: -2)	-0.035	0.083	-0.424	0.672
Treatment × 2020 (relative to 2021: -1)	-0.003	0.038	-0.07	0.944
Treatment × 2022 (relative to 2021: +1)	0.012	0.036	0.338	0.735
Treatment × 2023 (relative to 2021: +2)	-0.034	0.041	-0.815	0.415
Treatment × 2024 (relative to 2021: +3)	-0.05	0.051	-0.963	0.336

Table 3: Mean NPL and Differences Between Treatment and Control Group Commercial Banks

Reporting Year	Treatment Obs.	Treatment Banks	Treatment Mean NPL	Control Obs.	Control Banks	Control Mean NPL	Mean Difference (Treatment - Control)
2018	15	15	1.541	27	27	1.452	0.089
2019	15	15	1.488	27	27	1.389	0.099
2020	15	15	1.467	27	27	1.319	0.148
2021	15	15	1.351	27	27	1.204	0.148
2022	15	15	1.312	27	27	1.147	0.165
2023	15	15	1.271	27	27	1.114	0.157
2024	15	15	1.249	27	27	1.112	0.137

Figure 2: Event Study Regression Results of the Impact of the Carbon Emission Reduction Facility on Commercial Banks' NPL

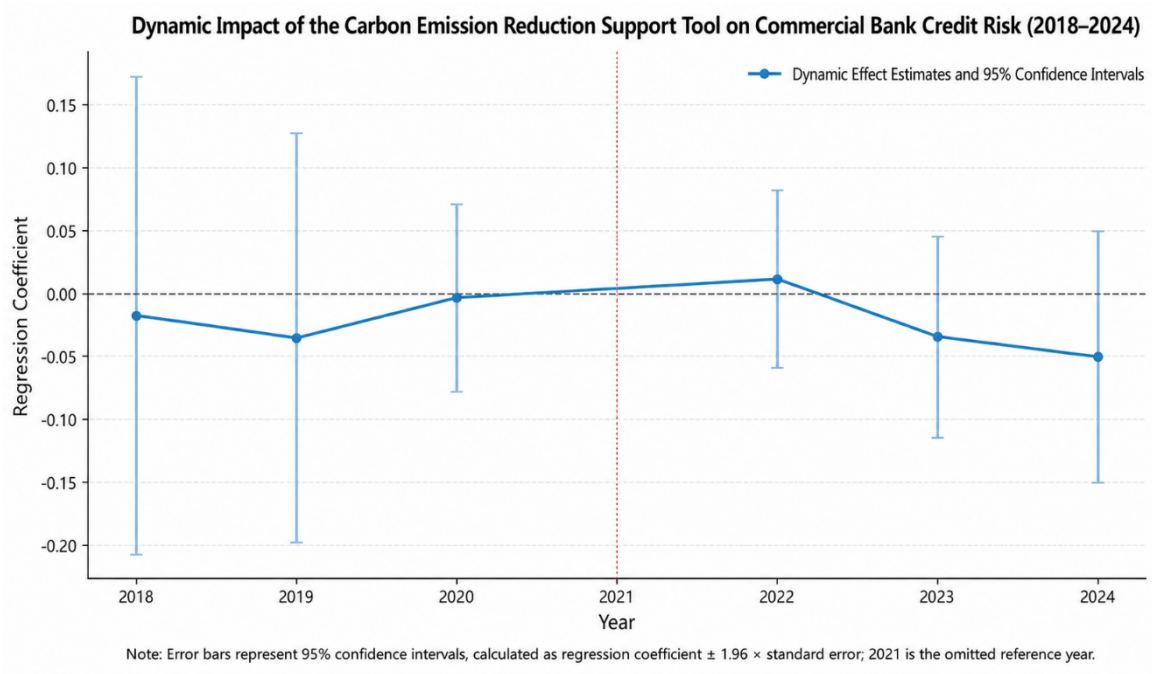


Figure 2 also shows that although banks in the treatment group expanded their green lending activities after entering the policy framework, improvements in asset quality did not emerge immediately. The expansion of green credit and the evolution of non-performing loan ratios appear to follow different adjustment paths over the short run. One possible explanation is that the development of green finance requires corresponding improvements in risk assessment, project screening, and post-loan management. For many projects in sectors such as renewable energy, energy conservation, and environmental protection, investment horizons are relatively long and cash flows tend to be realized gradually. As a result, the benefits associated with project performance may take time to be reflected in banks' balance sheets. In addition, differences in local industrial policies and the continuing evolution of green certification standards may increase the difficulty of identifying and evaluating qualified green assets during the early stage of policy implementation. Taken together, the evidence suggests that the Carbon Emission Reduction Facility may influence bank asset quality through a

gradual adjustment process. Its effects are more likely to emerge alongside longer-term industrial transformation and the maturation of green financial practices, rather than through an immediate reduction in credit risk.

4.3 Benchmark Regression Results and Economic Interpretation

Based on the two-way fixed effects model established earlier and the micro-level financial data provided by the Wind database, this paper conducts rigorous regression estimations using the empirical panel data. The detailed results are presented in Table 4.

Table 4: Empirical Results of the Impact of the Carbon Emission Reduction Facility on Commercial Banks' Credit Risk

Variables	(1) No Controls	(2) Controls Only	(3) Two-Way Fixed Effects (Full Benchmark t+1)
Core Explanatory Variable DID (Treat × Post)	-0.110	-0.071	0.026
	(0.069)	(0.068)	(0.056)
Log of Total Assets (LogAsset)		0.022**	0.248
		(0.010)	(0.234)
Profitability (ROA)		-0.251***	-0.725***
		(0.083)	(0.156)
Capital Adequacy Ratio (CAR)		-0.088***	-0.006
		(0.012)	(0.020)
Liquidity Ratio (Liquidity)		-0.004***	0.003**
		(0.001)	(0.002)
Financial Leverage Ratio (Leverage)		0.177***	0.112***
		(0.018)	(0.024)
Macroeconomic Growth (GDP Growth)		0.028***	Omitted
		(0.009)	
Constant	1.370***	1.437***	absorbed
	(0.018)	(0.192)	
Bank Fixed Effects (Bank FE)	No	No	Yes
Year Fixed Effects (Year FE)	No	No	Yes
Clustered Robust Standard Errors	No	No	Yes (Bank level)
Observations	420	420	420
R-squared	0.006	0.257	0.760

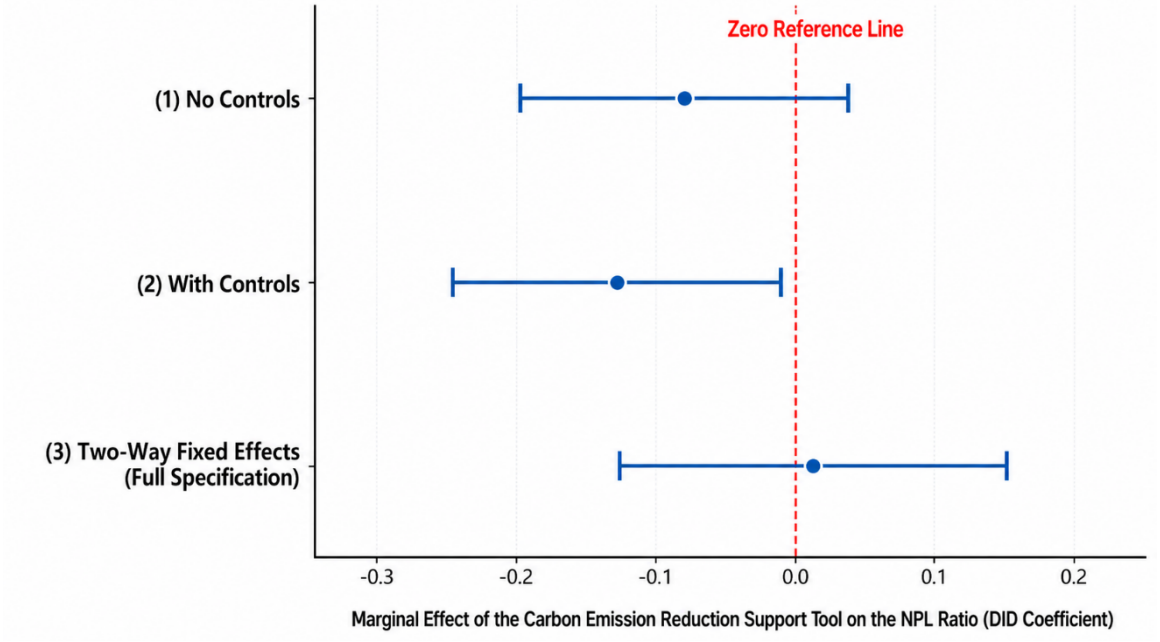
*Note: Standard errors are in parentheses; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.*

Table 4 reports the benchmark regression results. After controlling for bank-level characteristics, macroeconomic conditions, and both bank and year fixed effects, the coefficient on the DID term (Treat × Post) remains close to 0.026 and does not reach conventional levels of statistical significance. To alleviate potential concerns regarding reverse causality, the benchmark specification further employs a one-period lag of the dependent variable. After this adjustment, the effective sample size is reduced to 420 observations. The estimated coefficient on the DID term remains around 0.026 and continues to be statistically insignificant. The result suggests that the effect of the Carbon Emission Reduction Facility on banks' non-performing loan ratios was limited during the early stage of policy implementation. Compared with city commercial banks and rural commercial banks outside the policy coverage, the first batch of national financial institutions supported by the Carbon Emission Reduction Facility did not experience a statistically distinguishable change in next-year non-performing loan ratios. Rather than indicating that the policy was ineffective, this pattern may reflect the gradual nature of green financial transformation and the time required for policy effects to be transmitted into bank asset quality.

To further assess the stability of the benchmark results, Figure 3 presents the estimated coefficients and corresponding 95% confidence intervals under different model specifications. The dots represent coefficient estimates, while the horizontal bars denote confidence intervals. The vertical dashed line marks the zero benchmark. Several patterns emerge from the sequential specifications. In Model (1), which excludes both control variables and fixed effects, the estimated policy coefficient is statistically insignificant. After adding bank-level and macroeconomic controls in Model (2), the coefficient becomes negative (approximately

−0.071), although the confidence interval still overlaps with zero. This suggests that observable characteristics alone are insufficient to isolate the policy effect. Model (3) introduces both control variables and two-way fixed effects and corresponds to the benchmark specification reported in Table 4. Under this specification, the estimated coefficient returns to a positive value of approximately 0.026, while the confidence interval continues to include zero. The result remains statistically insignificant after accounting for both time-invariant bank characteristics and common time shocks. Taken together, the findings are consistent across alternative specifications. No clear evidence is found that the Carbon Emission Reduction Facility reduced the credit risk of participating banks during the sample period. The absence of a significant short-term effect may be related to the coexistence of policy support benefits and adjustment costs associated with the early stage of green transition, with neither force appearing strong enough to dominate the other within the observed time horizon.

Figure 3: Coefficient Plot of the Carbon Emission Reduction Facility under Different Model Specifications



A possible explanation for the insignificant policy effect lies in the interaction between policy support and adjustment costs during the early stage of green transition. On the one hand, the low-cost liquidity provided through the Carbon Emission Reduction Facility may help participating banks expand interest margins and strengthen their capacity to absorb potential losses. On the other hand, green projects often involve relatively long investment horizons, uncertain cash-flow realization, and higher information requirements. At the same time, the gradual withdrawal from traditional high-carbon sectors may create additional adjustment pressures. These opposing influences may have offset one another during the sample period, resulting in a limited short-term impact on banks' credit risk. Such a pattern is broadly consistent with the dynamic hedging hypothesis proposed in this study.

Several channels may help explain this outcome. First, the central bank's refinancing support lowered funding costs for eligible institutions and provided additional financial resources that could be used to strengthen balance-sheet resilience. Second, the policy framework introduced stricter disclosure and verification requirements for carbon-reduction loans. To obtain policy support, banks were required to improve project screening procedures and strengthen the monitoring of green lending activities. These institutional arrangements may have contributed to improvements in credit allocation quality.

However, many green projects supported under the policy remain at relatively early stages of development. In sectors such as renewable energy and environmental protection, investment returns are often realized gradually, while project risks may be difficult to evaluate using traditional credit assessment frameworks. As a result, improvements in asset quality may not become immediately visible in conventional risk indicators such as non-performing loan ratios.

The findings are also consistent with Zhou et al., who emphasize the adjustment costs and transition pressures associated with green finance policies [8]. Similarly, Kacperczyk and Peydró note that changes in credit allocation induced by environmental objectives may generate short-term frictions during the transition process [9]. In particular, the reallocation of credit away from carbon-intensive sectors may not immediately translate into improvements in underlying asset quality. Meanwhile, banks must devote additional resources to developing new risk assessment frameworks and internal management procedures for green finance. These factors may help explain why the short-term policy effect remains statistically weak.

Xue et al. argue that the effectiveness of green finance policies depends not only on policy incentives themselves but also on banks' ability to adapt their internal governance, risk management, and operational systems [10]. In this context, the identification of eligible green projects, the restructuring of existing credit portfolios, and the upgrading of risk-control mechanisms are likely to require time before measurable improvements in credit quality emerge.

The estimated coefficients of the control variables are generally in line with conventional expectations. Profitability (ROA) is negatively associated with the non-performing loan ratio, with a coefficient of −0.725 that is significant at the 1% level, suggesting that more profitable banks are generally better positioned to withstand credit risk. The coefficient on the capital adequacy ratio (CAR) is also negative, although its statistical significance is limited. Bank size (LogAsset) exhibits a negative but insignificant coefficient, possibly because persistent differences across banks have already been absorbed by the fixed effects. By contrast, both the liquidity ratio and financial leverage ratio are positively associated with credit risk and remain significant at the 1% level.

Taken together, the control variables behave largely as expected, while the policy effect remains statistically insignificant. Rather than pointing to a straightforward risk-reduction outcome, the results suggest that the relationship between green finance policies and bank risk may vary across stages of the transition process, a possibility also discussed by Feng et al. [11].

4.4 Heterogeneity Analysis

Differences in capital strength, risk management capability, and information systems may affect how banks respond to the Carbon Emission Reduction Facility. Compared with city commercial banks and rural commercial banks, large state-owned and joint-stock banks generally possess stronger capital bases, more mature risk-control frameworks, and greater capacity to absorb the adjustment costs associated with green transformation. They are also more likely to establish carbon accounting and environmental risk assessment systems within a relatively short period. At the same time, banks with stronger profitability and higher capital adequacy ratios usually have greater flexibility in dealing with uncertainties arising from changes in credit structure. As a result, the influence of the Carbon Emission Reduction Facility on credit risk may vary across banks with different financial characteristics. Based on this consideration, the following hypothesis is proposed:

H2: The impact of the Carbon Emission Reduction Facility on commercial banks' credit risk differs across banks with different asset sizes, profitability levels, and capital adequacy ratios.

To examine this possibility, heterogeneity tests are conducted by dividing the sample according to the median values of bank size, return on assets (ROA), and capital adequacy ratio (CAR). Separate regressions are then estimated for each subgroup. Following the benchmark specification, bank and year fixed effects are included and standard errors are clustered at the bank level. The results are reported in Table 5.

The subgroup regressions reported in Table 5 suggest that the relationship between the Carbon Emission Reduction Facility and bank credit risk varies across banks with different financial characteristics.

With respect to bank size, the coefficient on the DID term is 0.006 for the large-bank subsample (Column 1) and remains statistically insignificant. This result indicates that the introduction of the policy was not associated with a noticeable change in the non-performing loan ratio of large banks in the short run. For the small-bank subsample (Column 2), the DID term is omitted because of perfect collinearity. This is largely attributable to the composition of the sample. Most institutions included in the first batch of the Carbon Emission Reduction Facility were large national banks, whereas smaller city commercial banks and rural commercial banks were generally outside the policy coverage. After grouping by the sample median, the small-

bank subgroup contains only control-group observations, leaving insufficient variation for coefficient estimation.

Table 5: Subgroup Regression Results Based on Bank Financial Heterogeneity

Items	(1) Large-scale Banks	(2) Small-scale Banks	(3) High-profitability Banks	(4) Low-profitability Banks	(5) High-capital-ratio Banks	(6) Low-capital-ratio Banks
Core Explanatory Variable DID	0.006	Omitted	-0.065	0.102	-0.052	0.050
	(0.082)	(-)	(0.052)	(0.086)	(0.064)	(0.081)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	210	210	210	210	210	210
R-squared	0.815	-	0.772	0.787	0.777	0.800

Note: Robust standard errors clustered at the bank level are in parentheses. Groups are strictly divided by the median of each bank's sample-period mean. Each subgroup contains 21 banks, ensuring a fully balanced regression sample.

Differences also emerge across profitability groups. For banks with relatively high profitability (Column 3), the coefficient on the DID term is -0.065, whereas the corresponding coefficient for the low-profitability group (Column 4) is 0.102. Although neither estimate is statistically significant, the direction of the coefficients is noteworthy. Banks with stronger earnings capacity may be better able to absorb the adjustment costs associated with green transformation, while banks with weaker profitability appear more exposed to uncertainties arising from changes in credit allocation and longer investment recovery periods.

A similar pattern can be observed when banks are grouped according to capital adequacy ratios. The DID coefficient is -0.052 in the high-CAR subsample (Column 5) and 0.050 in the low-CAR subsample (Column 6). While statistical significance is not achieved, the results are broadly consistent with the view that stronger capital buffers may help banks cope with risks associated with the expansion of green credit, whereas banks with relatively limited capital cushions may face greater pressure during the adjustment process.

Overall, the subgroup results suggest that the effects of the Carbon Emission Reduction Facility are unlikely to be uniform across all banks. Although the reduced sample size within each subgroup limits statistical precision, the coefficient patterns indicate that banks with stronger financial fundamentals tend to exhibit weaker risk pressures following policy implementation. This heterogeneity may help explain why the average policy effect in the full-sample regression remains statistically insignificant, as differences across bank types partly offset each other in the aggregate results.

5. Policy Implications and Future Research

The empirical results suggest that the effects of the Carbon Emission Reduction Facility on bank credit risk may take time to emerge. Against this background, several implications can be drawn for both policymakers and financial institutions.

5.1 Implications for Policymakers

First, further expansion of structural monetary policy tools may need to take into account differences in the risk-management capacity of participating institutions. Compared with large national banks, many city commercial banks and rural commercial banks have more limited experience in environmental risk assessment and green project evaluation. As policy coverage expands, complementary support measures, such as technical assistance, staff training, and capacity-building programs, may help improve the effectiveness of policy implementation.

Second, improving information infrastructure could reduce the costs associated with identifying and evaluating green projects. Greater coordination among financial regulators, environmental authorities, and other government agencies may facilitate the development of more standardized carbon-related information

systems. Better information availability would help financial institutions assess project quality and reduce uncertainty in green lending decisions.

5.2 Implications for Commercial Banks

For commercial banks, the findings highlight the importance of strengthening internal risk-management frameworks during the process of green transformation. The expansion of green credit should be accompanied by improvements in environmental risk assessment, project monitoring, and internal governance arrangements. Integrating environmental and climate-related factors into existing credit management systems may contribute to more effective risk control.

In addition, the adjustment of credit portfolios is likely to be a gradual process. While increasing support for low-carbon industries, banks may also need to consider the transition characteristics of traditional sectors. A balanced approach could help mitigate potential disruptions associated with rapid shifts in credit allocation and contribute to the stability of asset quality during the transition period.

5.3 Future Research

Several issues remain open for further investigation. One direction would be to examine loan-level data, including information on pricing, collateral arrangements, and borrower characteristics, in order to better understand how policy incentives are transmitted through banks' lending decisions. Such evidence would provide a more detailed view of the channels linking structural monetary policy and credit risk. Another promising avenue is comparative research across countries. Future studies could explore differences in the design and implementation of green monetary policy tools across jurisdictions and examine whether institutional arrangements influence their effectiveness in supporting green finance while maintaining financial stability.

6. Conclusions

Using panel data for Chinese commercial banks from 2014 to 2024 and taking the introduction of the Carbon Emission Reduction Facility in late 2021 as a policy shock, this study examines whether the policy was associated with changes in banks' credit risk. A two-way fixed effects Difference-in-Differences framework is employed to compare banks included in the first batch of policy-supported institutions with those outside the policy coverage.

The results do not provide evidence that the Carbon Emission Reduction Facility significantly reduced banks' non-performing loan ratios during the sample period. Across the benchmark specifications, the estimated coefficient of the DID term remains statistically insignificant, suggesting that the policy did not generate an observable short-term effect on credit risk. One possible explanation is that the potential benefits associated with lower funding costs and policy support were offset, at least temporarily, by adjustment costs arising from changes in credit allocation and green transformation. The heterogeneity analysis points to differences across banks with varying financial characteristics. Although most subgroup estimates do not reach conventional significance levels, the coefficient patterns suggest that banks with stronger profitability and capital positions may have been better equipped to absorb the uncertainties associated with the transition process. By contrast, banks with relatively weaker financial foundations appear to have faced greater adjustment pressures.

Taken together, the findings suggest that the influence of the Carbon Emission Reduction Facility on bank credit risk may be gradual rather than immediate. The effects of structural monetary policy on financial stability are likely to depend not only on policy design itself but also on the characteristics of participating institutions and the pace of adjustment within the broader process of green transformation.

References

[1] Yao, S., Pan, Y., Sensoy, A., Uddin, G. S., & Cheng, F. (2021). Green credit policy and firm performance: What we learn from China. *Energy Economics*, 101, 105415.

[2] Cui Y, Geobey S, Weber O, et al. The Impact of Green Lending on Credit Risk in China. *Sustainability*, 2018, 10(6): 2008.

[3] Huang, F., Zhu, H., & Wu, S. (2025). Green credit, monetary policy, and bank risk-taking. *Finance Research Letters*, 79, 107289.

[4] Cao, G. H., Gao, X. W., Wang, T. Q., & Tian, R. Z. (2024). The impact of green credit on commercial bank risk: Evidence from a multi-period difference-in-differences validation of China's banking industry. *Journal of Financial Development Research*, (2), 55-63.

[5] Gao, X., & Guo, Y. (2022). The Green Credit Policy Impact on the Financial Performance of Commercial Banks: A Quasi-Natural Experiment from China. *Mathematical Problems in Engineering*, 2022, 9087498.

[6] Gong, B., Zhang, B., Yang, S. Y., & Xu, Z. Y. (2024). Research on the impact of carbon emission reduction facility on the market value of commercial banks under the “dual carbon” goal. *Journal of Financial Research*, (7), 50-68.

[7] Di Tommaso, C., Pacelli, V., & Povia, M. M. (2025). Green loans and bank risk: Navigating the path to sustainable finance. *International Review of Economics and Finance*, 101, 104138.

[8] Zhou X Y, Caldecott B, Hoepner A G F, et al. Bank green lending and credit risk: An empirical analysis of China's Green Credit Policy. *Business Strategy and the Environment*, 2022, 31(4): 1623-1640.

[9] Kacperczyk, M., & Peydró, J. L. (2024). Carbon Emissions and the Bank-Lending Channel. *ECGI Finance Working Paper*, N° 991/2024.

[10] Xue J, Sun S, Zhao L. Evaluation of the effects of implementing green credit in Chinese commercial banks, based on grounded theory. *SSRN Electronic Journal*, 2024.

[11] Feng, Y., et al. (2024). Green credit policy and bank risk-taking: Evidence from Chinese commercial banks. *Journal of Cleaner Production*, 437, 140698.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

Copyrights