Monetary Policy with Double Carbon Target in Collateral Framework: Theory and Empirical Analysis

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Abstract: *Green credit is included in the scope of qualified collateral, which reflects the policy intention of the central bank to increase its support for the green economy in order to serve the realization of the goal of double carbon. Commercial banks are an important part of the central bank's collateral framework. From the perspective of maximizing the profits of commercial banks, this paper theoretically analyzes the effect of bringing green credit into the qualified collateral framework, which is a monetary policy with double carbon targets. In June 2018, China's central bank announced the acceptance of green credit assets as qualified collateral for MLF, which was a quasi-natural experiment, and we used the method of double difference to make an empirical test. The results show that: firstly, the goal of maximizing commercial banks' own profits makes the green credit assets included in the scope of qualified collateral more valuable, and the central bank brings green credit into the framework of qualified collateral, which increases the financing availability of green credit enterprises; Second, the inclusion of green credit assets in the framework of qualified collateral will reduce the interest rate required by commercial banks to put green credit and reduce the financing cost of green credit enterprises.*

Keywords: *central bank collateral; Structural monetary policy; Green credit; Carbon peaking and carbon neutrality goals*

1. Introduction

Report to the 20th Communist Party of China National Congress pointed out that promoting green and low-carbon economic and social development is the key link to achieve high-quality development. Green development is the inevitable requirement of building a high-quality modern economic system and the fundamental solution to the pollution problem. We should adhere to green development, develop green finance, and innovate structural monetary policy tools to serve the green economic transformation and development. In recent years, the People's Bank of China has greatly enriched the monetary policy toolbox and innovatively introduced a variety of new monetary policy tools. As a part of the current new monetary policy, the central bank's collateral framework has attracted wide attention, especially since the People's Bank of China included high-quality green credit in the scope of qualified collateral for medium-term lending facilities in June 2018. The inclusion of green credit in the scope of qualified collateral reflects that the central bank has taken the service to achieve the goal of double carbon into consideration when making policy arrangements, and has increased its support for the green economy. Green credit is included in the scope of qualified collateral, which is equivalent to guaranteeing green credit enterprises with national credit, which will further improve the pledge and scarcity of green credit assets (BIS, 2015) [1].

The qualified collateral of the central bank refers to the guaranteed assets that the central bank allows or requires counterparties to provide as direct transactions or debt repayment during the operation of monetary policy (Ji Min et al., 2015) [2]. Since 2013, the central bank has innovatively introduced a variety of new monetary policy tools, such as open market short-term liquidity adjustment tool (SLO), standing loan facility (SLF), medium-term loan facility (MLF), etc. Through these monetary policy tools, the central bank provides commercial banks with funds of different maturities in the form of pledge to meet different levels of liquidity demand. In 2018, the central bank announced that it would give priority to the acceptance of qualified green credit as collateral, which reflected the hope of guiding more funds to the green field in China's monetary policy arrangement, serving the green development of the economy and enabling the realization of the dual-carbon goal.

Judging from the development status of China's green credit market, although green enterprises play an important role in China's ecological environment protection and high-quality development, due to the high cost of green projects and long recovery period, the motivation for banks to provide green credit is not strong (Lu Zhengwei and Fang Qi, 2018)[3], which leads to the financing difficulties and high financing costs of green credit enterprises, and the development of green credit enterprises lacks practical and effective support. Then, can the central bank effectively improve the financing level and reduce the financing cost of green credit enterprises by bringing green credit assets into the framework of qualified collateral? This needs further exploration and verification. This paper takes the event that China's central bank began to accept green credit assets as qualified collateral for MLF in June 2018 as a quasi-natural experiment, and uses the double difference model to analyze and verify this.

The main contributions of this paper are as follows: firstly, by exploring the influence of the central bank's inclusion of green credit assets in the scope of qualified mortgage on the financing availability and financing cost of green credit enterprises, the discussion on the policy effect of bringing new monetary policy tools into the double carbon target under the framework of collateral in China is enriched; Secondly, considering the important role of commercial banks in the central bank's collateral framework, theoretical analysis is carried out from the perspective of profit maximization of commercial banks, and the policy transmission of the bank's collateral framework is further clarified, and empirical analysis is carried out, which is of certain significance for understanding the effect of the new monetary policy collateral framework and how to use monetary policy tools to make structural adjustments, promote the development of green credit market and serve the dual-carbon goal.

2. Literature review

After the international financial crisis in 2008, due to the decline in the effectiveness of traditional monetary policies of central banks in various countries, the role and position of the qualified collateral framework of central banks have been continuously enhanced, and the research on the effect of monetary policies from collateral channels has also emerged. Francois and Koulischer(2014)[4] shows that a looser central bank collateral policy can reduce the interest margin, ease the credit crunch and increase output. BIS(2015) [1]comprehensively analyzed the central bank's collateral policy and its impact on the market for the first time, and put forward the scarce channels and structural channels for the central bank's collateral policy to play its role. Nyborg(2017)[5] pointed out that financial assets included in qualified collateral can be refinanced through the central bank, thus affecting their liquidity and price. Peng Xingyun (2015)[6] pointed out that the central bank can improve the liquidity of qualified collateral assets by adjusting the scope of qualified collateral and reduce the liquidity risk compensation of financial institutions for such assets. Research by Wang Yongqin and Wu Xian (2019)[7] shows that the expansion of collateral in China significantly reduces the credit spread of collateral bonds and plays a role in reducing the financing cost of enterprises. Guo Ye and Fang Fang (2021)[8] believe that the expansion of the central bank's collateral framework has a green effect, which can comprehensively use the central bank's qualified collateral framework to strengthen the directional regulation function of China's innovative structural monetary policy.

In the research on green credit and its related policies, Su Dongwei and Lian Lili (2018) [9]pointed out that green credit can inhibit the investment of heavily polluting enterprises, and Qian Shuitu et al. (2019)[10] showed that green credit can actively promote the upgrading of industrial structure. Li Xiaoxi (2017)[11] believes that China's green credit has low income, lack of investment attraction and insufficient market supply, and it needs multi-sector effective intervention to support the development of green credit. Wang Yao et al. (2019)[12] used DSGE model to analyze and pointed out that the three policies of discount, targeted cuts to required reserve ratios and refinancing for green credit can increase the amount of green credit without affecting the total output. The existing literature has made some explorations on the central bank's collateral framework and the effect of green credit, but there is little research on the inclusion of green credit in the central bank's collateral scope in 2018, and even less research has paid attention to the structural adjustment effect of this monetary policy arrangement.

3. Theoretical analysis and research hypothesis

Commercial banks play an important role in the framework of central bank collateral. A key function of commercial banks is to pool financial resources for productive investment. Referring to the research of McConnell et al. (2022)[13], the expression of profit maximization goal of commercial banks is constructed:

$$\max\ \pi^{Bank} = r_l L - r_m M - r_d D - r_c CB - C(D,L) \tag{1}$$

Among them, r_l indicates that the loan interest rate charged by commercial banks to financing enterprises, L represents the total amount of loans provided by commercial banks. r_m means the interest rate that commercial banks need to pay to obtain inter-bank funds, r_d means the interest rate that commercial banks pay to absorbed household deposits, and r_c means the interest rate that central bank funds are obtained through collateral channels. M、D、CB shows the inter-bank funds, absorbed household deposits and central bank funds obtained by commercial banks respectively. $C(D,L)$ represents the cost of daily operation and management of deposit and loan funds of commercial banks.

In order to make the structural monetary policy of collateral channel work, commercial banks are more inclined to obtain central bank funds among the three channels of capital acquisition, we set $r_c < r_m$ and $r_c < r_d$. Assume that the funds used by commercial banks to issue loans are equal to the funds from inter-bank funds, household deposits (excluding a certain proportion of deposit reserves) and central bank funds to meet the accounting identity, as shown in formula (2). Formula (3) indicates that under the collateral framework, commercial banks obtain central bank funds with qualified credit assets as collateral, $0 < \omega < 1$, it is the ratio that a given commercial bank can obtain central bank funds from the central bank with a certain amount of loans as collateral, that is, the mortgage rate.

$$L = M + D(1-\alpha) + CB \tag{2}$$

$$L\omega = CB \tag{3}$$

Substituting formulas (2) and (3) into formula (1), we can get:

$$\max\ \pi^{Bank} = r_l L - r_m(L - D(1-\alpha) - L\omega) - r_d D - r_c L\omega - C(D,L) \tag{4}$$

For the derivative of formula (4), the first-order condition of profit maximization is obtained:

$$r_l = r_m + C_l(D,L) + (r_c - r_m)\omega \tag{5}$$

Because $r_c < r_m$ and $0 < \omega < 1$, from the formula (5), it can be found that commercial banks can obtain central bank funds in the form of collateral, which can achieve the goal of maximizing their own profits at a lower lending rate. This can be explained by the fact that the central bank requires lower interest rates and the support of relevant policies under the collateral framework, which reduces the capital cost of commercial banks, thus reducing the lending interest rate required by commercial banks to maximize profits.

In order to explore the policy effect of bringing green credit into the scope of qualified collateral theoretically, and further classify the loans issued by commercial banks. According to the object of loans and the nature of loan purposes, loans are divided into green loans L_g and non-green loans L_b. The interest rates required by commercial banks for lending to green enterprises and non-green enterprises are expressed in r_g and r_b respectively. Then the expression of profit maximization and related constraints of commercial banks at this time is:

$$\max \pi^{Bank} = r_g L_g + r_b L_b - r_m M - r_d D - r_c CB - C(D,L) \tag{6}$$

$$L = M + D(1-\alpha) + CB \tag{7}$$

$$(L_g \mu_g + L_b \mu_b)\omega = CB \tag{8}$$

$$L = L_g + L_b \tag{9}$$

Substitute (7), (8) and (9) into (6), we get the following formula:

$$\max \pi^{Bamk} = r_g L_g + r_b L_b - r_m(L_g + L_b - D(1-\alpha) - (L_g \mu_g + L_b \mu_b)\omega)$$
$$- r_d D - r_c(L_g \mu_g + L_b \mu_b)\omega - C(D,L) \tag{10}$$

On the derivative of L_g and L_b, we can get the first-order condition of maximizing the profit of commercial banks:

$$r_g = r_m + + C_l(D, L) + (r_c - r_m)\omega\mu_g \tag{11}$$

$$r_b = r_m + + C_l(D, L) + (r_c - r_m)\omega\mu_b \tag{12}$$

μ_i means the ratio of central bank funds that can be obtained by using different types of credit assets as collateral. Green loans are included in the scope of qualified collateral, while non-green loans are not eligible for collateral, while $0 = \mu_b < \mu_g < 1$,combining formula (11) and formula (12),we can know $r_g < r_b$.

Starting from the maximization of their own profits, commercial banks are willing to obtain central bank funds through collateral channels. The inclusion of green credit in the scope of qualified collateral will increase the collateral value of green credit assets, and commercial banks are willing to put green credit at lower lending rates.

Based on this theoretical analysis, the following research hypotheses are put forward:

H1: The central bank included green credit in the scope of qualified collateral, which increased the financing availability of green credit enterprises.

H2: The central bank will include green credit in the scope of qualified collateral to reduce the financing cost of green credit enterprises.

4. Empirical analysis

In order to analyze the green effect of green credit assets being included in the scope of qualified collateral under the framework of central bank collateral, and to verify the research hypothesis put forward above, this paper establishes the following double difference model:

$$loan_{i,t} = \beta_0 + \beta_1 Post_t \times Treat_i + \beta_2 X_{i,t} + \beta_3 Y_t + \varphi_i + \lambda_t + \varepsilon_{i,t} \tag{13}$$

Among them, the explained variables are the credit financing indicators of enterprises, including the proportion of total credit financing and financing costs. Combined with theoretical analysis, considering that the policy arrangement that green credit is included in the scope of qualified collateral mainly affects the bank loan of enterprises, referring to Zhu Jigao's (2015)[14] method, the *Loanratio* of enterprises is measured by (long-term loan+short-term loan)/total assets. In addition, using the method of Li Guangzi and Liuli (2009)[15] for reference, this paper measures the enterprise's credit cost (*Insterest*) by the ratio of enterprise's financial expenses to total liabilities.

$Post_t$ stands for time dummy variable, which is decided by the central bank's inclusion of green credit into qualified collateral under the collateral framework in June 2018, before June 2018, the value is 0, and after June 2018, the value is 1. $Treat_i$ is a grouping virtual variable divided according to whether enterprises have green credit projects, and enterprises with green credit projects are the experimental group, with a value of 1; enterprises without green credit projects are the control group, with a value of 0. $X_{i,t}$ represents a series of enterprise characteristic control variables. Y_t is the macroeconomic control variable. φ_i and λ_t represent individual fixed effect and time fixed effect respectively, and $\varepsilon_{i,t}$ is a random error term.

4.1 Sample Selection and Data Source

This paper makes a quasi-natural experiment based on the event that the central bank included green credit in the scope of qualified collateral in June 2018, and selects A-share listed companies from the first quarter of 2016 to the fourth quarter of 2022 as the research object for empirical analysis. Through the method of text analysis, whether the enterprise has green credit projects is identified from the annual report and semi-annual report of the enterprise, and the experimental group and the control group are divided. Excluding enterprises with missing data, financial listed companies and enterprises

that have issued green bonds during this period, the unbalanced panel data of 2916 enterprises and 73558 observed values are preliminarily obtained.

The explained variables in the empirical analysis are the financing variables of enterprises, including the availability of corporate credit and the financing cost of enterprises. In addition, the enterprise characteristic variables such as enterprise scale, profitability, asset structure, cash holding level, financial leverage and macroeconomic variables M2 growth rate and GDP growth rate are introduced as control variables. In order to avoid the influence of extreme values, we winsorize all continuous explanatory variables at the 1% and 99% quantiles. The financial data of the company in this paper comes from GSMAR database, and the macroeconomic variable data comes from Wind database. Table 1 explains the definition of variables and specific calculation methods.

Table 1: Definition of variables

symbol	Paraphrase	Data processing	The variable belongs
LoanRatio	Credit availability	Bank loans/total assets	Explained variable
Interest	cost of credit	Financial expenses/total liabilities	Explained variable
Treat	Enterprise dummy variable	Take the value of 1 for green credit enterprises; Otherwise it is 0.	Explanatory variable
Post	Time dummy variable	Take the value of 1 after June 2018; Otherwise it is 0.	Explanatory variable
Lnasset	Scale of enterprise	Logarithm of total assets	Control variable
Roa	profitability	Net profit/total assets	Control variable
Fixratio	capital structure	Fixed assets/total assets	Control variable
Cashratio	Cash holding level	Cash balance/total assets	Control variable
Lev	financial leverage	Total liabilities/total assets	Control variable
Growth	Growth	Revenue growth rate	Control variable
M2	Monetary policy variables	Growth rate of M2	Control variable
GDP	economic growth	Growth rate of GDP	Control variable

4.2 Descriptive statistics

Table 2 is the descriptive statistics of the main variables. Combined with the analysis of statistical results, the average bank loan ratio of enterprises in the sample is 18.26%. The current financial expenses of enterprises account for about 2.19% of corporate liabilities, but there is a big gap between enterprises, indicating that some enterprises are facing more serious financing problems.

Table 2: Descriptive Statistics of Variables

Variables	N	Mean	sd	min	max
LoanRatio	73558	0.1826	0.1139	0	0.5840
Interest	73558	0.0219	0.3276	-1.8219	0.4217
Lnasset	73558	25.1396	1.5318	13.2213	30.2470
Roa	73558	0.0315	0.0778	-0.3462	0.2507
Fixratio	73558	0.3017	0.1893	0	0.9831
Cashratio	73558	0.4964	0.5002	0.0215	2.7019
Lev	73558	1.4903	0.3996	0.2219	3.6841
Growth	73558	0.1976	0.7318	-0.7968	4.9689
M2	73558	0.1328	0.0309	0.0680	0.1987
GDP	73558	0.0531	0.0056	0.0590	0.0721

4.3 Regression result analysis

Taking enterprise financing availability and financing cost as explained variables, this paper analyzes the influence of policies on financing availability and financing cost of green credit enterprises. The empirical results in the first column of Table 3 take the financing availability as the explained variable. The empirical results show that the coefficient of the double difference term is significantly positive, which verifies the previous assumption 1, that is, green credit is included in the qualified collateral framework, and the central bank is oriented to increase the credit of green credit enterprises, which effectively increases the financing availability of green credit enterprises. The second column of Table 3 is the result of regression with financing cost as the explained variable, and

the coefficient of double difference term is estimated to be negative at a significant level of 5%, indicating that the central bank's collateral policy is helpful to directionally support the financing of green credit enterprises, which not only increases their financing availability, but also effectively reduces the financing cost of green credit enterprises.

Table 3: Regression results

	Explained variable: *Loanratio*	Explained variable: *Interest*
Post × Treat	0.0216**	-0.0317**
	(2.39)	(-3.06)
Constant	-0.8139***	1.6352*
	(-2.98)	(1.69)
Controls	Yes	Yes
Individual fixed effect	Yes	Yes
Time-fixed effect	Yes	Yes
observations	73558	73558
R-Squared	0.0324	0.1813

Note:*P<0.1, **P<0.05,***P<0.01;the numbers in brackets are t values.

4.4 Robustness test

In order to verify the empirical validity of this paper, this paper first draws lessons from Jacobson et al. (1993) and tests whether the experimental group and the control group meet the parallel trend hypothesis before the policy and the dynamic effect after the policy through time analysis. The results show that before the implementation of the policy, the samples of the experimental group and the control group meet the basic parallel trend, and after the implementation of the policy, the estimated value of the double difference coefficient begins to be significantly positive, indicating that the empirical results of this paper pass the parallel trend test.

Further, in order to reduce the interference of grouping error on the empirical results, the sample enterprises were randomly divided into experimental group and control group. As shown in Table 4 ,the regression results show that the new double difference coefficient is not significant, which indicates that the impact of random grouping of green credit enterprises and non-green credit enterprises on corporate credit is not significant after the implementation of the policy, which alleviates the interference of grouping errors on the empirical results of this paper and helps to establish the causal relationship studied in this paper.

Table 4: Robustness test results

	Explained variable:*Loanratio*	Explained variable:*Interest*
Post × Treat	0.1321	-0.0532
	(1.21)	(-2.24)
Constant	-0.6021*	1.3762
	(-2.13)	(1.28)
Controls	Yes	Yes
Individual fixed effect	Yes	Yes
Time-fixed effect	Yes	Yes
observations	73558	73558
R-Squared	0.0116	0.0923

Note:*P<0.1, **P<0.05, ***P<0.01; the numbers in brackets are t values.

5. Conclusions and suggestions

As a part of the current innovative monetary policy, the central bank's collateral framework has attracted wide attention. As a key part of the central bank's collateral framework, commercial banks play an important role in the transmission of policies. Firstly, this paper makes a theoretical analysis based on the profit maximization goal of commercial banks, and finds that after green credit is included in the framework of qualified collateral of the central bank, its mortgage value will increase, and commercial banks pursuing their own profit maximization will be more willing to hold green credit as collateral to obtain central bank funds. So as to increase the investment in green credit, reduce the required interest rate, increase the financing availability of green credit enterprises and reduce the financing cost of green credit enterprises. In June 2018, China's central bank began to accept green credit as qualified collateral for MLF, which is a quasi-natural experiment to empirically test the policy

effect of the new monetary policy under this collateral framework. The research verifies the theoretical analysis based on the profit maximization of commercial banks, that is, bringing green credit into the scope of qualified collateral can increase the credit availability of green credit enterprises, reduce the credit financing cost of green credit enterprises, and thus promote the development of green enterprises.

Under the current policy background of "innovating structural monetary policy tools, guiding financial institutions to optimize credit institutions" and "adhering to green development", and in the general direction of China's government's efforts to achieve the goal of carbon neutrality and peak carbon dioxide emissions, we should attach importance to the regulatory role of the collateral framework in bank credit preference and give play to the lender of last resort function of the central bank's collateral framework. We should make rational use of the structural adjustment effect of the central bank's collateral, support the green and high-quality development of China's economy, further improve China's collateral framework, implement and refine the corresponding policy details, and fully explore and give play to the possibility of realizing the dual-carbon goal of structural monetary policy under the collateral framework.

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