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Research on the Impact of Green Finance on Regional Economic Growth--Empirical Evidence from Shanghai Municipality

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Abstract: *In the context of carbon neutrality, green transformation is the trend. As a starting point of green environmental protection, green finance is a new model of financial development, which plays a crucial role in China's overall economic future towards the goal of high-quality development and green sustainability.Therefore, the pilot development of green finance for the city and thus promote the national is not only a positive response to the national strategy, but also to meet the needs of economic development.This paper selects a typical representative of the city-Shanghai, analyzes the transmission mechanism affecting economic growth, and analyzes the current situation of green finance in Shanghai.This paper uses Shanghai as an empirical econometric analysis to study the impact of green finance development on regional economic growth. In response to the empirical conclusions, solutions are proposed: first, the government should strengthen the policy promotion of green finance and improve the efficiency of green finance development, and second, the financial market should accelerate the development of green financial products and increase investment in fixed assets.*

Keywords: *Green finance; regional economic growth; time series modeling*

1. Introduction

Over the past 40 years of reform and opening up, China's economic development has been thriving, and its comprehensive national strength has been significantly enhanced, but we can not ignore the environmental damage behind the rapid economic growth. Environmental problems such as factory water pollution, urban smog, and energy depletion are becoming increasingly prominent and serious. In 1987, the concept of "sustainable development" was first put forward, and the emergence of the green economy has become a new engine for the development of green finance worldwide. In 2016, China officially included green finance into the G20 issue, and the government has a great determination to develop and promote green development, so that the concept of green development and the system of green development has been put forward in the "13th Five-Year Plan".

In order to reduce carbon emissions, the Outline of the 14th Five-Year Plan puts forward the "dual-carbon target", which is in line with the process of modernization and is also a measure to improve long-term competitiveness. The 19th CPC National Congress issued a call for the development of green finance, and encouraged green actions in an all-round way, so as to build a green technological innovation system. To build a green technology innovation system. As an important driving force and cornerstone for leading economic development, green technology innovation is also closely dependent on the development and growth of green finance, which is nourished by sunlight. In recent years, green financial instruments such as green credits and bonds at the economic level have flourished, and the development of green financial instruments has been thriving. The era of carbon neutrality has already begun, and enterprises are taking the initiative to seek changes and pursuing green and low-carbon development, which affects the related investment and financing behaviors at the same time. Green finance is undoubtedly a powerful tool to promote the realization of China's "dual-carbon" goal, and it is of great significance to use green finance to find sustainable investment opportunities in slowing economic growth, promote regional economic growth and realize economic recovery and prosperity.[1]

2. Literature review

Scholars have carried out extensive discussions on the relationship between green finance and

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economic growth, this paper finds that: due to the late start of green finance and relatively short development process of green finance, China's economy is currently in the security of structural adjustment and model transformation. Under the "dual-carbon goals", Wang Youwei (2021)[2] believes that grasping the key of "dual carbon target", we can not only realize sustainable development, seize the new opportunities of the technological revolution and take advantage of the momentum to realize industrial change, but also contribute to the promotion of the "green recovery" of the world economy after the new crown epidemic. In terms of the role of the influence mechanism, Wang Yao et al. (2016)[3]believe that green finance can help promote economic structure and supply-side structural optimization. Green investment has led to the shift of social funds from high-pollution and high-consumption industries to environmentally friendly green projects, and this change in the flow of funds will optimize and upgrade of the industrial structure and even the economic structure. In terms of suggested measures, the Institute of Development of Southwestern University of Finance and Economics et al. (2015)[4]believe that the volume of green finance in China is relatively small, the products are single and lack of innovation, and the market is to be further improved, so the government should do a good job in improving the green financial regulations and systems and promote the construction of the market mechanism.

In summary, the current relationship between green finance and economic growth has basically converged on the conclusions obtained. However, the domestic development is late, such as green credit has only introduced relevant policies since 2007, so there are difficulties in data collection and data acquisition is relatively limited. Therefore, the research direction of more literature is based on theoretical research in the economic situation, and the empirical research is relatively less. In a small number of empirical research articles, most of the articles are analyzed around the national perspective or a certain urban agglomeration perspective, and it is rare to see the research on a specific city [5], and the literature on the object of the study of green credit accounted for a larger proportion.

3. Analysis of the current situation and problems

At this stage, China's green finance is dominated by green credit. The scale of the green finance market is expanding rapidly like a roller coaster, and the development of green bonds and green insurance as "new forces" is on the way. Through sorting out relevant policies, it is found that although the development of green financial services is lagging behind, the government of China attaches great importance to the green financial policies and regulations. Under the effective guidance of the policies, the development of green finance has entered the fast lane, with a wide range of related products and continuous expansion of the investment scale. By the end of 2020, China's green credit balance was about 12 trillion yuan, and the total green loans totaled 106.715 billion yuan, accounting for 35.03% of all loans. In terms of green insurance, since 2007 to the present, the pilot of environmental liability insurance in the country's vast majority of provinces has been carried out, with more than 50,000 insured enterprises in ten years. Green bonds have achieved an astonishing breakthrough from zero stock in 2016 to 813.2 billion stock in 2020. [6] However, due to the vast area, China's green financial regional development is abnormally light and heavy. There are more significant regional differences, and the overall development of the eastern region is better than the central and western regions.

Although Shanghai has made great contributions to the upgrading of the overall green financial system in China and promoted the green and low-carbon economy and society, due to the incomparable "financial highland" advantage and the current situation of international financial development, it is obvious that the development of green finance in Shanghai is like a budding flower, with huge potentials and to be stimulated. From the data, Shanghai failed to step into the top ten of the global green financial index, but at the same time it ranks at the top of the global financial center index, which exposes the room for improvement in the development of green finance in Shanghai. On the one hand, the globalization of the carbon financial market needs to be developed, the carbon trading mechanism is not perfect, and the carbon financial products are single. On the other hand, the green financial regulatory mechanism still needs to be strengthened, and the scope and mechanism of information disclosure need to be enhanced.[7]

4. Empirical analysis

4.1. Modeling

Throughout the existing literature, the model of this paper refers to the Cobb-Douglas production

ISSN 2616-5902 Vol. 5, Issue 23: 106-112, DOI: 10.25236/AJBM.2023.052316

function in the economic growth model. So combined with the Cobb-Douglas production function and its general application, this paper takes the variable of green finance(GF) development as an independent element and expands it to the following equation (1):

$$Y = AL^{\alpha}K^{\beta}GF^{\gamma}\mu \quad (1)$$

Where Y on the left side of the equation denotes the level of economic growth in Shanghai, expressed as GDP, and A, L, K and GF on the right side of the equation denote the level of technology, the inputs of labor, capital and green finance, respectively.μ denotes the error terms. α, β,γ represent the elasticity coefficients of labor, capital and green finance inputs, respectively.

In order to better fit the research direction of this paper and simplify the problem, this paper removes the impact of L and K factors on economic growth and takes the logarithm on both sides, and expresses Y in terms of GDP to obtain the equation (2):

$$lnGDP = a + \beta lnGF + \mu \quad (2)$$

In order to study the impact of green financial development on Shanghai's economic growth more comprehensively and make the formula more in line with the law of economic development, this paper introduces the control variables Shanghai municipal government pollution control inputs (PI)and Shanghai fixed asset investment (Inv) to get (3) equation:

$$lnGDP = a + \beta_1\, lnGF + \beta_2 lnPI + \beta_3\, lnInv + \mu \quad (3)$$

4.2. Variable selection and data description

4.2.1 Selection of variables

Explained variables: the level of economic growth (GDP). This paper studies the impact of green finance on Shanghai's economic growth, and selects Shanghai's total GDP from 2007 to 2020 to measure economic growth.

Important explanatory variables: the level of green financial development (GF) is selected.This paper takes the balance of green credit of 20 major banks as a representative of the level of green financial development. Referring to the practice of Li Hong et al. (2019) [8], the ratio of the number of outlets of the above major banks in Shanghai to the total number of outlets in the country is selected as the weight to be assigned, and then further green credit balances are calculated based on the data of the total green loan balances of the major banks in the Cathay Pacific database.

Control variables: investment (Inv), using the amount of investment in fixed assets in Shanghai. Environmental protection investment (PI), using pollution control investment as an indicator. It includes three dimensions: industrial pollution investment, forestry investment, ecological construction and protection of the total amount of investment completed this year. There are individual missing data in this paper using the trend prediction method to be supplemented.

4.2.2 Data sources

Since 2006 was the first year of green loans in China, and the state only introduced relevant green credit policies in 2007. Considering the completeness and availability of data, this paper adopts China's inter-provincial (Shanghai) time-series data from 2007 to 2020 for the empirical analysis of regional economic growth. The data are all obtained from the statistical yearbooks of the National Bureau of Statistics and the Shanghai Municipal Bureau of Statistics, as well as the database of the Shanghai Municipal Environmental Protection Bureau and Guotai'an.

4.2.3 Data processing

In order to ensure the significance of the empirical test results, strengthen the smooth accuracy of the data and meet the assumption of normality, the sample data are logarithmized due to the obvious fat tail of the time series data. Then, as shown in Tables 1 and 2 below, the correlation analysis and statistical description of the processed variables are performed:

Table 1: Correlation analysis table between lnGDP and explanatory variables

	LNGDP	LNGF	LNINV	LNPI
LNGDP	1.000000	0.928026	0.957943	0.991818
LNGF	0.928026	1.000000	0.845200	0.901991
LNINV	0.957943	0.845200	1.000000	0.979734
LNPI	0.991818	0.901991	0.979734	1.000000

ISSN 2616-5902 Vol. 5, Issue 23: 106-112, DOI: 10.25236/AJBM.2023.052316

Table 2: Descriptive statistics of variables

	LNGDP	LNGF	LNINV	LNPI
average value	10.06503	6.644888	8.710746	6.498962
upper quartile	10.09472	7.093943	8.670634	6.480450
maximum values	10.56361	7.968575	9.086757	7.056921
minimum value	9.463330	3.520675	8.402592	5.902961
Std. Dev.	0.351576	1.293159	0.207270	0.361157
Skewness	-0.202917	-1.294573	0.341040	0.023084
brochure	14	14	14	14

Through the analysis of covariance, the correlation coefficients of LNGDP , LNGF, LNINV and LNPI were obtained as 0.9280, 0.9579, and 0.9918, respectively, which preliminarily showed that there was a strong positive correlation between green finance and environmental protection investment, investment and economic growth.

4.3. Empirical tests

4.3.1 Unit root test for a sequence of variables

As most of the time series data selected in this paper are not stationary, direct regression analysis is not possible. In order to ensure the model estimation results, the variables will be firstly subjected to the unit root test so that it can be determined to regress with stationary variables. In this paper, the ADF test is chosen to determine whether each series is smooth or not. The smoothness was determined based on the minimum criterion of AIC value, SC value and HQ value during the operation of Eviews 8.0.The results of ADF test are shown in Table 3 as follows.

Table 3: ADF test results

variant	Forms of testing (C T L)	Threshold 5%	ADF test value	P-value	steady
LNGDP	(0,0,2)	-3.933364	-2.809708	0.2245	uneven
LNGF	(0,0,1)	-3.875302	-12.78535	0.0001	smoothly
LNPI	(0,0,0)	-3.828975	-3.119680	0.1424	uneven
LNINV	(0,0,2)	-3.933364	-1.112517	0.8762	uneven
ΔLNGDP1	(0,0,1)	-3.933364	-4.705143	0.0174	smoothly
ΔLNGF	(0,0,1)	-3.175352	-10.90255	0.0000	smoothly
ΔLNPI	(0,0,0)	-3.144920	-4.977610	0.0026	smoothly
ΔLNINV	(0,0,1)	--3.933364	-6.367336	0.0022	smoothly

According to the unit root test above, it can be concluded that at the 5% level, the original series of LNGDP, LNINV and LNPI are not smooth, i.e., the explanatory variables and control variables are unstable, which is considered to have a unit root, and the series of LNGF variables is a smooth series. From the above table, it can be seen that all of them are converged to be stable after the first-order differencing, and therefore can be regarded as a unit root process as well.

4.3.2 Multicollinearity test

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.149649	1.329334	4.626111	0.0009
LNGF	0.036734	0.020908	1.756905	0.1095
LNINV	-0.362398	0.281178	-1.288855	0.2265
LNPI	1.050637	0.199752	5.259696	0.0004

R-squared	0.991161	Mean dependent var	10.06503
Adjusted R-squared	0.988510	S.D. dependent var	0.351576
S.E. of regression	0.037686	Akaike info criterion	-3.484095
Sum squared resid	0.014202	Schwarz criterion	-3.301507
Log likelihood	28.38866	Hannan-Quinn criter.	-3.500996
F-statistic	373.8022	Durbin-Watson stat	1.674619
Prob(F-statistic)	0.000000		

Figure 1: Simple regression model

As in Figure 1, the goodness-of-fit R-square is 0.9912, and the F-statistic test is less than 0.05, which indicates that the three variables LNGF, LNPI, and LNINV have a linear effect on LNGDP. However, the t-test shows that LNINV is not significant at the 10% level, and we can suspect that there is

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multicollinearity in the model according to the results of the correlation analysis in Table 1 above. It is initially suspected that the model is multicollinear. According to the variance inflation factor method (Figure 2 below), the VIF is 6.691, 31.090 and 47.638, respectively. If the VIF of the two variables are greater than 10, it is recognized that the model has a certain degree of multicollinearity, and the next step is to take a step-by-step regression method to eliminate the multicollinearity.

Variance Inflation Factors
Date: 03/12/22 Time: 14:10
Sample: 2007 2020
Included observations: 14

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
LNGF	0.000437	196.9616	6.691361
LNINV	0.079061	59165.35	31.08970
LNPI	0.039901	16660.24	47.63828
C	1.767130	17419.44	NA

Figure 2: Variance expansion factor method

Using the stepwise regression method that comes with eviews 8.0, and the results are shown in Figure 3 below.

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
C	4.489306	0.337726	13.29276	0.0000
LNPI	0.808113	0.069016	11.70905	0.0000
LNGF	0.048734	0.019275	2.528332	0.0281

R-squared	0.989693	Mean dependent var	10.06503
Adjusted R-squared	0.987819	S.D. dependent var	0.351576
S.E. of regression	0.038802	Akaike info criterion	-3.473274
Sum squared resid	0.016562	Schwarz criterion	-3.336333
Log likelihood	27.31292	Hannan-Quinn criter.	-3.485951
F-statistic	528.1298	Durbin-Watson stat	1.455159
Prob(F-statistic)	0.000000		

Figure 3: Stepwise regression results (Stepwise Forwards)

Therefore, the model after correcting for multicollinearity is obtained: $lnGDP = a + \beta_1 lnGF + \beta_2 lnPI$. Excluding LNINV as an explanatory variable means that the other explanatory variables have explanatory significance for this explanatory variable. In order to further analyze the cointegration relationship of the same-order difference series, the following cointegration test is carried out.

4.3.3 Cointegration tests of variable series

To determine whether there is a long-run equilibrium relationship between LNGDP and LNGF and LNPI, the E-G two-step method was used to conduct the test in the following steps:

Firstly, simple linear regression (OLS method) is performed and regression results are obtained for LNGDP, LNGF, and LNPI, and the regression results are obtained to generate the residual series (ECM).

Then, a root-of-unit test is performed on the residual sequence. From the general law, we know that the test equation should choose nothing to contain ("None"), resulting in an adjoint probability of P-value of 0.0093, t-value of -2.7909 (as shown in Fig. 4). Due to the number of variables is 4 and the number of samples is 14, at the significance level of 5%, querying the table of critical values for cointegration regression and the formula for calculating the critical values gives C(α) = -4.9772<-2.7909, which rejects the original hypothesis that there is a cointegration relationship. Therefore, the residual series does not contain a unit root, i.e., the residual series is smooth, which means that there is a long-run equilibrium relationship between the explained variables and the explanatory and control variables.

ISSN 2616-5902 Vol. 5, Issue 23: 106-112, DOI: 10.25236/AJBM.2023.052316

Null Hypothesis: ECM has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=2)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.790876	0.0093
Test critical values:	1% level	-2.754993	
	5% level	-1.970978	
	10% level	-1.603693	

Figure 4: Cointegration test of the E-G two-step approach

4.3.4 Granger causality tests

The cointegration test proves that there is a long-term equilibrium and causal relationship between the two variables, green finance (LNGF), environmental protection investment (LNPI) and Shanghai's economic growth (LNGDP). But we don't know exactly "which one causes which one to change". In order to find out the direction of causality, i.e., to test the Granger causality between variables, according to the standard of lag length in the evaluation of VAR operation and the comparison of AIC and SC indexes, we choose the lag number of 2. In order to improve the smoothness and normality, we take the logarithmic difference, and apply the Granger causality test to get the following table 4:

Table 4: Results of Granger causality test

original hypothesis	P-value	conclusion
Granger reasons why DLNGF is not a DLNGDP	0.0675	rejection
Granger reasons why DLNGDP is not DLNGF	0.6004	acceptance
Granger reasons why DLNPI is not DLNGDP	0.2088	acceptance
Granger reasons why DLNGDP is not DLNPI	0.5769	acceptance
Granger reasons why DLNPI is not DLNGF	0.2418	acceptance
Granger reasons why DLNGF is not DLNPI	0.8942	acceptance

As seen in Table 4, 0.0675<0.1, at the significance level of 10%, green financial development LNGF is the Granger cause of economic growth LNGDP, and vice versa, indicating that the development of green finance will boost regional economic growth . There is no Granger causality between the remaining variables. The conclusion, which complements the findings of the cointegration test, is that there is a unidirectional impact relationship between green financial development and Shanghai regional economic growth, and green finance has a certain impact on Shanghai's regional economic growth.

5. Conclusions and policy recommendations

Taking the practice of green finance in Shanghai as an example, this paper uses a time series model to investigate the impact of green finance on Shanghai's economic growth. According to the above empirical research and analysis, the results show that there is a long-term balance between green financial development, environmental protection investment and economic growth, but the short-term influence is limited. The impact of green finance on the regional economic growth has a certain time lag and short-term equilibrium has yet to be examined, and the reasons and mechanisms need to further study the internal mechanism of the impact between green finance and regional economic growth. In this paper, we also see that green finance has a positive impact on the growth of the regional economy. We must grasp the positive significance of increasing the investment in green credit, and gradually developing the scale of the green credit market on the regional economic growth, which also confirms the viewpoints of this paper. So the development of green finance is a big deal, and there is an indispensable need to develop green finance.

Based on the above empirical evidence and analysis, the following three recommendations for Shanghai: First, in terms of policy, the government should strengthen the policy promotion of green finance. The empirical evidence shows that Shanghai's green finance has an effect on economic growth but is weak, and the Shanghai market effect is better in the analysis of the current situation, but as the first batch of pilot areas to carry out carbon emission trading, there is a lack of progress in the overall policy promotion of the government. The second is to comply with the green low-carbon call, accelerate the development of green financial industry, and increase investment in related industries. The empirical evidence in the control variable environmental protection investment also plays a positive role in economic growth, so in order to better achieve high-quality development, it should promote each other,

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and ultimately achieve economic growth.

All in all, in the face of the urgent need for high-quality development and the goal of "dual-carbon", not only Shanghai, but also the provinces in China should actively respond to the call of green economy, catch the train of "green finance to promote economic development", and participate in the construction of beautiful China in a down-to-earth manner.

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