An Empirical Study on How Financial Development Influences Carbon Emissions in Yangtze River Delta

Minglei Han [1,*], Zhuohan Liu [2], Jiaxuan Zhou [3], Tengda Gou [1]

[1] Elite College, Harbin University of Commerce, Harbin, China, 150000

[2.]School of Economics, Harbin University of Commerce, Harbin, China, 150000

[3.]School of Accounting, Harbin University of Commerce, Harbin, China, 150000

* Corresponding Author Email: 15588635787@163.com

Abstract. Financial development influences economic development to some extent. China is in the important stage of economic restructuring and upgradation, while facing both the foreign and the domestic pressure of developing low-carbon economy and promoting energy conservation and emissions reduction, requiring people to understand the relationship between financial development and carbon emissions. This paper examines how financial development influences the carbon emissions using the panel data composed by 37 prefecture-level cities in Yangtze River delta during the 2008-2017 period. This paper build the multiple regression model based on modified environmental impact assessment model (EIA) and measure financial development level using the percentage of loan balance of financial institutions in GDP and the percentage of saving balance of urban residents in GDP. The result shows a negative association between financial development and carbon emissions among 37 cities in Yangtze River Delta. Therefore, the policymakers should try to maximize the supporting of financial institutions to local economies, develop green finance and promote the regional information sharing and cooperation.

Keywords: Financial development, Carbon emission, Regional Integration of the Yangtze River Delta, EIA model.

1. Introduction

Financial development, as one of the important measures of a modern economy, can, on the one hand, promote the structural transformation of the economy and the tilting of capital towards socially responsible low-carbon enterprises, curbing the growth of carbon emissions by supporting them to improve their production technology and enhance their innovation capacity; on the other hand, the problem of information asymmetry in financial development has led to the inefficient flow and allocation of loans, which, together with some enterprises' obsession with expanding On the other hand, the problem of information asymmetry in financial development leads to the inefficient flow and allocation of loans, which, together with some enterprises' obsession with expanding their production scale, leads to the growth of carbon emissions[1-3]. The above findings suggest that there is both an incremental and inhibitory effect of financial development on carbon dioxide emissions under different circumstances, and the exact relationship still needs further research. Therefore, efforts to bring into play the inhibiting effect of financial development on carbon emissions and avoid the increasing effect of financial development on carbon emissions, so as to provide more policy recommendations for promoting the regional integration strategy of the Yangtze River Delta, are the focus of current research and analysis, and have high social value and research significance.

2. Review of the literature

2.1. A study on the relationship between economic growth and environmental pollution

Research on the relationship between economic growth and environmental pollution began in the 1990s by foreign scholars.Gross and Krueger (1991) creatively put forward the environmental Kuznets theory, which found that economic development and environmental pollution have an

inverted U-shaped curve distribution, i.e. the impact of economic growth on environmental pollution is first increased and then suppressed. Different scholars have adopted different indicators to measure the level of economic growth. Barra and Zotti (2017) used GMM estimation to measure the level of economic development of 120 countries between 2000 and 2009 in terms of real GDP per capita, and concluded that with the increase in GDP per capita, the influx of population to cities and the rapid development of industries caused an increase in environmental pollution, and some countries have increased environmental pollution by adopting strict By adopting strict environmental protection regulations and promoting industrial transformation, some countries were able to slow down environmental pollution again after the inflection point, confirming the inverted U-shaped distribution of the environmental Kuznets curve.

Since this century, domestic scholars have also conducted in-depth studies on the environmental Kuznets theory. By using economic agglomeration as a measure of economic development, Shao Shuai et al. (2019) used data from 30 provincial-level regions in China to form a panel Durbin model, and found that economic agglomeration plays a positive role in energy saving and emission reduction after reaching a certain threshold, and that economic agglomeration can also have an indirect effect on carbon emissions through energy intensity[4]. Xu Zhengsong and Kong Fanbin (2014) used principal component analysis to study the pollution situation in Jiangxi Province. The study concluded that the three main characteristics of economic development were the increase in the proportion of industrial value added to GDP, the increase in trade openness and the upgrading of industrial structure, which showed a positive correlation with environmental pollution, and combined with the fact that Jiangxi Province was not at a high level of development and was in a developing region, the results were consistent with the environmental The first half of the Kuznets theory[5, 6].

2.2. Analysis of the factors influencing carbon emissions

As for the factors affecting carbon emissions, domestic and foreign scholars have further analysed them in terms of indicators such as economic development, foreign trade, energy consumption and industrial development.

In terms of industrial development, Shaheen et al. (2020) refute the view of some scholars that in developing countries like Pakistan, the degree of industrialisation is not directly related to carbon emissions due to the weak industrial base and low level of industrial development, which mainly affects carbon emissions in middle and high-income countries[7].

In terms of economic development and foreign trade, Ahmad (2019) finds a long-term equilibrium relationship between Japan's GDP situation from 1970 to 2010, import and export volumes and carbon emission data for the corresponding years, and that these factors significantly contribute to the increase in carbon emissions in both the long and short term[8].

In terms of energy consumption, Liu (2019) analysed the factors influencing the scale and intensity of carbon emissions from industrial energy consumption in Jiangsu province based on the STIRPA model, and the results showed that they were more significantly influenced by the share of coal consumption, and that energy efficiency and labour-average output had a stronger effect on carbon emissions in the long term[9].

However, Gu Hongmei and He Bin (2012) conclude that most scholars still focus on the impact of economic development mode, population distribution, consumption philosophy, energy structure, energy intensity and industrial structure on carbon emissions, often ignoring financial development as a determinant of economic development. According to the environmental Kuznets theory, this study is in line with the current situation in the early stage of China's economic development[10].

2.3. Study on the impact of financial development on carbon emissions

Since the turn of the century, most domestic and foreign scholars have also paid more attention to the relationship between financial development and environmental protection, and especially to the impact of financial development on carbon emissions. Regarding the relationship between financial development and carbon emissions, scholars generally believe that there are both pro-increasing and

inhibiting effects, while some scholars believe that there is no direct relationship between financial development and carbon emissions.

From the perspective of financial structure, financial development has an incremental effect on carbon emissions. In terms of financial structure, Xiong Ling and Qi Shaozhou (2016) argue that the deepening of financial development, the increase in financial intermediation and the continuous improvement of the financial system have promoted the efficient flow of economic capital. As China's financial development is still at a primary stage of development, the data suggest that the upgrading of the financial structure has led to an increase in the overall level of carbon emissions in 30 provinces in China.

In terms of technological innovation and the development of green energy hood, financial development has a suppressive effect on carbon emissions. He Wujie et al. (2019) study the relationship between the level of green financial development and carbon emissions in China in recent years based on a VAR model, and the results show that with the development of green credit, green securities, green insurance and green investment and the efficient use of renewable energy, the unit carbon emissions are suppressed to some extent and green financial services have made a significant contribution to environmental improvement. The increase in the level of financial development, combined with the need for green financial development, requires high polluting enterprises to strive to obtain more financing and achieve sustainable development through technological innovation and improved production techniques. The transformation of highly polluting enterprises has made a significant contribution to slowing down the rate of CO2 emissions and promoting energy saving and emission reduction.

According to the current domestic and international literature, academic research on the relationship between financial development and carbon emissions still focuses on inter-provincial panel data and national panel data, while few focus on specific prefecture-level city data, so research on the relationship between regional finance and environmental protection is relatively lacking, making it difficult to provide valuable policy recommendations for local areas. This paper innovatively investigates the impact of financial development on carbon emissions in prefecture-level cities in the Yangtze River Delta region under the Yangtze River Delta regional integration strategy, and selects more precise data to measure carbon emissions and financial development, which to a certain extent remedies the shortcomings of previous studies.

3. Analysis of the mechanisms by which financial development affects carbon emissions

The analysis of the impact mechanism of financial development on carbon emissions can be explained in depth in terms of the scale effect, structural effect, wealth effect and technology effect. Under the scale effect, financial development promotes the agglomeration of economic assets through economies of scale, which leads to an increase in the productivity of society as a whole, with enterprises expanding their production and increasing the amount of investment in fixed assets, which in turn affects the level of environmental pollution. Under the structural effect, financial development is inextricably linked to economic development, promoting economic transformation by regulating the structure of economic production, supporting different industries and promoting the rapid development of low-carbon enterprises, resulting in certain environmental changes. Under the wealth effect, enterprises and individuals accumulate more social wealth, which affects the whole industry through the transmission effect of wealth and promotes the increase of disposable income of urban residents, which in turn affects the level of carbon emissionsThe four effects are analyzed in Figure 1.

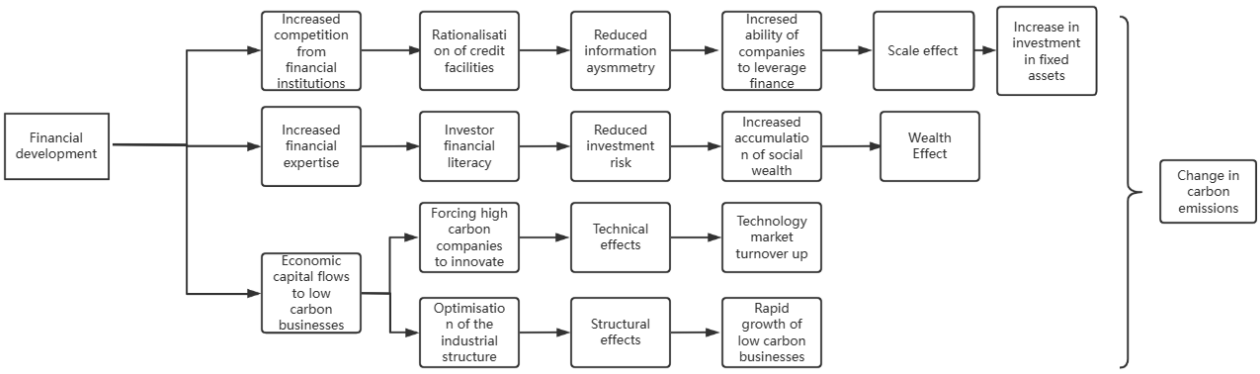

Figure 1. Analysis of the four main effects

To make up for the shortcomings of other studies based on inter-provincial panel papers and to focus more precisely on the impact of financial development of prefecture-level cities on carbon emissions, this paper constructs a panel data model for 2008-2017 for each prefecture-level city in the Yangtze River Delta region to explore in depth the relationship between financial development and carbon emissions among different prefecture-level cities, and to put forward conclusions and policy recommendations.

4. An empirical analysis of the impact of financial development on carbon emissions in the Yangtze River Delta city cluster

4.1. Sample data selection

Due to the limited sample data, this paper uses panel data of 37 prefecture-level cities in three provinces and one city in the Yangtze River Delta region (Jiangsu, Zhejiang, Anhui and Shanghai) from 2008 to 2017. The data were mainly obtained from the Statistical Yearbook published by the statistical bureaus of each prefecture-level city, and some data were obtained from the China Statistical Yearbook, the China Financial Statistics Yearbook and the China City Statistics Yearbook. Some missing data were estimated by the median method or difference method.

Note: Statistics for Huai'an City, Jiangsu Province, Lishui City, Zhejiang Province and Liu'an City, Anhui Province are ignored in this paper due to a serious lack of statistical data for these three cities.

4.2. Description of variable selection and measurement methods

4.2.1 Selection of financial development variables

This paper uses two indicators to measure the level of financial development: the balance of loans by financial institutions as a proportion of GDP and the balance of savings by urban and rural residents as a proportion of GDP.

A more traditional theoretical approach is the Financial Related Ratio (FIR) proposed by Goldsmith, which is defined as the ratio of the value of all financial assets to the value of all physical assets (i.e. national wealth). This paper will also adopt this approach. Based on the practical availability of data, this paper defines the loan balance of financial institutions as the value of all financial assets and the gross regional product as the value of all physical assets, i.e. the loan balance of financial institutions as a proportion of GDP as one of the measures of financial development.

The level of residents' savings balance affects whether financial institutions have sufficient funds to further grant loans to enterprises and individuals, participate in risky investments and purchase securities, and influences financial institution practitioners to make different decisions, so the savings balance also has a certain degree of influence on financial development. This paper uses the savings balance of urban and rural residents as a proportion of GDP as a second measure of financial development.

4.2.2 Calculation of carbon dioxide emissions

At present, China does not provide official data on carbon dioxide emissions, so most scholars need to use other methods to accurately measure carbon emissions. The mainstream methodology used by major scholars for empirical studies is derived from a set of more accurate reference methods published by the United Nations Intergovernmental Panel on Climate Change (IPCC) in 2006, which will also be used in this paper for empirical studies.

$$CO_2 = \sum_{i=1}^{8} E_i \times CCER_i \times K_i \times (44/12) \quad (1)$$

Explanation: As some studies only consider three to four major energy sources for measurement, their accuracy may be low. In this paper, we mainly consider the carbon emissions corresponding to eight major energy sources, namely raw coal, washed coal, coke, gasoline, paraffin, diesel, LPG and natural gas, and the above data are obtained from the Statistical Yearbook of each prefecture-level city, and the small part of missing data is measured by the median and difference methods, and the results are relatively accurate.

where: represents the estimated value of carbon dioxide emissions, i=1,2,...,8 represents the eight major energy sources used in this paper, respectively, represents the consumption of these eight major energy sources, is the energy conversion standard coal coefficient provided in the appendix of the China Energy Statistics Yearbook, is the carbon emission coefficient provided in the Guidelines for the Preparation of Provincial Greenhouse Gas Inventories, 44 and 12 represent the carbon dioxide and carbon molecular weights.

4.3. Model derivation

According to the environmental impact assessment model modified by Dietz and Rosa (1994), the level of carbon emissions can be assessed by the demographic, technological and wealth factors, whose relationship is shown in equation (1). Where, denotes carbon emissions, denotes the model coefficients, P denotes the population factor, A denotes the wealth factor, T denotes the technology factor, b, c and d belong to the respective variable indices, and e is the random error term.

$$C_{it} = \alpha \times P_{it}^{b} \times A_{it}^{c} \times T_{it}^{d} \times \mathrm{e} \quad (2)$$

In empirical analysis, it is common to take the logarithm of both sides of the equation, which after taking the logarithm is as in equation (3). where is the random perturbation term.

$$LnC_{it} = Ln\alpha + \mathrm{b}LnP_{it} + cLnA_{it} + dLnT_{it} + u_{it} \quad (3)$$

Based on equation (2), this paper will be expressed as (GDP per capita), as (amount of investment in fixed assets) and as (amount of technology market turnover). Considering other factors affecting the level of carbon emissions, this paper introduces two more control variables, (urban residents' disposable income per capita) and (trade openness), for a total of the above five control variables. To demonstrate the impact of financial development on carbon emissions, this paper uses two core variables (urban and rural residents' savings balance as a proportion of GDP) and (financial institutions' loan balance as a proportion of GDP). The final derived equation (3) is as follows.

$$\begin{aligned} LnC_{it} = \beta_1 + \beta_2 LnIncome_{it} + \beta_3 LnOpen_{it} + \beta_4 LnAsset_{it} + \beta_5 LnTEC_{it} + \beta_6 LnPgdp_{it} + \\ \beta_7 LnFinance_{it} + \beta_8 LnSave_{it} + \varepsilon_{it} \end{aligned} \quad (4)$$

Where: log of carbon emissions, is the explanatory variable; represents log of per capita disposable income of urban residents; represents degree of trade openness (log of import and export volume); represents log of total fixed asset investment;represents log of technology market turnover; represents log of GDP per capita; represents log of loan balance of financial institutions as a proportion of GDP (financial related ratio); represents log of savings balance of urban and rural residents as a proportion of GDP; is a random disturbance term.

4.4. Analysis of empirical results

4.4.1 Descriptive analysis

Table 1. Results of descriptive analysis

Variable	Obs	Mean	Std.Dev.	Min	Max
LnC	370	11.253	1.232	6.2	13.365
LnIncome	370	10.194	.387	9.199	11.044
LnOpen	370	8.797	1.924	4.431	13.073
LnAsset	370	11.893	.85	9.77	13.493
LnTEC	370	7.294	5.843	-3.551	15.976
LnPGDP	370	10.775	.661	8.776	11.999
LnFinance	370	0	.41	-1.012	1.282
LnSave	370	8.86	.344	8.234	10.157

This paper selects panel data for 37 prefecture-level cities in the Yangtze River Delta region for the decade 2008-2017, with a total sample size of 370. The two core variables selected for this paper have small standard deviations and the data are relatively stable. Among the control variables, the standard deviation of the logarithm of technology market turnover is large and the data are more discrete. Overall, there are no extreme outliers in the data. The results of the analysis are shown in Table 1.

4.4.2 System GMM model analysis

In this paper, a systematic GMM approach is used to estimate the model to reflect the dynamic adjustment characteristics of the impact of financial development on carbon emissions and the trend of carbon emissions in each prefecture-level city of the Yangtze River Delta in China. To ensure the validity of the estimated model results of the systematic GMM, this paper uses first-order series AR (1), second-order series AR (2) and over-identification constraint tests to identify the estimated results. From the results reported in the table below, the first-order serial correlation of the system GMM is significant, but the p-values of the second-order serial correlation AR(2) test and the Hanson over-identification test are both greater than 0.05, indicating the existence of first-order autocorrelation and the absence of second-order autocorrelation. The hypothesis of serial correlation of the error term in the level equation is rejected, and the hypothesis of the validity of the instrumental variables is accepted, and there is no over-identification problem. Therefore, the whole model is reasonably set up and the estimation results are reliable and valid. The results of the analysis are shown in Table 2.

From the regression results, it can be seen that the lagged one-period regression coefficients of the explanatory variables all exhibit a significant positive effect on the local level, indicating that carbon emissions are significantly affected by their lagged one-period effects. From the regression model of the Yangtze River Delta sample, among the core variables, the share of loans from financial institutions in GDP (LnFinance) shows a non-significant inhibitory effect on carbon emissions, i.e. an increase in the share of loans from financial institutions in GDP will lead to a decrease in carbon emissions; the share of urban and rural residents' savings in GDP shows a significant inhibitory effect on carbon emissions, i.e. an increase in the share of urban and rural residents' savings in GDP will lead to a decrease in carbon emissions. In other words, an increase in the share of urban and rural residents' savings in GDP will lead to a decrease in carbon emissions. Specifically, for every unit increase in the share of loans from financial institutions in GDP, carbon emissions fall by 0.0091%; for every unit increase in the share of savings of urban and rural residents in GDP, carbon emissions fall by 0.0185%.

Of all the control variables, income per capita (LnIncome) and investment in fixed assets (LnAsset) had significant negative effects on carbon emissions (LnC). For each percentage point increase in per capita income, carbon emissions decreased by 0.0735%; for each percentage point increase in fixed asset investment, carbon emissions decreased by 0.0346%. Other control variables, including trade

openness (LnOpen), technology market turnover (LnTEC), and GDP per capita (LnPGDP) all have a positive effect on carbon emissions (LnC). For each percentage point increase in trade openness, carbon emissions rose by 0.0016%, for each percentage point increase in technology market turnover, carbon emissions rose by 0.0004%, and for each percentage point increase in GDP per capita, carbon emissions rose by 0.0221%.

Table 2. Basic analysis results

Variables	Models (1)	Models (2)
L.LnC	0.9974*** (41.06)	1.0123*** (123.17)
LnFinance	-0.0091 (-1.35)	
LnSave		-0.0185*** (-3.28)
LnIncome	-0.0884*** (-6.85)	-0.0735*** (-7.33)
LnOpen	0.0020 (0.49)	0.0016 (0.83)
LnAsset	-0.0201 (-1.52)	-0.0346*** (-4.58)
LnTEC	0.0005 (0.57)	0.0004 (0.56)
LnPGDP	0.0306*** (3.89)	0.0221*** (2.81)
Constant term	0.8628*** (5.14)	0.9765*** (10.34)
Number of samples	333	333
AR(1)Test p-value	-2.28**	-2.29**
AR(2)Test p-value	-1.54	0.109
HansonTest p-value	0.824	0.843

* $p < .1$, ** $p < .05$, *** $p < .01$

According to the results of the systematic GMM model, it can be seen that in recent years, the disposable income of urban residents in the Yangtze River Delta region has increased rapidly and the scale of fixed asset investment has increased further, resulting in a significant decrease in carbon emissions performance, while the increase in imports and exports, the increase in technology market turnover and the increase in GDP per capita have resulted in an increase in carbon emissions performance. This shows that economic development and income growth are not on the same level. The fact that income growth in the Yangtze River Delta is outpacing economic development shows that people's living standards in the region have improved significantly and that income growth is not limited to economic development but is also influenced by a number of factors. Generally speaking, improving people's standard of living is conducive to enhancing people's happiness. The above results also further show that the improvement of people's happiness is not contradictory to the implementation of energy saving and emission reduction policies. In the long run, it is still necessary for China's Yangtze River Delta region to continue to maintain high quality economic development while strengthening the construction of ecological civilisation, and at the same time improve people's happiness to find an inner balance. In addition, the empirical analysis shows that technological factors contribute to carbon emissions to a certain extent, and it can be presumed that there is still an unbalanced and inefficient flow of technology in the Yangtze River Delta region, but with

technological progress, optimised resource allocation efficiency and better financial policies, a balance point between technological progress and energy saving and carbon reduction will be found.

5. Conclusion

Based on the results derived from the panel data of 37 municipalities in the Yangtze River Delta region from 2008 to 2017, this paper draws the following conclusions.

The increase in loan balance of financial institutions as a proportion of GDP and savings balance of urban and rural residents as a proportion of GDP show a suppressive effect on carbon emissions in prefecture-level cities in the Yangtze River Delta region. Therefore, to bring into play the inhibiting effect of financial development on carbon emissions, it is necessary to strongly support the ability of financial institutions to absorb deposits and issue loans, and to expand the supporting effect of financial development on the local real economy; in addition to the disposable income of urban residents, the rise in the amount of in and out, the rise in the total investment in fixed assets, the gradual increase in the turnover of the technology market and the year-on-year rise in per capita GDP show an increasing and promoting effect on carbon emissions in the prefecture-level cities in the Yangtze River Delta region. Therefore, the region is still in the early stages of the inverted U-shape of the Kuznets theory of the environment, i.e. economic development brings higher carbon emissions. Balancing the relationship between economic development and environmental protection is important for achieving the task of energy conservation and emission reduction. While implementing the development of green finance, the region should actively explore new and innovative means to further enhance the efficiency of economic operations through financial means and enter the inflection point of declining carbon emissions at an early date.

References

[1] Gu, Hongmei, He, Bin. A study on financial development and carbon emissions in China's provinces [J]. China Population - Resources and Environment, 2012, 22(8): 22-27.

[2] Liu Xiaoyan. Analysis of factors influencing carbon emissions from industrial energy consumption based on STIRPAT model [J]. Ecological economy, 2019, 35(03): 27-31.

[3] He Wujie, Chen Hanhua, Wang Zhuo. An empirical study on the relationship between green financial development and carbon emission dynamics--a test based on VAR model [J]. Journal of Guizhou Normal University (Social Science Edition), 2019(01): 99-108.

[4] Shao, Shuai, Zhang, Ke, Dou, Jianmin. Energy saving and emission reduction effects of economic agglomeration: Theory and Chinese experience [J]. Management World, 2019, 35(01): 36-60+226.

[5] Liu, Chenyue, Xu, Yingzhi. Marketization, structural overcapacity and environmental pollution - a test based on systematic GMM and threshold effects [J]. Statistical Research, 2019, 36(01): 51-64.

[6] AHMAD W, KHAN S, Yunis M S. The Relationship of Macroeconomic Factors with Carbon Dioxide Emissions in Japan [J]. FWU Journal of Social Sciences, 2019, 13(2), 14–24.

[7] MAJI I K, HABIBULLAH M S, SAARY M Y. Financial Development and Sectoral CO2 Emissions in Malaysia [J]. Environmental Science and Pollution Research International, 2017, 24(8), 7160–7176.

[8] XU Z, BALOCH M A, DANISH, et al. Nexus between Financial Development and CO2 Emissions in Saudi Arabia: Analyzing the Role of Globalization [J]. Environmental Science and Pollution Research International, 2018, 25(28), 28378–28390.

[9] SOUKIAZIS E, PROENCA S, CERQUEIRA P A, et al. The Interconnections between Renewable Energy, Economic Development and Environmental Pollution: A Simultaneous Equation System Approach [J]. Energy Journal, 2019, 40(4), 1–23.

[10] BARRA C and ROBERTO Z. Investigating the Non-Linearity between National Income and Environmental Pollution: International Evidence of Kuznets Curve [J]. Environmental Economics & Policy Studies, 2018, 20(1), 179–210.