Green finance, Carbon Emission and Chinese Government

Abstract

This paper uses the data of 298 cities in China from 2012 to 2019, exploring the impact of green financial development on carbon emission through a panel data model. Based on the different model settings and variable measures, we control the endogeneity of the related variables. The empirical results show that financial development has a positive impact on carbon emissions, indicating that China's financial development is still at an extensive stage. Additionally, most green finance policies show little effect on cutting carbon emissions in the short term except for infrastructures and associations, which, on the contrary, have positive effects on carbon emissions. We also analyze the underlying mechanism of how documents influence other market actions. We find that apart from local governments, local bank competition also strongly affects green finance policies and their impacts. These findings show that, in the short term, green finance policies have little impact on reducing carbon emissions and may also be interrupted by other factors like bank competition.

1. Introduction

The practice of green finance is originated in the U.S., when the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), also known as Superfund, was established. The act forces the parties who are responsible for the contamination to either clean up the pollution or reimburse the government for cleanup work led by Environmental Protection Agency (EPA). After that, governments and international organizations from all over the world such as the UK, Japan, Euro Union, have tried many methods related to green finance and gained some experience. However, it seems challenging to reach consensus on the definition of green finance. There are narrow and broad definitions of green finance internationally. The narrow definition focuses on identifying green financial assets, green financial industries and technologies, etc., while the broad one focuses on the sustainability, stability and efficiency of the financial system, e.g.,Chenghui Zhang (2016). In China, there are three mainstream views: the first one concentrates on credit, which means that the financial industry specifically supports the green industry and gives preferential policies in terms of credit allocation, investment volume, maturity and interest rates, e.g., He (1998). The second indicates that green finance is a kind of strategy for sustainable financial development that financial sector uses to promote environmental resource protection, e.g., Gao (1998). The third one is mainly about financial tools which are good for resource conservation such as green credit and green insurance, e.g., Pan (2007). Some scholar like Li (2015) have synthesized these three views. However, in this article an extremely precise definition of green finance will not benefit us too much in solving

the more important problems and it will probably make the article confusing. Therefore, to make it clear, green finance in this article is more about green finance policies, including eight aspects, based on Local Green Finance Development Index and Evaluation Report (2019) from Green Finance Research Institute of Central University of Finance and Economics.

While many studies agree that green finance conduces to reducing the carbon emission e.g., An (1998), Jiangui He et al(2006), Shahbaz et al (2013), Lei Zhang (2003), Wang (2016), Lin et al (2009), Youguo Zhang (2010), whether finance itself can help to reduce the carbon emission is controversial. Some scholars opine that the development of the financial market can cut carbon emission for three main reasons. Firstly, the development of capital markets has reduced the cost of financing for companies, making them more focused on long-term development, technology investment and enhancing its trustworthy image in capital market especially for firms in developing countries, e.g., Tamazian et al (2009), Shahbaz et al (2013). Secondly, mature financial systems are more conducive to the establishment of carbon trading markets. In mature financial markets, environmental regulators would bring pollution emission rights to market and require firms to disclose information about their environmental performance, e.g. Shahbaz et al (2013). Additionally, financial industry itself is low in carbon emission, e.g. Dongbo Zhu et al (2018), Shahbaz et al (2013). Some researchers argue that the crude financial development in many countries increases local carbon emission. From the perspective of foreign investment introduction, after introducing the foreign capital, the growing industry may pollute the environment and increase carbon emission, e.g. Omri (2015), Li and Qi (2011), Tamazian and Rao (2010). From the perspective of internal investment and consumption, it is believed that some firms will invest on non-environmental projects because the financing is easier and consumers are more likely to buy some bulk commodities like cars, houses or refrigerators once their budget constraint is smoothed by loans, e.g. Zhang (2011), Al-Mulali (2015), Boutabba (2014), Sadorsky (2010). To solve the controversy, Yan (2016) proposes Financial Environmental Kuznets Curve (FEKC) for the first time which describes the inverted U-shaped curve relationship between the development of finance and carbon emission where with financial system developing, carbon emission will rise at first and then fall. When the financial system in a country is immature, the development of finance will increase carbon emission. Ralph (2019) supposes that the key to address this problem depends on the structure of financing: a financial structure that relies more on equity financing can significantly reduce the carbon emission per capita. Inspired by Yan, we introduce the FEKC into this article to identify China's development stage of finance, which is extremely interesting and appealing. The Chinese government has long introduced many green finance policies intended to reduce carbon emissions. However, if China's development stage of finance is not yet identified, according to the FEKC, it's difficult to make sure that the policies will have effects as intended, which is definitely bad news for the Chinese government, especially when it is trying to achieve the carbon peaking and carbon neutrality goals.

In this paper we use the data sample in Chinese cities from 2012 to 2019 to analyze

the present stage of China's financial development and the role that the Chinese government plays in cutting carbon emission. The challenge of climate is looming as extreme weather occurs around the globe. To address the global problem, countries that account for 91% of global carbon emissions are setting up or have already set up carbon neutralization goals, including China. Today China is one of the largest carbon emitters in the world, with 10523.03 million tons of carbon emissions in 2021. Meanwhile, since the "Eleventh Five-Year Plan" stage, energy saving and emission reduction have become important development goals in China.

Our analysis relies on several data sources: for the panel data, combining the availability of data, this paper selects various types of data for 298 prefecture-level cities from 2012-2019 as the initial sample. Drawing on Song (2017), we exclude the data in Tibet, Hong Kong, Macao and Taiwan due to the high degree of missing and interpolate and fill the rest to get the final valid sample containing 298 prefecture-level cities. For the green finance data, referring to Local Green Finance Development Index and Evaluation Report (2019) from Central University of Finance and Economics, we adopt manual collection and establish a series of eight green finance indicators including green finance provincial documents, city-level documents, public private partnership cooperation, green financial infrastructures, green finance associations, green finance pilot zones, municipal documents that support green finance bonds and loans, which mainly comes from the official websites of provincial and municipal governments, environmental protection bureaus, China Public Private Partnerships Center and WIND database.

By using the panel data we find that the overall level of China's current finance is still at a relatively crude development stage, which means that the development of finance in China will enhance total carbon emission. Therefore, when the Chinese government is designing and implementing green finance policies, the negative effect of finance policy should be taken into consideration. In the short term, it is likely that the implementation of green finance policies may increase carbon emissions.

Armed with these indicators, we construct models to estimate effects of the green finance policies on cutting carbon emissions. We find that most green finance policies are irrelevant with the changes of carbon emissions unexpectedly and although green finance infrastructures and associations have significant impacts on carbon emissions, they actually increase the level of carbon dioxide. This anomaly can be explained that it takes a long time from implementation of policies to the completion of the construction of project and eight years from 2012 to 2019 may not be enough for observing positive effects. Additionally, when projects are under construction, a great amount of carbon dioxide is emitted, which is counterproductive on cutting carbon emissions. Moreover, since China's financial development is still in crude stage, green finance policies boost financial development and therefore, increase carbon emissions.

To learn the mechanism behind, we use some other regressions and find that green financial infrastructures are closely related to city-level documents, meaning that those projects receive more municipal attention, which helps to explain why infrastructures have significant impacts on carbon emissions. Despite green bond and loan policies are also both tightly related to city-level documents, their effects are probably disturbed by

local banking competition.

Overall, we use the new data to measure the current stage of finance in China whereas most of the previous studies look at the relationship between economy development and carbon emission e.g., Cai et al (2008), Lin et al (2009), Huan Zhu et al (2020), Xiao et al (2021) or focus on qualitative analysis e.g., Qinmin Yan (2010). The new data also make our results more reflective of current reality than previous studies, e.g., Yan (2016). Moreover, we manage to shed some light on the effects green finance policies have on carbon emissions by combining existing studies to screen indicators as proxy variables for green finance and some studies of green finance also lack quantitative analysis, e.g., An (2008), Wang (2016).

The remainder of the paper is structured as follows: section II provides an introduction of China's green finance development. Section III presents data sources and the way we construct our main variables. Section IV presents empirical estimates of China's financial development stage and the impacts of green finance policies. Section V sheds some light on the underlying mechanisms. Section VI concludes.

2. Current Stage of China’s Green Finance Development

2.1 Start-up Stage: From 2007 to 2015

Before 2010, China initially emerged potential tendency of developing the green finance market. Some regulation policies and practices were primarily established, laying the foundation for green finance’s future development in China. On the regulation side, China Banking Regulatory Commission enacted Guidance on Credit Provision to Energy Saving and Emission in 2007. The regulatory framework addressed the importance of supporting energy conservation and regulating the credits flowing to high pollution and high-energy-costing industries. On the market side, China's Industrial Bank launched the first green credit products with the cooperation of IFC. It also committed to obeying Greenwich Principles in 2008.

After 2010, the establishment of government’s policy framework for the green credit market was to begin. China Banking Regulatory Commission published Green Credit Guidelines Notice in 2012. This document was the programmatic document for the building of china’s green credits market. It required China commercial banks to enhance the role of green credits in allocating resources and industrial upgrading. Those banks also had to successfully manage the risks related to the environment. After this document, China Banking Regulatory Commission followed to release several documents, including “General Office of the China Banking Regulatory Commission Opinions on Green Credit Implementation”, “Notice of the CBRC on KPIs of Green Credit Implementation” and “Notice of the China Banking Regulatory Commission on Submission of Green Credit Statistics Form”. From then on, the green credit policy system was refined with the cornerstones of the assessment mechanism and credit assessment system.

2.2 Mature Stage: From 2015 to 2019

After the initial stage, green financing in China was primarily established. The whole market began to mature from both the regulatory aspect and the diversified green finance tools aspect. Guidance on building a green financial system was jointly issued by the government's seven state ministries in 2016. This event meant that the country's top framework of green financing was promoted. It also represented that China had become the first country in the world to set clear standards in green financing. The guidance cleared out the definition of green financing and encouraged greater development for varied tools in green market implementation, such as green insurance, investment in the green sector, and green bonds. In 2017, the division scheme of Guidance on building a green financial system was produced. With the instruction, diversified green financing facilities were gradually set up.

As for the innovative pilot zones, the State Council of China's Cabinet announced the decision of establishing pilot zones for green finance reform and innovations in 2017. These first pilot zones were built in Jiangxi, Guangdong, Zhejiang, Guizhou provinces, and Xinjiang Uygur autonomous region. The pilot zones were aimed at setting up green finance departments and branches, accelerating the development of green credits, exploring the markets for trading environmental rights, and providing support to green sectors or green projects. Above all, in these areas, six sides of reformation were expected to complete, involving the system, market, products and services, and institutional innovation. In November 2019, the second batch of the pilot zone for green finance reform and innovations was set up in Gansu province. The nine zones had their emphasis and strengths, creating replicable ways to boost green financing in China.

As for the green credit aspect, the green banking system started to play a vital role in supplying credit to green investments. In 2018, "Notice of the People's Bank of China on Conducting Green Credit Performance Evaluation of Banking Depository Financial Institutions" was released, striving to develop green credit. The People's Bank of China developed detailed rules for green credit evaluations. The main indicators for the evaluation are classified into two categories: quantitative indicators and qualitative indicators. The Quantitative indicator consists of the proportion and the growth of green loans. The qualitative scores include self-evaluation and implementation of green policies. The final mark of the evaluation would influence the Micro Prudential Assessment of those banks, therefore those banks had to attach importance to greening banks. In addition, the range of banks participating in this evaluation had grown from 20 major banks to all the banking depository financial institutions.

As for the green bonds market, PBC released "the Announcement on Matters Concerning the Issue of Green Financial Bonds on the Inter-bank Bond Market" in 2015. As follows, incorporated financial institutions, companies, and financial institutions enacted adequate and effective rules on credit extension, risk control, and marketing, among others, to set up green industry projects and a mature business team in 2017. The first green bond of the nation was issued in 2015 by Xinjiang Gold-wind Sci & Tech Company. The market for green bonds was booming as the perfected system of

the green bond policy covered the entire market. From 2016 to 2017, the issuing scale of green bonds increased to 3983.6 billion RMB. According to the data from CBI, the labeled green bonds issuance of China outperformed the United States, becoming the biggest issuer in the world.

As for the national carbon emissions trading market, China strove toward carbon neutrality amid market-based explorations. In 2017, "Working guidance for establishing national carbon trading market" was issued by NDRC, to promote the establishment of a national carbon emissions trading scheme. Meanwhile, Chinese emissions allowances were set by the State of Council in 2017. According to the standard, the trading system allowed trading models containing listing trading by agreement, bulk trading by agreement, and one-way bidding. The perfected policy-making indicated the design and layout of China's national carbon market were complete.

2.3 Development Stage: 2020-2022

In the development stage, unified criteria of green finance are formed. The green finance market was developing rapidly.

As for the policy framework, PBC preliminarily established the policy design for green finance development, which features "three functions" and "five pillars". The three functions included managing the risk related to climate change, allocating and redistributing the resources, and discovering prices in the carbon trading market. The five pillars contained building complete development architecture for green finance, refining the regulation and information disclosure requirements, enhancing the incentive and restraint mechanisms, enriching the products in the green finance market, and joining in international cooperation. Apart from this, the standard became more unified as a series of general basic standards were clarified in "Green Industry Guidance Catalogue (2019 Edition)". In this catalog, standards for information disclosure, product services, risk management, general principles, statistical methods, and credit rating were all cleared out.

For the bank sector, firstly, CBIRC published the Green Finance Guidelines for Banking and Insurance Sectors in 2022. These guidelines required not only banks but also insurance institutions to promote green finance development. The guidelines also emphasized that the business scope relevant to green finance had to cover both green credits and other green financing businesses. Secondly, China's green credits grew more rapidly compared with other kinds of credits. The total scale of green credits in China was 19.55 trillion RMB by 2022H1. The year-on-year growth of those green credits was 40.4%, which was significantly greater than other kinds' growth of 29.6%.

For the green bond sector, firstly, the standard and regulation of green bonds were more coordinated internationally, and more uniform. In 2021, PBC, CSRC, and NDRC published Green Bond Endorsed Projects Catalogue (2021 Edition). This document ensured the uniformity of the standards of all kinds of green bonds, including green financial bonds, green corporate bonds, ABS, and so on. In 2022, NTC377, the standardization commission for green manufacturing technology released Green Bond Principals of China. The publication of these documents used the international

experience for reference, such as the principals from ICMA. Until 2022, China had become the greatest green bond release country as the stock of these green bonds surpassed 1 trillion RMB in 2022. By 2021, the stock of green bonds in China was nearly 2.1 trillion RMB.

3. Data and Variables

3.1 Data Sources

The data used in this essay could be mainly divided into 2 parts. The first part is the data related to the prefecture-level city's panel data. Under the limitation of availability and quality of the data, the article selects data during the 2012-2019 period. According to Song(2017), considering the high data dearth in Xizang Autonomous Region, Hong Kong, Macao, and Taiwan, we remove those data and fill the panel with the interpolation method. The regression uses 1437 valid and effective samples. The panel data are from the CEAD database, WIND database, the Statistical Review Yearbook, and CEINET.

The second part is the data related to China's green finance development. We construct the green finance indexes with the reference from "The Evaluation for the Development of Green Finance(2019)".The green finance indexes include the number of green finance pilot zones, the number of province-level and city-level documents relevant to green finance, green finance infrastructure, green credit policy, and green bond policy. The data resources are the WIND database, the Department of Environment Protection, the PKUlaw database and the government's official websites.

3.2 Indicator and Regression Construction

In our empirical analysis, we first examine China's current financial development stage with the models below. We add a quadratic term to regression (2) based on regression (1) in order to find out whether China's financial development fits FEKC.

$$\begin{aligned} CO_{2_{i,t}} = {} & \beta_0 + \beta_1 CO_{2_{i,t-1}} + \beta_2 Finance_{i,t-1} + \beta_3 Bank_{i,t} + \beta_4 Structure_{i,t} \\ & + \beta_5 Industry_{i,t} + \beta_6 Technology_{i,t} + \beta_7 Expenditure_{i,t} \\ & + \beta_8 GDP_{i,t} + FIXEDEFFECT + e_{i,t} \end{aligned} \tag{1}$$

$$\begin{aligned} CO_{2_{i,t}} = {} & \beta_0 + \beta_1 CO_{2_{i,t-1}} + \beta_2 Finance_{i,t-1} + \beta_3 Finance^2_{i,t-1} + \beta_4 Bank_{i,t} \\ & + \beta_5 Structure_{i,t} + \beta_6 Industry_{i,t} + \beta_7 Technology_{i,t} \\ & + \beta_8 Expenditure_{i,t} + \beta_9 GDP_{i,t} + FIXEDEFFECT + e_{i,t} \end{aligned} \tag{2}$$

$CO_{2_{it}}$ is carbon dioxide emission intensity, representing the ration of carbon emissions (tons) of a prefecture-level city i in year t to the GDP (million yuan) of that

city in that year, which refers to the method in Yan (2016). The prefecture-level city$i$corresponds to 285 prefecture-level cities and the time span is from 2013 to 2019.

[Figure 1]

In addition, there has been a different focus and degree of economic development between eastern and Midwestern China, which at the same time also leads to the variability of carbon emission intensity between regions. Figure 2 shows the difference in carbon emissions between eastern and Midwestern China from 2013 to 2017, where the total annual carbon emissions in the Midwest are significantly higher than the East, but the median value in the eastern part is much higher than that in Midwestern China.

[Figure 2]

$Finance_{i,t}$indicates China's financial development, which is the logarithmic form of the sum of the balances of loans and deposits of financial institutions at the end of the year, under consideration of transmission mechanism of financial development affecting the economy and the availability of data, e.g., Sadorsky(2010). The prefecture-level city$i$corresponds to 285 prefecture-level cities and the time span is from 2003 to 2017. Since the loan balances of financial institutions reflect the ease of financing for enterprises, the higher the $Finance_{i,t}$, the less difficult it is for the enterprises to finance, which means the higher the level of financial development.

$Bank_{i,t}$, $Structure_{i,t}$, $Industry_{i,t}$, $Technology_{i,t}$, $Expenditure_{i,t}$, $GDP_{i,t}$ are selected for control variables. All of them are highly related to carbon emissions and therefore the results we get could be more reliable after these factors are controlled.

$Bank_{i,t}$is the number of local banks in the year, conducive to showing the impact of bank competition on carbon emission reduction. Rong Chen and Jie Zhang (2022) find that the level of competition formed between China's unique large and small banks has a significant inhibitory effect on micro-enterprise innovation, which we suppose might increase carbon emissions. However, according to Shanshan Wu (2018), while bank credits have a scale effect on carbon emissions, they also have a significant negative effect on carbon intensity, indicating technological effects.

$Structure_{i,t}$is the share of secondary industry value added in GDP. The financial sector is a tertiary sector which is inherently clean and has low energy consumption, so financial development may reduce carbon emissions, e.g., Dongbo Zhu et al (2018). At the same time, industry and manufacturing have the characteristics of high energy consumption and high pollution, whose emissions intensity is much larger than other industries. Moreover, China has focused on the development of heavy industry to stimulate economic growth for a very long time and a large amount of financing flows into high-polluting industries, which leads to the fact that the secondary industry in China's GDP occupies a large proportion.

$Industry_{i,t}$is the number of industrial enterprises above designated size. It is a statistical term used in China to refer to industrial enterprises with annual main business revenue of 20 million yuan or more. Although people assume that industries positively

correlate with carbon emissions, since oil and gas extraction industries and ferrous metal mining and selection industries occupy significant amounts of them, China has been phasing out backward production capacity since 2012. Therefore, the impact of industrial enterprises still needs to be explored.

$Technology_{i,t}$is the logarithmic form of scientific expenditures. In some studies, patents are usually used to represent outputs of research and development (R&D), which can largely reflect technological innovation, e.g., Wei (2010). Technological progress and innovation are the driving forces of a country's economic development. Increased energy utilization and renewable energy use brought about by technological innovation can have an impact on carbon emissions, and an important way of technological progress is to improve the stock of knowledge through independent research and development.

$Expenditure_{i,t}$is logarithmic local finance general budget expenditure. Shuanyou Ma et al (2003) find that local governments could influence the growth of the low-carbon economy in two ways.The first way is increasing the scale and structure of fiscal expenditure, and the second is enhancing environmental regulation. Research shows that different public expenditure scales and different expenditure structures have different low-carbon economic growth effects. In China, local government plays a non-negligible role in the transition to a low-carbon economy.

$GDP_{i,t}$is logarithmic regional gross domestic product. Feng Wang et al (2010) used Logarithmic Mean Divisia Index Method to decompose and analyse factors that boosted China's carbon emissions, maintaining that GDP contributed 15.82% of emissions.

We then use the regressions below to find out whether green finance and China's government help to cut down carbon emissions.

$$\begin{aligned} CO_{2_{i,t}} = {} & \beta_0 + \beta_1 CO_{2_{i,t-1}} + \beta_2 Finance_{i,t-1} + \beta_3 ProvinDoc_{i,t-1} \\ & + \beta_4 ProvinDoc_{i,t-1} * Finance_{i,t-1} + \beta_5 Bank_{i,t} \\ & + \beta_6 Structure_{i,t} + \beta_7 Industry_{i,t} + \beta_8 Technology_{i,t} \\ & + \beta_9 Expenditure_{i,t} + \beta_{10} GDP_{i,t} + FIXEDEFFECT + e_{i,t} \end{aligned} \tag{3}$$

$ProvinDoc_{i,t-1}$is the cumulative number of provincial documents related to green finance, indicating how provincial officials focus on green finance.

$$\begin{aligned} CO_{2_{i,t}} = {} & \beta_0 + \beta_1 CO_{2_{i,t-1}} + \beta_2 Finance_{i,t-1} + \beta_3 CityDoc_{i,t-1} \\ & + \beta_4 CityDoc_{i,t-1} * Finance_{i,t-1} + \beta_5 Bank_{i,t} \\ & + \beta_6 Structure_{i,t} + \beta_7 Industry_{i,t} + \beta_8 Technology_{i,t} \\ & + \beta_9 Expenditure_{i,t} + \beta_{10} GDP_{i,t} + FIXEDEFFECT + e_{i,t} \end{aligned} \tag{4}$$

$CityDoc_{i,t-1}$is the cumulative number of municipal documents related to green finance, indicating the degree of attention to green finance at the municipal level.

$$CO_{2_{i,t}} = \beta_0 + \beta_1 CO_{2_{i,t-1}} + \beta_2 Finance_{i,t-1} + \beta_3 Cooperation_{i,t-1} + \beta_4 Cooperation_{i,t-1} * Finance_{i,t-1} + \beta_5 Bank_{i,t} + \beta_6 Structure_{i,t} + \beta_7 Industry_{i,t} + \beta_8 Technology_{i,t} + \beta_9 Expenditure_{i,t} + \beta_{10} GDP_{i,t} + FIXEDEFFECT + e_{i,t} \quad (5)$$

$Cooperation_{i,t-1}$is the cumulative number of Public-Private Partnership projects on ecological construction and the environment from 2013 to 2019, standing for government collaborations with private sectors.

$$CO_{2_{i,t}} = \beta_0 + \beta_1 CO_{2_{i,t-1}} + \beta_2 Finance_{i,t-1} + \beta_3 Infrastructure_{i,t-1} + \beta_4 Infrastructure_{i,t-1} * Finance_{i,t-1} + \beta_5 Bank_{i,t} + \beta_6 Structure_{i,t} + \beta_7 Industry_{i,t} + \beta_8 Technology_{i,t} + \beta_9 Expenditure_{i,t} + \beta_{10} GDP_{i,t} + FIXEDEFFECT + e_{i,t} \quad (6)$$

$Infrastructure_{i,t-1}$is the dummy variable of green financial towns and green financial service platforms in every city from 2013 to 2019. Green financial towns generally attract green funds and green asset trading in business, aiming to guide capital to invest in green industry. Green financial service platforms serve as agencies to help companies get green loans more conveniently.

$$CO_{2_{i,t}} = \beta_0 + \beta_1 CO_{2_{i,t-1}} + \beta_2 Finance_{i,t-1} + \beta_3 Association_{i,t-1} + \beta_4 Association_{i,t-1} * finance_{i,t-1} + \beta_5 Bank_{i,t} + \beta_6 Structure_{i,t} + \beta_7 Industry_{i,t} + \beta_8 Technology_{i,t} + \beta_9 Expenditure_{i,t} + \beta_{10} GDP_{i,t} + FIXEDEFFECT + e_{i,t} \quad (7)$$

$Association_{i,t-1}$ is the dummy variable of professional associations of green finance in every city. Different financial institutions join in as members and negotiate about green financial self- discipline.

$$CO_{2_{i,t}} = \beta_0 + \beta_1 CO_{2_{i,t-1}} + \beta_2 Finance_{i,t-1} + \beta_3 Zone_{i,t-1} + \beta_4 Zone_{i,t-1} * Finance_{i,t-1} + \beta_5 Bank_{i,t} + \beta_6 Structure_{i,t} + \beta_7 Industry_{i,t} + \beta_8 Technology_{i,t} + \beta_9 Expenditure_{i,t} + \beta_{10} GDP_{i,t} + FIXEDEFFECT + e_{i,t} \quad (8)$$

$Zone_{i,t-1}$ is the dummy variable of national-level green finance reform and innovation pilot zones established in a specific province from 2013 onwards, which indicates one of provincial approaches to cutting emissions.

$$CO_{2_{i,t}} = \beta_0 + \beta_1 CO_{2_{i,t-1}} + \beta_2 Finance_{i,t-1} + \beta_3 Bond_{i,t-1} + \beta_4 Bond_{i,t-1} * Finance_{i,t-1} + \beta_5 Bank_{i,t} + \beta_6 Structure_{i,t} + \beta_7 Industry_{i,t} + \beta_8 Technology_{i,t} + \beta_9 Expenditure_{i,t} + \beta_{10} GDP_{i,t} + FIXEDEFFECT + e_{i,t} \quad (9)$$

$Bond_{i,t-1}$is the cumulative number of municipal documents that governments offer corporate bonds discount at an interest rate if the bonds are classified as green bonds.

$$CO_{2_{i,t}} = \beta_0 + \beta_1 CO_{2_{i,t-1}} + \beta_2 Finance_{i,t-1} + \beta_3 Loan_{i,t-1} + \beta_4 Loan_{i,t-1} * Finance_{i,t-1} + \beta_5 Bank_{i,t} + \beta_6 Structure_{i,t} + \beta_7 Industry_{i,t} + \beta_8 Technology_{i,t} + \beta_9 Expenditure_{i,t} + \beta_{10} GDP_{i,t} + FIXEDEFFECT + e_{i,t} \quad (10)$$

$Loan_{i,t-1}$is the cumulative number of municipal documents that support green loans, including green loan subsidies, refinancing directed to support green projects, assessing green loans performance with MBA criteria.

$ProvinDoc_{i,t-1}$ and $Zone_{i,t-1}$ represent the government's provincial holistic policy promotion.

$CityDoc_{i,t-1}$, $Cooperation_{i,t-1}$, $Infrastructure_{i,t-1}$, $Association_{i,t-1}$, $Bond_{i,t-1}$and$Loan_{i,t-1}$indicate city and county level of government's efforts.

4. Empirical Evidence

4.1 Descriptive statistics

[Table 1]

Table 1 shows the descriptive statistics for each variable invovled in regression. We can see that compared with other variables, bank data confronts lots of missings. Data values from infrastructure and association are quite low, due to the fact that only a few cities establish green financial towns, service platforms and professional green financial associations.

4.2 Formal Test

[Table 2]

First comes determing China's financial development stage. According to Table 2, finance is significant at the 1% level and has a coefficient of 0.160, indicating a positive effect on carbon emissions. In addition, the quadratic term in regression (2) is not significant, showing that the current relationship between financial development and carbon emissions in China is not in line with FEKC. That being said, China's financial

system is still in a rough and tumble stage of development, where growing finances probably boost carbon emissions. Therefore, even though some green finance policies are responsible for cutting emissions, we still can not guarantee the final effects are positive on reducing carbon emissions , which is why we introduce green finance indicators into our regression.

[Table 3]

[Table 4]

Table 3 and Table 4 show that among eight green finance indicators, only infrastructure and association are significant, where infrastructure is at the 5% level and association is at the 1% level. Furthermore, infrastructure and association both have positive coefficients. In the short term, provincial and municipal documents as well as PPP programs are hard to take into effect, since policies have a lagging effect, and the peak of policy release is often in the early stage, and the latter is often the implementation of policies. In addition, going through the process from construction to starting operation, projects will also need a great amount of time to reduce carbon emissions. As a result, due to the fact that infrastructures and associations directly influence the whole market without long periods of waiting for construction, we can clearly observe their impacts. However, as financial development is able to boost carbon emissions, the foundation of green finance associations, green financial towns and service platforms fails to lead to carbon abatement. More specifically, the effect of increasing carbon dioxide from financial development outweighs the emission reduction effects of these measures.

5. Mechanism

In order to analyse the mechanism of policy transmission, how provincial documents affect municipal documents and further affect other approaches to cut emissions, and why some policies are in full force and some are not, we focus on the relationships among green finance policies with regression (11) - (20).

$$\begin{aligned} CityDoc_{i,t} = {} & \beta_0 + \beta_1 CO_{2_{i,t-1}} + \beta_2 ProvinDoc_{i,t-1} + \beta_3 Bank_{i,t} \\ & + \beta_4 ProvinDoc_{i,t-1} * Bank_{i,t} + \beta_5 Expenditure_{i,t} \\ & + \beta_6 GDP_{i,t} + FIXEDEFFECT + e_{i,t} \end{aligned} \tag{11}$$

Regression (11) shows the impact of provincial documents on municipal documents, which we assume is the beginning of the mechanism: provincial governments first come up with new policies and local governments follow as well as take different kinds of actions.

$$Cooperation_{i,t} = \beta_0 + \beta_1 CO_{2_{i,t-1}} + \beta_2 ProvinDoc_{i,t-1} + \beta_3 Bank_{i,t} + \beta_4 ProvinDoc_{i,t-1} * Bank_{i,t} + \beta_5 Expenditure_{i,t} + \beta_6 GDP_{i,t} + FIXEDEFFECT + e_{i,t} \quad (12)$$

$$Infrastructure_{i,t} = \beta_0 + \beta_1 CO_{2_{i,t-1}} + \beta_2 ProvinDoc_{i,t-1} + \beta_3 Bank_{i,t} + \beta_4 ProvinDoc_{i,t-1} * Bank_{i,t} + \beta_5 Expenditure_{i,t} + \beta_6 GDP_{i,t} + FIXEDEFFECT + e_{i,t} \quad (13)$$

$$Zone_{i,t} = \beta_0 + \beta_1 CO_{2_{i,t-1}} + \beta_2 ProvinDoc_{i,t-1} + \beta_3 Bank_{i,t} + \beta_4 ProvinDoc_{i,t-1} * Bank_{i,t} + \beta_5 Expenditure_{i,t} + \beta_6 GDP_{i,t} + FIXEDEFFECT + e_{i,t} \quad (14)$$

$$Bond_{i,t} = \beta_0 + \beta_1 CO_{2_{i,t-1}} + \beta_2 ProvinDoc_{i,t-1} + \beta_3 Bank_{i,t} + \beta_4 ProvinDoc_{i,t-1} * Bank_{i,t} + \beta_5 Expenditure_{i,t} + \beta_6 GDP_{i,t} + FIXEDEFFECT + e_{i,t} \quad (15)$$

$$Loan_{i,t} = \beta_0 + \beta_1 CO_{2_{i,t-1}} + \beta_2 ProvinDoc_{i,t-1} + \beta_3 Bank_{i,t} + \beta_4 ProvinDoc_{i,t-1} * Bank_{i,t} + \beta_5 Expenditure_{i,t} + \beta_6 GDP_{i,t} + FIXEDEFFECT + e_{i,t} \quad (16)$$

Regression (12) - (16) are used to examine whether provincial documents are able to influence other green finance indicators directly without municipal documents taking effect.

Then with regression (17) - (20), the second step is to explore whether relationships among municipal documents and other green financial approaches exist and how municipal documents direct them.

$$Cooperation_{i,t} = \beta_0 + \beta_1 CO2_{i,t-1} + \beta_2 CityDoc_{i,t-1} + \beta_3 Bank_{i,t} + \beta_4 CityDoc_{i,t-1} * Bank_{i,t} + \beta_5 Expenditure_{i,t} + \beta_6 GDP_{i,t} + FIXEDEFFECT + e_{i,t} \quad (17)$$

$$Infrastructure_{i,t} = \beta_0 + \beta_1 CO2_{i,t-1} + \beta_2 CityDoc_{i,t-1} + \beta_3 Bank_{i,t} + \beta_4 CityDoc_{i,t-1} * Bank_{i,t} + \beta_5 Expenditure_{i,t} + \beta_6 GDP_{i,t} + FIXEDEFFECT + e_{i,t} \quad (18)$$

$$Bond_{i,t} = \beta_0 + \beta_1 CO2_{i,t-1} + \beta_2 CityDoc_{i,t-1} + \beta_3 Bank_{i,t} + \beta_4 CityDoc_{i,t-1} * Bank_{i,t} + \beta_5 Expenditure_{i,t} + \beta_6 GDP_{i,t} + FIXEDEFFECT + e_{i,t} \quad (19)$$

$$Loan_{i,t} = \beta_0 + \beta_1 CO2_{i,t-1} + \beta_2 CityDoc_{i,t-1} + \beta_3 Bank_{i,t} + \beta_4 CityDoc_{i,t-1} * Bank_{i,t} + \beta_5 Expenditure_{i,t} + \beta_6 GDP_{i,t} + FIXEDEFFECT + e_{i,t} \quad (20)$$

We add the interaction terms of market competition rate and city-level green finance policy, in order to investigate whether the implementation of city-level policy will influence green infrastructure construction, and the establishment of green credit policy or green bond policy.

[Table 5]

According to the regression results reported in Table 5, the green finance infrastructures and other policies have close connections with city-level policy, but have low correlations with provincial policy. In the regression where green finance infrastructure, green credit policy, and green bond policy are dependent variable respectively, the city-level policy variable is significantly positive at 1% level, 10% level, and 1% level as follows.

The first reason is the policy implementers take adverse actions based on their interests. The local government is required to pay for environmental management. But the adjacent areas could also benefit from the better environment as pollution regulation brings positive externality. The externality finally leads to gambling between policy

implementers. Secondly, the overextended policy implementation is harmful. The implementers could attach some new and improper contents which are not mentioned in the original policies to pursue personal interests. That may lead to the target, scope, and intensity of the policies exceeding the original requirements. Thirdly, the overlapping among various executing agencies' functions could cause implementation stalls. The overlapping brings problems of low efficiency, expanded authority, and wrangling.

According to the regression results reported in Table 5, the interaction term of market competition rate and city-level green finance policy is all significantly negative at the 10% significance level when the green bond policy or green credit policy is the dependent variable respectively. The data confirms that the contribution of city-level green finance policy to the issuance of green bonds and green credit policy is weakened, with the increase of local bank competition rate. On the other hand, relations would be strengthened when the competition rate increased.

The first reason is those banks with monopolistic power, could form long-term and stable lending relationships with their counterparts easily. They also have stable clienteles and are good at risk management. With strength, environmental risks could hardly impact them, so they don't like to shift their operation strategies and issue green credits. The second reason is, in those areas with strong banking market power, fewer restrictions would limit commercial banks from pursuing short-term benefits. In the long term, green credits are good for environmental protection. But in the short term, those banks with high discourse are still waiting and seeing. The issuance of green credits will increase the operating costs of banks, and reduce the profits they earn from high-pollution entrepreneurs, thus leading to a decline in their operating performance. Meanwhile, local protectionism is also a reason. Commercial banks, especially those state-owned banks, have the responsibility to support macroeconomic development. They establish long-term lending relationships with many companies that are regarded as high-quality customers and the pillar of regional development. These companies also have the characteristics of high profits and high energy consumption and pollution output. The banks have to protect these companies' interests. As a result, the green credit policy is insensitive to city-level green finance policies.

6. Concluding Remarks

Using a sample of China's carbon emissions and green financial policies from both provincial and city levels from 2013 to 2019, we find little evidence to support FEKC with Chinese data. Instead, China's current financial development fits linear function more and is still in an extensive developing stage. We also confirm that green finance policies have limited effects on reducing carbon emissions. Our analysis presents that in the short term it is unclear about their noticeable impacts on cutting down emissions except for infrastructures and associations. Infrastructures and associations directly influence market players behaviors and, meanwhile, prompt carbon emissions because of the current crude financial development, meaning that the more positive impacts of green finance policies we expected may happen in a longer period. Our analysis also

presents that city-level green financial policies are more functional compared with province-level policies. In addition, the forces of local banks would impede city-level green financial policies stimulating the release of green bonds or green credit policies, and the establishment of green infrastructures.

To develop the green finance market, we put forward several suggestions according to our analysis. Firstly, the country has to promote green financial legislation and strengthen law enforcement. The green financial system should be established in the form of law, such as the Commercial Bank Law, the Securities Law, and other related laws. Also, the country should improve the laws and regulations on environmental protection further to clarify the legal responsibilities of polluters. A premise legislation system should enact different laws in different regions according to local conditions. Meanwhile, strict law enforcement is strongly needed.

Second, the country should strengthen coordination among government departments and other institutions based on an improved information-sharing system. The development of green finance involves multiple parties, including the PBC, CSRC, CBRC，NDRC, the Ministry of Finance, the Ministry of Environmental Protection, and financial institutions. Therefore, cooperation and information sharing among these organizations is vital.

Third, the country has to improve the green financial policy-support system. With the cooperation of tax, monetary, credit, and industrial policies, the government could guide financial institutions to accelerate the innovation of green financial products and adjust their investment portfolios to meet the needs of green development. As a result, financial institutions could strengthen their incentives for green financial business development.

Fourth, as for the banking system, introducing an environmental stress test system and evaluation system for different types of financial asset portfolios is significant. Also, the government should increase the return on green credit, and reduce the cost of green credit. We should give support to commercial banks that actively implement green credit by fiscal and tax policies, and risk-loss compensation. For example, eligible green credit should not be included in the deposit-to-loan ratio assessment.

7. Figures

Figure 1: Carbon emissions in China and globe, 2012-2019

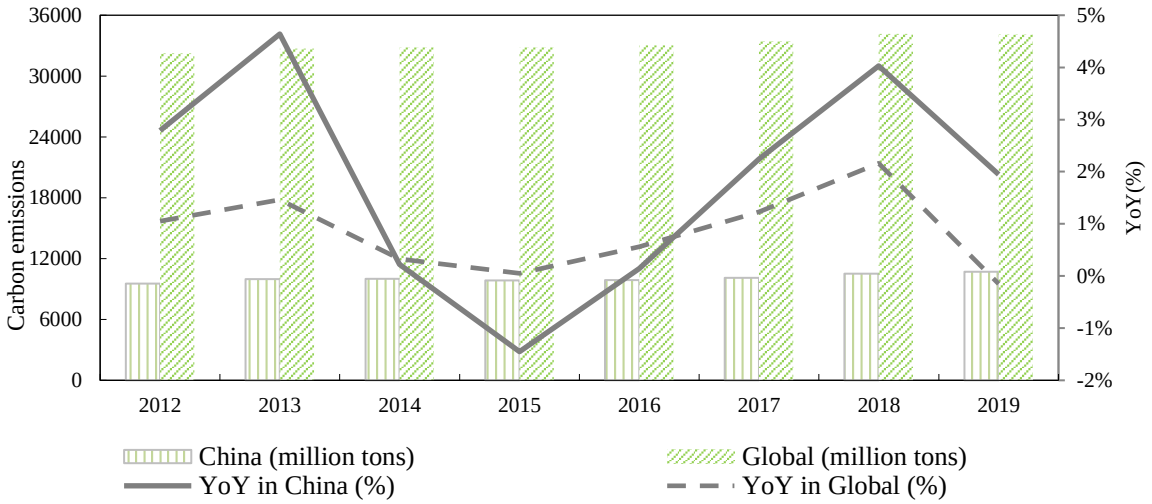
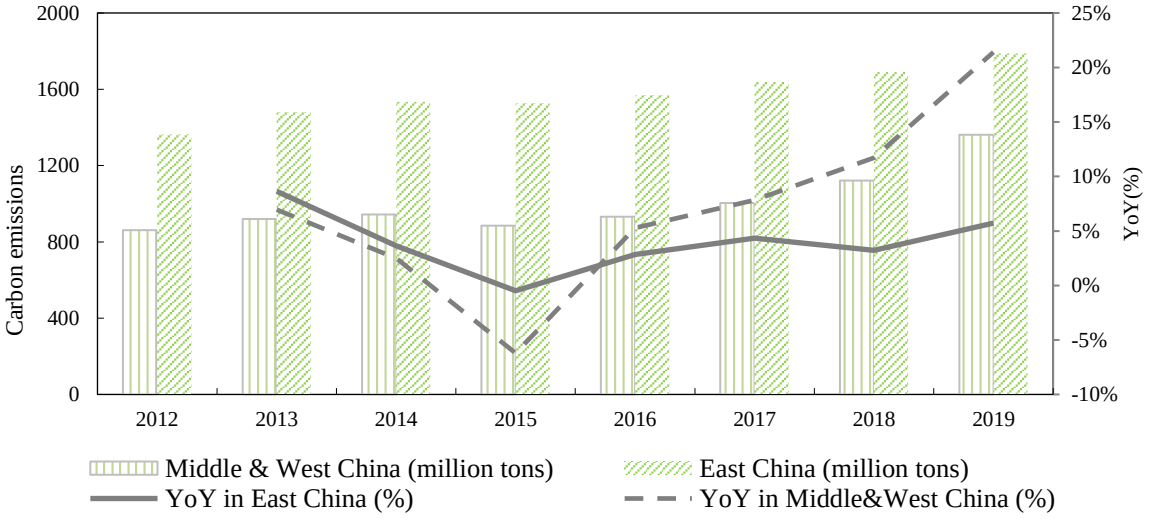


Figure 2: Carbon emissions in Midwest and East China, 2012-2019



8. Tables

Table 1: Summary statistics for main variables

Variables	Observations	Mean	Standard deviation	Minimum	Maximum
(log) CO_2	2,264	6.141	1.124	2.647	10.037
(log) Finance	2,339	17.384	1.096	11.614	21.59
ProvinDoc	2,384	8.262	10.273	0	52
CityDoc	2,384	1.483	3.399	0	53
Cooperation	2,384	0.992	3.071	0	82
Infrastructure	2,384	0.005	0.071	0	1
Association	2,384	0.005	0.068	0	1
Zone	2,384	0.047	0.211	0	1
Bond	2,384	0.615	1.417	0	13
Loan	2,384	2.557	3.738	0	51
Bank	1,810	41.978	95.589	0	1977
(ratio) Structure	2,038	46.346	10.773	10.6	88
Industry	2,326	1245.664	1523.027	3	11042
(log) Technology	2,335	10.396	1.404	6.252	15.529
(log) Expenditure	2,335	14.911	0.732	12.187	18.241
(log) GDP	2,287	16.576	0.932	14.121	19.760

Table 2: Regression of China's financial development

Dependent variable:	(log) $CO_{2\ t}$	
	(1)	(2)
(log) $CO_{2\ t-1}$	0.606***	0.606***
	(7.03)	(7.03)
(log) $Finance_{t-1}$	0.160***	0.079
	(2.64)	(0.21)
(log) $Finance^2_{t-1}$		0.002
		(0.23)
$Bank_t$	0.000	0.000
	(1.32)	(1.30)
(ratio) $Structure_t$	0.002	0.002
	(1.17)	(1.15)
$Industry_t$	-0.000**	-0.000**
	(-2.02)	(-2.01)
(log) $Technology_t$	-0.012	-0.013
	(-0.71)	(-0.73)
(log) $Expenditure_t$	-0.094*	-0.094*
	(-1.94)	(-1.94)
(log) GDP_t	0.210***	0.208***
	(3.69)	(3.69)
Observations	1,285	1,285
R-squared	0.456	0.456
City FE	YES	YES
Year FE	YES	YES

Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Regression of green finance policy effects

Dependent variable:	(log) $CO_{2\ t}$			
	(3)	(4)	(5)	(6)
(log) $CO_{2\ t-1}$	0.605***	0.605***	0.605***	0.605***
	(7.05)	(6.99)	(6.90)	(7.02)
(log) $Finance_{t-1}$	0.162***	0.158***	0.160***	0.159***
	(2.69)	(2.61)	(2.64)	(2.63)
$ProvinDoc_{t-1}$	-0.005			
	(-0.37)			
$ProvinDoc_{t-1}$*$Finance_{t-1}$	0.000			
	(0.45)			
$CityDoc_{t-1}$		-0.000		
		(-0.01)		
$CityDoc_{t-1}$*$Finance_{t-1}$		-0.000		
		(-0.06)		
$Cooperation_{t-1}$			-0.016	
			(-0.31)	
$Cooperation_{t-1}$*$Finance_{t-1}$			0.001	
			(0.32)	
$Infrastructure_{t-1}$				0.572**
				(2.50)
Infrastructuret-1*$Finance_{t-1}$				-0.033***
				(-2.95)
$Bank_t$	0.000	0.000	0.000	0.000
	(1.26)	(1.13)	(1.23)	(1.31)
(ratio) $Structure_t$	0.002	0.002	0.002	0.002
	(1.12)	(1.20)	(1.16)	(1.17)
$Industry_t$	-0.000**	-0.000**	-0.000*	-0.000*
	(-2.09)	(-2.05)	(-1.80)	(-1.96)
(log) $Technology_t$	-0.014	-0.012	-0.012	-0.012
	(-0.78)	(-0.70)	(-0.68)	(-0.69)
(log) $Expenditure_t$	-0.097**	-0.093*	-0.094*	-0.092
	(-2.02)	(-1.93)	(-1.93)	(-1.88)
(log) GDP_t	0.206***	0.214***	0.211***	0.208***
	(3.55)	(3.71)	(3.66)	(3.66)
Observations	1,285	1,285	1,285	1,285
R-squared	0.457	0.456	0.456	0.457
City FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Regression of green finance policy effects

Dependent variable:	(log) $CO_{2\ t}$			
	(7)	(8)	(9)	(10)
(log) $CO_{2\ t-1}$	0.606***	0.605***	0.603***	0.603***
	(7.02)	(7.02)	(6.91)	(6.96)
(log) $Finance_{t-1}$	0.160***	0.160***	0.162***	0.153**
	(2.65)	(2.64)	(2.67)	(2.53)
$Association_{t-1}$	0.417***			
	(3.18)			
$Association_{t-1}$*$Finance_{t-1}$	-0.020***			
	(-3.08)			
$Zone_{t-1}$		0.297		
		(0.79)		
$Zone_{t-1}$*$Finance_{t-1}$		-0.015		
		(-0.75)		
$Bond_{t-1}$			-0.031	
			(-0.55)	
$Bond_{t-1}$*$Finance_{t-1}$			0.001	
			(0.47)	
$Loan_{t-1}$				-0.015
				(-0.79)
$Loan_{t-1}$*$Finance_{t-1}$				0.001
				(0.64)
$Bank_t$	0.000	0.000	0.000	0.000
	(1.30)	(1.28)	(1.18)	(1.21)
(ratio) $Structure_t$	0.002	0.002	0.002	0.002
	(1.17)	(1.20)	(1.13)	(1.18)
$Industry_t$	-0.000**	-0.000**	-0.000**	-0.000**
	(-2.01)	(-2.12)	(-2.13)	(-2.33)
(log) $Technology_t$	-0.012	-0.013	-0.013	-0.013
	(-0.71)	(-0.75)	(-0.79)	(-0.73)
(log) $Expenditure_t$	-0.096*	-0.098**	-0.096*	-0.095*
	(-1.96)	(-1.99)	(-1.95)	(-1.94)
(log) GDP_t	0.210***	0.208***	0.225***	0.221***
	(3.69)	(3.67)	(3.66)	(3.83)
Observations	1,285	1,285	1,285	1,285
R-squared	0.457	0.457	0.457	0.457
City FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Regression of determining mechanism about policy effects

Dependent variable:	$CityDoc_t$	$Cooperation_t$	$Infrastructure_t$	$Zone_t$	$Bond_t$	$Loan_t$
	(11)	(12)	(13)	(14)	(15)	(16)
(log) $CO_{2\ t-1}$	-0.434*	-0.579	0.003	0.012	-0.343*	-0.620**
	(-1.76)	(-1.42)	(1.00)	(0.33)	(-1.80)	(-2.02)
$ProvinDoc_{t-1}$	0.110	0.020	-0.001	0.013***	0.013	-0.001
	(1.40)	(0.38)	(-0.53)	(5.28)	(0.66)	(-0.02)
$Bank_t$	-0.008*	0.000	-0.000	0.000	-0.003**	-0.005
	(-1.85)	(0.07)	(-1.50)	(0.30)	(-2.06)	(-1.57)
$ProvinDoc_{t-1}$*$Bank_t$	-0.002	0.000	0.000	-0.000	-0.000	-0.001
	(-1.48)	(0.36)	(0.68)	(-0.49)	(-1.10)	(-1.49)
(log) $Expenditure_t$	0.647	-0.153	0.017	0.175***	-0.577	-0.734
	(0.42)	(-0.30)	(0.64)	(2.60)	(-1.61)	(-1.08)
(log) GDP_t	3.024***	3.901***	0.019	0.032	2.084***	2.493***
	(-0.33)	(-0.33)	(-0.33)	(-0.33)	(-0.33)	(-0.33)
Observations	1,485	1,485	1,485	1,485	1,485	1,485
R-squared	0.394	0.168	0.044	0.215	0.465	0.506
		(17)	(18)		(19)	(20)
(log) $CO_{2\ t-1}$		-0.569	0.008*		-0.274	-0.495**
		(-1.47)	(1.81)		(-1.63)	(-2.00)
$CityDoc_{t-1}$		-0.033	0.016***		0.239***	0.536***
		(-0.50)	(3.08)		(4.45)	(5.73)
$Bank_t$		0.002	-0.000		-0.001	-0.002
		(0.89)	(-0.77)		(-1.15)	(-0.68)
$CityDoc_{t-1}$*$Bank_t$		-0.001***	-0.000		-0.000*	-0.001*
		(-2.94)	(-0.51)		(-1.86))	(-1.70)
(log) $Expenditure_t$		-0.002	0.015		-0.612*	-0.987*
		(-0.00)	(0.58)		(-1.85)	(-1.74)
(log) GDP_t		4.155***	-0.036		1.471***	0.907*
		(3.68)	(-1.31)		(4.19)	(1.67)
Observations		1,485	1,485		1,485	1,485
R-squared		0.169	0.238		0.588	0.673
City FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

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