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Effect of Green Credit Policy on PM 2.5 in China Based on Panel Regression Model

Yu Yan[1,†], Yining Zhou[2,†], and Haoyu Zhu[3,a,*,†]

[1]*School of Humanities and Economics and Management, China Agricultural University, Yantai, China*
[2]*School of Management, Fudan University, Shanghai, China*
[3]*School of Social Science, University of California San Diego, San Diego, USA*
a. h9zhu@ucsd.edu
**corresponding author*
[†]*Those authors contributed equally.*

Abstract: With China's fast economic and urban development, the problem of PM 2.5 has become increasingly apparent. Although China has announced the Green Credit Policy that aims to mitigate the air pollution problems, the effect of this policy is controversial. The data used in this paper contain measurements of PM 2.5 Level and other factors that can affect the PM 2.5 concentration in different areas of China from 2008 to 2018. By analyzing the data using Panel Regression Model, this paper will show the effect of Green Credit Policy on PM 2.5 and the differ-ences between its effects on the whole region, eastern, central and western region. It will also demonstrate how does green credit policy affect PM 2.5. The results illustrate that even though Green Credit Policy can reduce the concentration of PM 2.5 in general, the mitigation effect is not significant in eastern and central ar-eas. It also shows that the policy lowers PM 2.5 concentration by promoting technological progress and improving production efficiency. Moreover, urbaniza-tion and economic development play an important role in reducing the PM 2.5 level in all regions. High openness only affects PM 2.5 level in the western re-gions.

Keywords: PM 2.5, Green Credit Policy, Panel Regression, Environmental Problems.

1. Introduction

Over the last few decades, China has been developing at a rapid rate. However, this fast growth in economy and urbanization is achieved at the cost of environmental quality. Particulate matter 2.5 (PM 2.5) is one of the major environmental problems that China is facing nowadays [1]. In the field of environmental science, PM 2.5 is defined as the aerodynamically equivalent particles with diameters equal to and less than 2.5 microns. The main cause of PM 2.5 is human activities such as automobile exhaust emissions, boiler combustion, waste incineration, resident firewood burning and etcetera [2].

As one of the biggest economies in the world, China has encountered serious haze pollution and the PM 2.5 level has reached an all-time high in many cities [3]. PM 2.5 does not only reduce the visibility, which is threatening to the safety of ground traffic and the takeoff and landing of aircraft,

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it is also detrimental to people's health. According to Xu, for every 10 MCG/m3 increase in ambient PM 2.5 concentration, the risk of death from cardiovascular disease increases by 12%. A rise of 20 micrograms per cubic meter of PM 2.5 could result in about 340,000 deaths a year in China and India [4]. Studies also show that the exposure to PM 2.5 is associated with neurodegenerations such as Alzheimer's Diseases and Parkinson's Diseases [5]. The severity of this environmental problem has raised people's attention all over the world.

Fortunately, the Chinese government has already taken steps to lower the PM 2.5 level after realizing the harmfulness of this air pollutant. One of the actions taken to handle the environmental issues is the Green Credit Policy. The policy states that banks should consider the environmental factors when lending loans to companies [6]. The goal of this policy is to restrict capital allocation in companies that produces large pollution and divert resources from highly polluting production capacity [7]. Although theoretically the Green Credit Policy is helpful to resolve environmental issues, many scholars are arguing about the actual effectiveness of this policy. In Wang's words, even though many researchers stated that the policy is efficacious, it is reasonable to doubt its effectiveness as the air pollution in China is still high [8]. Thus, it is important to examine whether this policy works and how it works. Also, the PM 2.5 concentrations vary greatly in different areas, it tends to be higher in the North regions compared to the South [9]. The difference in concentrations reflects the fact that the effect of this policy varies from region to region. This variation indicates the significance to analyze the effect of Green Credit Policy in different areas and make some adjustment in policy for each region based on the results.

This paper intends to analyze the effect of Green Credit Policy on PM 2.5 level by using statistical models. The data analysis will mainly answer two questions. First, the effect of Green Credit Policy on PM 2.5 and the differences between its effects on the whole region, eastern, central and western regions. Second, in what ways does the Green Credit Policy influence PM 2.5. The result is helpful for the future improvement of the policy and the PM 2.5 level in different regions.

2. Methodology

The data collected in this paper are mainly from wind database, CSMAR and China Industrial Statistical Yearbook and etc. The Green Credit Policy was officially carried out in China until 2007 [10]. Due to there is a certain lag from the policy promulgation to the implementation, the data includes data starting at 2008. Moreover, in order to avoid the impact of heteroscedasticity, some variables are refined using logarithmic processing.

Table 1: Variable Meaning and Calculation Method.

	Symbol	Meaning	Calculation Method
Explained Variable	PM2	PM2.5 concentrations	Geographically weighted PM2.5 concentration by province
Explanatory Variable	GC	Green Credit Level	1-Interest payments for six energy-intensive industries/Total industrial interest expenditure
Covariate	UR	Urbanization Level	Non-rural population/total population
	OPEN	Openness of the Region	Import and export/GDP
	PGDP	Economic Development Level	GDP/Total Population
	IS	Industrial Structure	Production value of the secondary industry/Production value of the tertiary industry

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Mediator	LP	Technological Progress	GDP/Total Employment

According to Table 1, the data contain 7 variables. Specifically, 1 explained variable, 1 explanatory variable, 4 covariates and 1 mediator. PM 2 is the explained variable (Quantitative data, Ratio), it shows geographically weighted PM2.5 concentrations in different province and this paper uses this variable to compare PM 2.5 concentrations at the provincial level.

Explanatory Variable GC (Quantitative data, Ratio): GC represents the Green Credit Level. This paper uses the ratio of interest expenditure of industries other than the six energy-intensive industries to measure the Green Credit Level [11]. It shows the extent to which green credit is implemented in different areas.

Covariate UR (Quantitative data, Ratio): UR represents the Urbanization Level. As the urbanization level increases, rural people flood into cities to live and work, which rises the demands for housing, vehicles and etc. The construction process and the increase in vehicles will lead to an increase in PM 2.5. Therefore, the proportion of non-rural residents in the entire population of each area is utilized to show the urbanization level.

Covariate OPEN (Quantitative data, Interval scale): OPEN shows the openness of the province. A relatively high openness will attract advanced foreign investment companies, leading to more advanced corporate governance model and clean technology. Through technology spill-over effects, the clean technology in the province will be developed. As a result, it will effectively reduce the PM 2.5 concentration.

Covariate PGDP (Quantitative data, Ratio): To compare PM 2.5 concentrations at the provincial level, this paper uses population of each province to scale the GDP of each province, that is, the ratio of GDP of each province to the total population of each province.

Covariate IS (Quantitative data, Ratio): IS represents the ratio of the production value of the secondary industry to the tertiary industry. This ratio can clearly show the change of industrial structure. When IS increases, the province is developing towards industrialization. When IS decreases, the province is developing towards service industries.

Mediator LP (Quantitative data, Ratio): LP shows the progress of technology. Green Credit Policy will cause an increase of the investment in research and development in the environmental protection industry, thereby promoting technological progress. Technical progress is reflected by the improvement of production efficiency. This paper uses labor productivity as an indicator to measure technological progress, which is represented by the ratio of GDP to the total number of employed people.

Table 2: Descriptive Statistics.

Variable	Mean	Median	Var	SD
pm2	37.762	35.650	271.078	16.464
gc	0.465	0.473	0.022	0.147
lnpgdp	8.188	8.250	0.547	0.740
lnopen	7.945	8.295	3.767	1.941
ur	0.553	0.533	0.017	0.131
is	1.059	0.882	0.361	0.601

According to Table 2, the mean value of PM2 in the whole region was 37.762, and the standard deviation is 16.464. It shows that there are high variabilities among the data, which reflects the difference in PM 2.5 concentrations in different regions.

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The data used in this paper is panel data, which means that the data contain multiple variables and their measurement over time. In the case of this paper, the data contain measurements of PM2, GC, UR, OPEN, PGDP, IS and LP in different regions of China from 2008 to 2018. Because of the data structure, this paper selects Panel Regression Model as the method. Panel Regression Model is an effective method when dealing with cross section data measured at different time periods. This model has the capacity of showing the Best Linear Unbiased Estimation [12].

3. Results and Discussion

3.1. Panel Regression Model

Based on the R language, the Hausman test is performed. The test statistic is 57.821, with a P-value of less than 0.01, so a panel regression model with fixed effects is used, and then formula (1) is introduced to continue the empirical analysis.

$$\mathrm{PM2.5} = \beta_1 GC_{it} + x'_{it}\theta + \mu_i + \gamma_t + \epsilon_{it} \quad (1)$$

β_1 refers to the coefficient of the main explanatory variable GC.θ represents the coefficient matrix of the control variable x'_{it}. μ_i indicates the province-fixed effect. γ_t means the time-fixed effect.ϵ_{it} represents the random disturbance matrix.

Based on the regional classification criteria of the China National Bureau of Statistics, panel regression is performed to show the influence of green credit and other variables on the geographically weighted PM2.5 level in the east, west and central areas.

Table 3: Hausman Test.

	The Overall Region (30 provinces; 1,2,3 of region1)	The Eastern and Central Region (1,2 of region1)	The Western Region (3 of region1)
GC	-11.4395**	-7.4911	-15.4342*
	[4.7692]	[5.8369]	[8.3015]
UR	-53.6050***	-56.9832***	-150.00***
	[18.6326]	[21.0264]	[48.0014]
lnOPEN	-0.9778**	-0.7004	-0.9196**
	[0.4528]	[1.0526]	[0.4579]
lnPGDP	-28 3979***	-40 2338***	-23 5624
	[8.7815]	[11.3218]	[16.6840]
IS	4.3517**	5.3482**	0.6841
	[1.9590]	[2.3716]	[3.3150]
Time-fixed Effect	Control	Control	Control
Individual-fixed Effect	Control	Control	Control
N	330	209	121
R Square	0.6315	0.6879	0.6818
Standard errors in brackets * p<0.1, ** p<0.05, *** p<0.01			

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3.1.1. The Impact of Green Credit on PM2.5

For China as an overall region, eastern and central regions, and western regions, with each unit increase in the green credit level, PM2.5 concentrations were reduced by 11.4395,7.4911, and 15.4342 units respectively. So the execution of green credit has made a great contribution to the reduction of PM2.5.

But in different areas, the mitigation effect of green credit on PM2.5 concentrations is different: in the western region, the carry out of this policy can is efficacious in decreasing PM2.5 concentrations; in the east and central areas, the remission effect on the PM2.5 level is not significant. The reason for this difference may be: despite the western regions are relatively behindhand in terms of development and the air quality is relatively low, with the major support of Chinese government policies, the compensation function of the policy makes considerable contributions to elevate the environmental quality.

3.1.2. Influence of Other Control Variables

The first analysis focuses on the urbanization level. The regression coefficient of the overall region, the east and central areas, and the west is respectively-53.6050, -56.9832, and-150, and all differ significantly from the 0 at the 1% significance level. This means that under the development of urbanization, more and more rural population is transferred to the urban regions to work. With the change of people's life style, the tertiary industry has developed rapidly and formed a certain scale effect in cities. This urbanization effectively reduces the PM2.5 concentrations.

In terms of openness, the lnOPEN's coefficients in the overall region, the eastern and central regions, as well as the western regions are -0.9778, -0.7005, and-0.9196 respectively. The coefficients in the overall region and western regions are significant at the 5% significance level, and fail to be significant at the 10% significance level in the eastern and central regions. This illustrates that technology spillover and high-level management model brought by high openness have an outstanding influence on decreasing the concentration of PM2.5 in the relatively backward western regions. As the eastern and central region are comparatively developed regions, the technology spillover and the management model fail to significantly reduce PM2.5 concentrations.

The third one is economic development, lnPGDP in the overall region, the eastern and central region, as well as the western region is -28.3979, -0.4467, and-30.9524respectively, and they are all significantly different from 0 at the significance level of 1%. This shows that China has made progress in science and technology, resource utilization and other aspects in its process of transforming its economic growth model, and China's economic development has a crucial mitigation effect on the PM2.5 concentrations. China is gradually transforming its previous extensive economic development into sustainable development, so the level of economic development can alleviate the concentration of PM2.5.

When it comes to industrial structure, the coefficients of IS in the overall region, the eastern and central regions and the western regions, are respectively 4.3517, 5.3482 and 0.6841. The coefficients of the overall region and the eastern and central regions are significant at the 5% significance level, while the coefficient in the western regions fails to be significant at the 10% significance level. This illustrates that if a province is developing toward industrialization, its PM2.5 concentrations will increase.

3.2. Mechanism Analysis of How the Green Credit Influences the PM2.5 Concentration

In this paper, the stepwise regression method in the mediation effect is used to analyze the influence mechanism of green credit on PM2.5. A detailed step description is shown in Fig. 1.

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In the application of this stepwise regression method, Y represents PM2.5 concentration, X represents the degree of green credit implementation, M represents the level of technological progress. Coefficient c=-11.4395, coefficient a=0.4865, coefficient c'=-8.6573, and coefficient b=-5.7189.

According to the stepwise regression method, the intermediary effect is obtained by multiplying the corresponding coefficient, so the technological-progress intermediary effect of green credit affecting PM2.5 concentration is -2.7822 (0.4865*(-5.7189)). The negative technological-progress effect indicates that green credit improves production efficiency by promoting technological progress, thus leading to the reduction of PM2.5 concentration. Its total effect is -11.4395(-8.6573+ (-2.7822)), which is not much different from the green credit coefficient of -11.4395 in the overall region, thereby further verifying the correctness of the analysis of green credit's effect on the PM2.5 concentration through technological-progress mechanism. In a word, China's green credit policy, which serves a major role in facilitating the environmental control in China, is conducive to reducing the PM2.5 level.

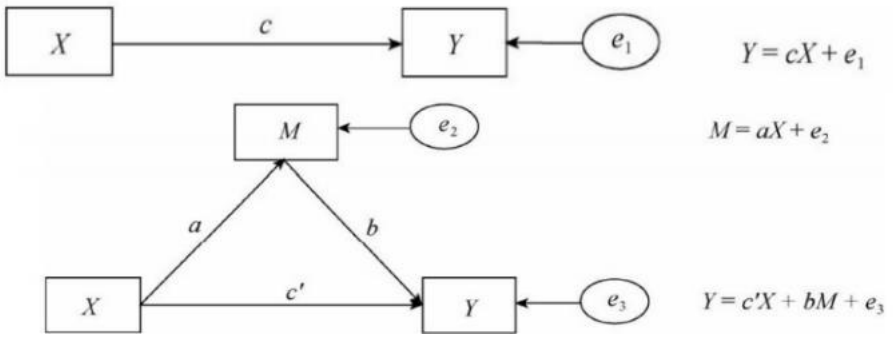

Figure 1: The step of stepwise regression.

Table 4: Mediation Effect.

	Explained Variable lnLP(Correspond to Coefficient c)	Explained Variable lnLP(Correspond to Coefficient a)	Explained Variable PM2.5(Correspond to Coefficient c')
GC	-11.4395**	0.4865***	-8.6573*
	[4.7692]	[0.0928]	[4.9716]
lnLP			-5.7189*
			[3.0313]
UR	-53.6050***	2.1103***	-41.5363**
	[18.6326]	[0.3625]	[19.6215]
lnOPEN	-0.9778**	-0.0037	-0.9991**
	[0.4528]	[0.0088]	[0.4509]
lnPGDP	-28.3979***	-0.4467***	-30.9524***
	[8.7815]	[0.1708]	[8.8466]
IS	4.3517**	-0.2569***	2.8824
	[1.9590]	[0.0381]	[2.1000]
Time-fixed Effect	Control	Control	Control
Individual-fixed Effect	Control	Control	Control
N	330	330	330
R Square	0.6315	0.937	0.636
Standard errors in brackets * p<0.1, ** p<0.05, *** p<0.01			

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4. Conclusion

For China as an overall region, eastern, western and central areas, the execution of green credit proves to be helpful in alleviating PM2.5. But in different areas, the mitigation effect of green credit on the PM2.5 level varies greatly. In the west China, the execution of green credit leads to a remarkable reduction on the PM2.5 concentration. In the east and central areas, the mitigation effect of green credit implementation on the PM2.5 concentration is not significant.

The reason for this difference may be that even though the western regions is relatively undeveloped, the compensation measures of green credit policies serve a crucial role to improve the environmental quality under the strong support of government policies.

Green credit has led to the lower PM2.5 concentration of China by promoting technological progress and improving production efficiency. This plays an important role in promoting environmental protection in China.

Urbanization generates a notable reduction in the PM2.5 level in every region; High degree of openness triggers a remarkable alleviation on the PM2.5 level in the west, but it does not work well in the east and central China; China's current economic development contributes greatly to lower PM2.5 level across the region; When the industrial structure develops toward industrialization, the concentration of PM2,5 will increase.

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