Does China’s carbon emission trading policy alleviate urban carbon emissions?

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Abstract. The essence of carbon emission right is a legalized right, and carbon emission right trading is to commercialize this right based on the market. This paper uses panel data of 226 prefecture-level cities in China from 2007 to 2016 as samples to examine the effect and mechanism of carbon emission trading policies on urban carbon emission intensity. The study found that the carbon emission trading policy has a significant promotion of reducing carbon emission, with the adjustment of industrial structure and energy-saving emission reduction methods. It can effectively reduce the city’s carbon emission.

1. Introduction

With the continuous and rapid growth of population and economy, China has consumed a lot of energy in the past few decades. The Chinese government has made reducing carbon emissions and developing a low-carbon economy as a national strategy [1].

It is not an easy task to achieve China’s emission reduction goals. On June 18, 2013, China’s first carbon emissions trading platform was launched in Shenzhen, marking a key step in the construction of China's carbon trading market. Since then, Beijing, Tianjin, Shanghai, Guangdong, Hubei, Chongqing and other provinces and cities have successively launched pilots for carbon emissions trading. This carbon emission rights trading method has gradually become an important way for China to deal with energy conservation and emission reduction issues. Due to the heterogeneity of resource endowments in various regions of China, the implementation of carbon trading policies in different regions is significantly different. In specific cases, can carbon trading policies effectively reduce the intensity of carbon emissions? Can they play a coordinating role in economic development and environmental improvement? These have also become carbon emissions trading key points for further promotion of market policy across the country.

2. Literature Review

Foreign scholars have conducted empirical research on this issue: Li Bin et al. (2014) believe that environmental pollutions caused by excessive carbon emissions have negative externalities [2]. To solve the negative externalities caused by environmental pollution, we must rely on environmental regulations [3]. Carbon emission trading is a quantitative environmental regulation method to control carbon emissions through market transactions [4]. Borghese et al. (2015) found that the implementation of European carbon trading policies has effectively reduced the carbon of Italian manufacturing sectors [5]. There are also many studies on China's carbon emissions trading market: Zhang et al. (2016) used Chinese provincial panel data to empirically analyze the effects of carbon trading policy, finding that
the policy can reduce the carbon emission intensity [6]. Dong et al. (2019) also conducted an empirical analysis of the effects of provincial panel data on carbon trading policy through a double-difference method [7]. Peng (2017) through PSM-DID method evaluates the effect of the carbon emission rights trading policy from the enterprise level [8].

The existing researches on China's carbon emissions trading policies are mostly based on the provincial level but not city level. And most of the literatures analyse the industrial structure and energy structure as the mechanisms of carbon emissions trading, but did not consider other influence mechanisms. The contribution of this article mainly lies in: First, using the advantages of large samples at the city level. Second, this paper further introduces the mechanism variable of scientific research input to analyze and evaluate the policy's emission reduction effect from a new perspective.

3. Theoretical analysis and model construction

3.1. Theoretical analysis

The important reason why China has become the world's largest carbon dioxide emitter is that the industrial structure, high energy intensity and insufficient technological innovation. First, in terms of industrial structure, the secondary industrial sector, main source of carbon emissions, is still the core sector of economic development. The industrial structure needs to be optimized. Secondly, from the perspective of energy intensity, due to the uneven distribution of resources in China, China can only dominate coal at present [10], and the proportion of electricity consumption in China is still dominated by thermal power at this stage [9]. Finally, there still need to be developed in the low-carbon manufacturing industry and the company's energy utilization rate is low [11].

According to the reasons mentioned above, there are three ways for China to implement the policy: adjusting the industrial structure [12], reducing energy intensity [13], and increasing investment in scientific research [14]. In summary, this paper believes that through the adjustment of industrial structure, energy intensity, and increase of scientific research investment, the carbon emission intensity can be effectively reduced by the carbon emission right trading regulation. The following assumptions:

H1: The carbon emission trading policy can reduce the carbon emission of the pilot regions.

H2: The pilot regions with the carbon emission trading policy will reduce the carbon emission by adjusting the industrial structure.

H3: The pilot regions with the carbon emission trading policy will reduce the carbon emission by reducing the energy intensity.

H4: The pilot regions with the carbon emission trading policy will reduce the carbon emission by increasing investment in scientific research.

3.2. Model construction

3.2.1. Model construction and variables selection. The article choses the classic policy evaluation model of the double differential model, and considers the impact of carbon emissions trading policy. To test Hypothesis 1, this paper sets up the following panel model:

\[ Y_{it} = \alpha_0 + \alpha_1 dum_y \ast dum_c + \beta CV + \epsilon_{it} \]  

\( Y_{it} \) is the explained variable, is the carbon emission of each city in the article, and the measurement of the carbon emission is expressed by the logarithm of the carbon emission intensity (lncarbon). dum_y is the dummy variable of the time point of external policy. dum_c is the dummy variable of the city that started the policy. In terms of control variables, the city’s carbon emission intensity is not only affected by energy use, but also by the level of economic development and population. Therefore, GDP per capital (pgdp), the city’s population at the end of the year (pop) is selected. In addition, the energy intensity, electricity consumption per unit of GDP (energy), and the proportion of the secondary industry are selected (ratio2) and scientific research investment (tech) as mechanism variables for testing H2-H4.
3.2.2. **Variables descriptive statistics**. Excluding the missing data, this paper selects 226 prefecture-level cities nationwide as sample data during 2007-2016. A total of 36 prefecture-level cities in 7 provinces and cities that had begun policy trials in 2014 are selected as the experimental group, and a total of 190 prefecture-level cities in other non-pilot provinces are used as the control group. For the calculation of the explained variables, the calculation formula is [15]:

\[ I = kE_g + \gamma E_o + \phi \tau E_e \]  

(2)

Where \( I \) represents the estimated total \( \text{CO}_2 \) emissions of each city, \( k \) and \( \gamma \) are \( \text{CO}_2 \) emission coefficient of natural gas and liquefied petroleum; \( \phi \) is the greenhouse gas emission coefficient of coal-fired fuel; \( \tau \) is the proportion of coal-fired electricity generation in total electricity generation; \( E_g, E_o, E_e \) are the city’s consumption of natural gas, liquefied petroleum gas and electricity. The data comes from "China Electric Power Yearbook" and "China City Statistical Yearbook".

| Symbol  | Definition                                      | Max      | Mean      | Min       |
|---------|------------------------------------------------|----------|-----------|-----------|
| lncarbon| Carbon emission intensity (kg / yuan)           | 4.57     | 2.219274  | 0.39      |
| pgdp    | Per capita GDP(yuan)                           | 467749   | 55780.79  | 4134      |
| pop     | Total population(ten thousand people)          | 2417.48  | 187.5435  | 5.87      |
| tech    | Science investment(ten thousand yuan)          | 4035240  | 60566.29  | 52        |
| energy  | Energy intensity (kWh / yuan)                  | 0.701075 | 0.101534  | 0.014551  |
| ratio2  | Proportion of secondary industry               | 87.97    | 51.0413   | 9.74      |

### 4. Empirical analysis

**4.1. Basic regression**

The basic regression results are shown in column (1)-(4) of Table 2:
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Table 2. Basic regression results (left) and impact mechanism results (right).

| Dependent | Incarbon | Incarbon |
|-----------|----------|----------|
| dumy      | (1)      | (2)      | (3)      |
| dumy * dumc | (4)      | (5)      | (6)      |
| population | (7)      |          |          |
| pgdp       |          |          |          |
| tech       |          |          |          |
| energy     |          |          |          |
| retio2     |          |          |          |
| constant   | (1)      | (2)      | (3)      |
| time effect|          |          |          |
| individual effect |      |          |          |
| within R²  | 0.1268   | 0.1939   | 0.1268   |
| samples    | 2260     | 2260     | 2260     |

*indicates p<0.05; **indicates p<0.01; ***indicates p<0.001

Columns (3) and (4) have controlled time and individual fixed effects, and columns (1) and (2) have not. No control variables are added to columns (1) and (3) while all control variables are added to columns (2) and (4). In column (1), the regression results show that the coefficient of the dumy * dumc variable is negative and significantly positive at the 10% level, indicating that cities having carbon trading policy can decrease the carbon emission compared with cities have not. H1 is initially verified. The results in column (1)-(4) show that the coefficients of dumy * dumc are all negative, so the impact of carbon trading policy is reducing the emission after adding control variables and controlling the fixed effects, which indicates that the result is steady.

4.2. Impact mechanism analysis
In the column (5)-(7) of Table 2, the coefficients of tech, energy, ratio2 consider the impact mechanism of carbon emission trading policy. The coefficients of these mechanism variables like energy and ratio2 are positive and significant at the 10% level which indicates that trading policy will reduce carbon emission of cities through adjusting the industrial structure and the energy intensity, then verify H2, H3. The coefficient of tech is not significant which indicates that scientific research investment has not truly reduces carbon emission, so that the scientific research investment needs to focus on carbon emission technology improvement.

5. Conclusion
The following conclusions can be drawn like that: First, carbon trading policy, as the new method recently, can significantly reduce carbon emission of cities. Therefore, it is necessary to put the policy in a more important position for future environmental treatment. Secondly, about the specific method of the government to reduce carbon emission, adjusting the industrial structure and the energy intensity could be helpful means. However, the scientific research investment does not have a significant effect on reducing carbon emission. That is to say, the structure of science investment maybe needs to focus on improving the carbon emission reducing.
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