Decomposition analysis on the air pollutant baseline emission factors in China’s power sector

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Abstract

Air pollution is one of the major problem in China’s power sector. This paper calculates the baseline emission factor in the power sector and uses the index decomposition method to analyze the variation trend of the emission factor. For the SO2, the simple average baseline emission factor is 1.15 kg/MWh. The east China has the highest emission factor and the central has the lowest number. As for the NOx, the simple average is 1.76 kg/MWh, the northeast China has the highest emission factor, and the South China has the lowest emission factor. And the decomposition analysis takes into account three driving factors: pollution control technology level, fuel mix and power structure. The variation from 2005 to 2013 of the SO2 baseline emission factor is mostly influenced by the pollutant control technology improvement, and fuel mix in thermal power industry makes small contribution on the emission reduction and the influence brought by fuel mix varies a lot among different regions. As for the variation of NOx emission factor from 2007 to 2013, the technology level causes biggest variation too. The fuel mix also makes some positive contribution on east and central China. And the power structure don’t have significant influence on the variation of both SO2 and NOx baseline emission factor.

Keywords: Power sector; Air pollution; Baseline; Decomposition Analysis

1. Introduction

Air pollution has been a major problem for China. Research from the Nature[1] find that the air pollution has the severest impact on China comparing with other countries, where about 1.4 million premature death is because of it. So the air pollution causes government suffering great pressure. On the
other hand, China also faces great pressure from climate change issues and has already determined to adjust the energy structure to solve the problem[2]. And the air pollution reduction can also be regarded as the co-benefit[3] from carbon reduction. And among all the sectors. The power sector is the biggest air pollutant emitter in China for the highly dependence on thermal power plant. According to the statistics, power sector has been the top emitter in the industry in 2014, which emitted 6.82 million tons SO₂, 33.4% of the total SO₂ emission in China, and 9.28 million tons NOₓ, 41.7% of the total NOₓ emission in China[4].

Many researches have already done some decomposition on the power sector[5], but their decomposition targets are usually the total carbon emission. But in this case, it is not reasonable to conduct the decomposition analysis on the total air pollutant emission. For the air pollutant emissions in power sector are determined by the power generation and emission factors, while the power generation is influenced by many social economic factors. So if we conduct decomposition on the total emission, the results and the policy implication based on the results will take into many other social economic factors such as the population and economic growth rate. And this paper will conduct the decomposition analyses on the power plant emission factors, including the influences brought by technology level, fuel mix and power structure, which are the key parts to develop the environmental protection strategy inside the power sector. And I choose the baseline emission factors to conduct my research as it is already proven to be a scientific index for the power sector. The baseline emission factor method is a tool to calculate the emission factor for an electricity system issued by CDM Executive Board (CDM-EB)[6]. And this method has been widely used into some models such as the Greenhouse gas and Air Pollution Interaction and Synergies (GAINs) developed by the International Institute for Applied System Analysis (IIASA) and other cooperating agencies[7].

2. Method
2.1 The method to calculate the baseline emission factor
The method of calculating the baseline emission factor can be found in related research[8]. And the data source can be found in the appendix A.

2.2 The method to analyze the variation trend of SO₂ OM emission factor
This paper uses the index decomposition analysis to explain how different determinants affect the variation trend.

First, I make an amendment on the OM emission formula, that is change the denominator from the electricity from delivered to the grid, not including low-cost/must-run power plants, which is actually the electricity produced by thermal power plant, to the total electricity.

Then I need to change the form of the formula to separate the three determinants as formula (1):

\[
EF_{\text{grid,OM,r}} = \left(\frac{r_{p,r} - p_{r}}{p_{r}}\right) \times \frac{1 - r_{s,r}}{R_{s,r}} \times \frac{K_{t,r}}{K_{t,r}} \times \frac{F_{C,OM,r}}{F_{C,OM,r}} = \sum_{i,j} \left(1 - p_{r,j}\right) \frac{K_{j,r}F_{C,OM,r}}{K_{t,r}F_{C,OM,r}} + \frac{EF_{\text{thermal,OM,r}}}{EF_{\text{grid,OM,r}}} \tag{1}
\]

So the OM emission factor is decomposed into three determinants, in which the TE_r represents the technology level, i.e. the emission rate of the thermal power plant after the emission control treatment. The determinants is influenced by the deployment rate of the pollutant control equipment in region j and the remove rate of the pollution control technology, the S_j represents the fuel mix in the thermal power industry in region j, where our research classify the fuel into three type, the solid type consist of all kinds of coal; the liquid type, consist of heavy oil, diesel, gasoline and so on; the gas type, consist of the coke oven gas, converter gas and other coal gas, and natural gas. And the P represents power structure in region j which is the proportion of the electricity generated by the thermal power plant.

And this paper chooses the logarithmic mean weight Divisia method to conduct the decomposition[9]. And the specific formula (2) are as follows

\[
\Delta EF_{OM} = EF_{OM}^T - EF_{OM}^0 = \Delta EF_{OM,TE} + \Delta EF_{OM,S} + \Delta EF_{OM,P}
\]
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