Research on the Decomposition of the Economic Impact Factors of Air Pollution in Hubei Province in China

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Abstract. With the economic growth, nowadays environmental problems in our country are becoming more and more serious, especially air pollution. In this paper, we use the Grossman decomposition model to analysis the relationship among economies scale, economic structure, technical factors, population growth and industrial emissions through the index data of 1996-2011 in Hubei Province. The results show that: the scale effect and population effect are positive, which indicates that the economic expansion and population growth will increase the industrial waste emissions. The industrial structure of the impact of changes in wastewater discharge uncertainty, indicating that we should increase the industrial structure adjustment. Reduction effect is negative, indicating that it is useful to improve mitigation technologies.

Introduction

In recent years, the global environment problem is more and more serious, especially air pollution. Hubei Province, an important province in center of China, has developed rapidly in these years, but the problem of environmental pollution is more prominent at the same time, such as haze. In this paper, we use economic and environmental data (mainly air pollution) of Hubei Province as an example to analyze economic factors impact on the environment, such as economic scale, economic structure, technological progress, population growth. Through the data, we can get some result of various economic growth factors in the role of environment coordination, and put forward scientific advice for economic sustainable development in Hubei province.

Econometric models of choice

In 1995, Grossman and Krueger pointed out that economic growth may affect the environment through three channels, namely the scale effect, structure effect and technology effect; he gave the dynamic equations of pollution emissions decomposition as followed.

$$E_t = \sum_{j=1}^{n} Y_t \left(\frac{E_{jt}}{Y_{jt}}\right)\left(\frac{Y_{jt}}{Y_t}\right) \quad j = 1, \cdots n$$

There Y_t is GDP. $\boldsymbol{E_{jt}}$ is the pollutants discharge of j industry in period t. $\boldsymbol{Y_{jt}}$ is the GDP (Or value added) in period t. $\frac{\boldsymbol{E_{jt}}}{\boldsymbol{Y_{jt}}}$ is the industrial pollution intensity, recorded as $\boldsymbol{I_{jt}}$.

$\frac{\boldsymbol{Y_{jt}}}{\boldsymbol{Y_t}}$ is the proportion of GDP in j industry to GDP, recorded as $\boldsymbol{S_{jt}}$.

It can be expressed as $E_t = \sum_{j=1}^{n} Y_t I_{jt} S_{jt}$

We take the logarithm and differentiation on both sides, and then divided by E_t

$$\frac{\dot{E}}{E} = \frac{\dot{Y}}{Y} + \sum_{j=1}^{n} e_j \frac{\dot{S}_j}{S_j} + \sum_{j=1}^{n} e_j \frac{\dot{I}_j}{I_j}$$

The $\boldsymbol{e_{jt}}$ above refers to the share of the total emissions of pollutants in period t.

The first part on the right side of the equation is scale effect which reflects the per capita income changes impact on environmental, the second is population effect, which reflects change rate of population's impact on the environment, the third is the structure effect, which reflects the effect of the industrial structure transformation on pollution emission, and the fourth is the reduction effect.

Stem (2003) and Panayotou (2000) in the papers also introduced the Grossman decomposition model, the industry in accordance with the three industrial structure division, we use the following model to carry out analysis:

$$\boldsymbol{E_t = \frac{Y_t}{P_t} P_t \sum_{j=1}^{3} \frac{E_{jt}}{Y_{jt}} \frac{Y_{jt}}{Y_t}}$$

There Yt is GDP. $\boldsymbol{E_{jt}}$ is the pollutants discharge of j industry in period t. $\boldsymbol{Y_{jt}}$ is the GDP (or value added) in period t. $\frac{\boldsymbol{E_{jt}}}{\boldsymbol{Y_{jt}}}$ is the industrial pollution intensity, recorded as $\boldsymbol{I_{jt}}$.

$\frac{\boldsymbol{Y_{jt}}}{\boldsymbol{Y_t}}$ is the proportion of GDP in j industry to GDP, recorded as $\boldsymbol{S_{jt}}$. $\boldsymbol{y_t}$ is the per

capita income $\frac{Y_t}{P_t}$ .Then the above equation can be changed to:

$$E_t = y_t P_t \sum_{j=1}^{3} I_{jt} S_{jt}$$

We take the logarithm and differentiation on both sides,

$$\hat{E}_t = \hat{y}_t + \hat{P}_t + \sum_{j=1}^{3} e_{jt} \hat{S}_{jt} + \sum_{j=1}^{3} e_{jt} \hat{I}_{jt}$$

The e_{jt} above refers to the share of the total emissions of pollutants in period t.

We only discuss the decomposition effect of pollutants and discharge change, and choose environmental quality index for industrial emissions, industrial wastewater emissions and industrial solid waste production. Since these three kinds of environmental pollution indicators only involves the industrial sector, we choose in the above formula, then $e_{1t} = 0, e_{3t} = 0, e_{2t} = 1$, then $\hat{E}_t = \hat{y}_t + \hat{P}_t + \hat{S}_{2t} + \hat{I}_{2t}$

Selection of factor decomposition method

From the perspective of methodology, factor decomposition method can be divided into Structural Decomposition Analysis(SDA) and Index Decomposition Analysis(IDA). In this paper, we choose the IDA method, and the Divisia index decomposition method is the analytical framework of the energy and environmental issues. it includes arithmetic mean Divisia index （AMDI) and logarthmic mean Divisia index(LMDI), the error of the method LMDI is small and even zero, so it is a complete decomposition method. We use method LMDI to analyze decomposition of industrial waste gas。

We compute the integral on both sides, and use E_{T0} and E_T to indicate the Initial emissions and current emissions, then

$$E_T - E_{T_0} = \int_0^T \frac{\hat{y}}{y} E dt + \int_0^T \frac{\hat{P}}{P} E dt + \int_0^T \frac{\hat{S}_2}{S_2} E dt + \int_0^T \frac{\hat{I}_2}{I_2} E dt = \Delta E_1 + \Delta E_2 + \Delta E_3 + \Delta E_4$$

In order to solve the integral problem, we use the logarithm function as the weight, the logarithm function is

$$L(x,y) = \begin{cases} \frac{y-x}{\ln y - \ln x} & x \neq y \\ x & x = y \end{cases}$$

Then we get the following four formulas:

$$\Delta E_1 = \frac{E_T - E_{T_0}}{\ln E_T - \ln E_{T_0}} \ln \frac{y_T}{y_{T_0}} \qquad \Delta E_2 = \frac{E_T - E_{T_0}}{\ln E_T - \ln E_{T_0}} \ln \frac{P_T}{P_{T_0}}$$

$$\Delta E_3 = \frac{E_T - E_{T_0}}{\ln E_T - \ln E_{T_0}} \ln \frac{S_{2T}}{S_{2T_0}} \qquad \Delta E_4 = \frac{E_T - E_{T_0}}{\ln E_T - \ln E_{T_0}} \ln \frac{I_{2T}}{I_{2T_0}}$$

Where $\Delta E_1, \Delta E_2, \Delta E_3, \Delta E_4$ respectively are economic scale effect, population growth effect, industrial structure effect and reduction effect:

Variable selection:

We choose the industrial waste emissions (unit: million standard cubic meters), number of population (unit: thousand), industrial production (unit: a hundred million Yuan) in Hubei province from 1996 to 2011.These datum are from China statistical yearbook and statistical yearbook of Hubei province.

Industrial waste gas decomposition results and analysis

We put the data into the above formula and get table 1. Negative values in the table show that correlation effect and pollutant emission in the opposite direction.

Table 1 The effects decomposition of industrial waste emissions rate

Year	The growth rate of Industrial waste gas (%)	Economic scale effect (%)	Population growth effect (%)	Industrial structure effect (%)	Reduction effect (%)
1996-1997	5.63	14.62	0.78	2.79	-12.56
1997-1998	11.17	6.72	0.56	1.50	2.42
1998-1999	8.78	3.90	0.50	3.21	1.17
1999-2000	1.90	15.19	-4.99	1.46	-9.75
2000-2001	2.80	8.61	0.21	-0.07	-5.95
2001-2002	22.87	7.58	0.24	14.93	4.34
2001-2003	3.97	11.68	0.22	-6.67	-1.27
2003-2004	26.26	14.57	0.19	-24.05	33.39
2004-2005	7.05	15.00	0.20	5.82	-13.98
2005-2006	13.82	13.43	-0.28	1.35	-00.68
2006-2007	-8.13	21.21	0.11	0.01	-29.46
2007-2008	11.69	18.08	0.19	0.99	-7.58
2008-2009	-2.75	13.45	0.16	3.82	-20.18
2009-2010	18.79	18.73	0.05	3.91	-3.89
2010-2011	39.60	16.09	0.48	2.16	20.87

We can see that the quantity of Industrial waste gas in Hubei has an overall phase characteristics, decrement and increment occur alternately. Economies of scale has positive effects for wastewater emissions, the impact of population and industrial structure is uncertainty. Reduction effect is nearly negative. Economic growth can only increase the size of pollutant emissions.

Population growth is also the reason for the increase of Industrial waste gas, but has little impact. Effects of industrial structure have fluctuated. When the industrial share of GDP rises, it will increase the emissions. While this proportion falls, it will reduce emissions. This shows that industrial production is still high polluting industries. Reduction effect described waste gas of per unit GDP reduction in favor of reducing the amount of waste gas discharge.

Conclusion

First, the scale effect and population effect is positive, which indicates that the economic expansion and population growth will increase the industrial waste emissions. At present, we need expand the production scale to meet the needs from the increasing population, and China's family planning policy has taken control of the birth rate, so it is unrealistic to reduce pollutant emissions from population size and economies scale. Second, the industrial structure of the impact of changes in wastewater discharge uncertainty, indicating that we should increase the industrial structure adjustment. Reduction effect is negative, indicating that it is useful to improve mitigation technologies

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