Trade-Off between Environmental Pollution and Economic Growth

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Abstract. Environmental improvements and deteriorations are more reflected in a systematically comprehensive issue related to economic production, consumption, energy use and environmental change. To fathom how to effectively control environmental pollution in China's economic growth process, the article discusses the construction of indicators that takes environmental pollution into economic construction in existing research and points out the imperfection of the environmental efficiency results of various regions in China calculated by these indicators in the existing research as well as proposes that researchers should arise from the perspective of the consumer and recognize the inevitable uncertainty of the emission inventory list when concerning regional environmental efficiency.

Keywords: Environmental Efficiency, Economic Growth, Environmental Indicator

1. Introduction

Since the promulgation of the "Twelfth Five-Year Plan" in China, local governments have been pursuing urban construction with the goal of accelerating economic development and shifting to energy conservation and emission reduction, resource-saving and environment-friendly. With the improvement in comprehensive and objective cognition of modern society, people's attention has developed from short-term temporary benefits of long-term permanent benefits. Extensive attention to the living environment has led people to pay more attention to the study of environmental related issues. As resources are increasingly depleted, energy prices are soaring, environmental pollution is deteriorating, and global climate is changing abnormally, the development of any economy is beginning to face the major pressure of a low-carbon transition. After experiencing high-speed economic growth and heavy chemical industrialization again this century, the Chinese economy has also reached a crossroads of transformation and upgrading. Therefore, the "Twelfth Five-Year Plan" clearly requires the theme of scientific development and the acceleration of the transformation of economic development methods. Among them, the low-carbon transition characterized by energy conservation and emission reduction, building a resource-saving and environment-friendly society has become Clear paths and important grips. In the process of economic development, energy and environmental issues have received increasing attention. A general consensus is that the improvement and deterioration of the environment is not only a technical issue in physics or environmental science, nor is it a policy issue that can be resolved by administrative orders.
for but a systematically comprehensive issues of economic production and consumption, energy use and environmental change.

2. Indicators and Research Methods of Environmental Pollution and Economic Growth Coordination

Coming to the balance issue between urban environmental construction and economic development in each region, what kind of indicator is used to measure the comprehensive development level of the region is an issue that is constantly discussed in the existing literature. The assessment of the energy and environmental efficiency of different regions or industries according to different classification standards and assessment methods not only helps people understand the differences between energy and environmental efficiency between the various assessment units, but also provides a favorable scientific indication for improving energy efficiency and environmental efficiency [1]. The existing literature mostly evaluates the environmental performance from two indicators with energy efficiency and environmental production efficiency.

2.1 Energy Efficiency Indicators and Research Methods
The basis of measuring single-factor energy efficiency is the ratio of energy input to economic output, which is defined as energy intensity in the existing literature and is usually calculated in unit GDP. Unlike single-factor energy indicators, total factor energy efficiency indicators will affect various influencing factors such as labor and capital that have an impact on economic output are included in the model instead of considering only the same input factors as energy, as in single-factor energy indicators. The concept of total factor energy efficiency first appeared in Hu and Wang (2006), and was defined as the ratio of the optimal energy input to the actual energy input under the optimal economic output. Optimal energy input means the minimum amount of energy consumed at the same economic output. Due to the inclusion of more considerations, the calculation method and model application of total factor energy efficiency are much more complicated than the single factor energy efficiency. In practical applications, most of the analysis methods are based on production frontiers analysis, including data envelope analysis (DEA) and Frontier Stochastic Analysis (SFA) [2].

2.2 Environmental Efficiency Indicators and Research Methods
Analogous to energy efficiency indicators, environmental production efficiency indicators include single factor environmental production efficiency and total factor environment production efficiency. The single factor production efficiency uses the ratio of the amount of environmental pollution emissions and an economic variable as an index to compare and analyze the environmental efficiency of the cities in each region with the discharge of pollutants accompanying the unit economic output as a standard [3]. For example, Kaya and Yokobor (1998) proposed carbon production efficiency (i.e., the ratio of GDP to carbon dioxide emissions) indicators to reflect the environmental costs of a country or region while pursuing economic growth. Mielnik and Goldemberg (1999) proposed carbon dioxide emissions per unit of energy consumption as an evaluation standard for developing countries' efforts to combat climate change. However, because the single factor environmental efficiency does not take the systemic role of each input factor of the production process into account, it is considered that this indicator has certain limitations of providing a support for policy decisions.

In order to properly characterize the actual production process, many studies have conducted environmental efficiency evaluations under a total factor production framework that includes input factors, expected outputs and undesired outputs. Environmental pollutants are usually by-products of inputs in producing the desired output, and are often called undesired outputs. Similar to the definition of total factor energy efficiency, total factor environmental efficiency can be defined as the ratio of the optimal amount of pollution emissions (the theoretically smallest amount of pollution emissions) to the actual amount of pollution emissions. The data envelopment analysis method is often used in the research, that is, the optimal amount of each production link is used to build the production front to be compared with other production combinations with Pareto improvement to achieve environment
efficiency [4]. Not only does economic output increase with an increase in undesired output, it is also assumed that economic output cannot be increased in production without undesired output. In the establishment of the function, it is divided into a radial distance function and a non-radial distance function based on the assumption that the input factors and output showed a year-on-year increase or decrease [5]. The measurement of environmental efficiency uses different function models to comprehensively analyze the relationship between the input of energy, capital, and labor and undesired output in various regions to evaluate production level and provide relevant policy recommendations [6].

3. Analysis and Enlightenment of the Coordination of Environmental Pollution and Economic Growth

3.1 Environmental Performance Research Review
With the increasingly prominent environmental problems in China, the evaluation of environmental performance has also received widespread attention from scholars. In recent years, a great deal of literature has emerged in this area. Many scholars have used different methods to calculate the total factor carbon emission efficiency and emission reduction potential in China. For example, Wang Qunwei et al. (2010) used the Shephard distance function to examine the dynamic carbon emission performance of various regions in China [7]. Chen et al. (2010) used data from 38 industrial double-digit sub-industries in China from 1980 to 2008 to calculate the carbon dioxide emission efficiency of each decision-making unit based on the radial distance function. Wang Bing et al. (2011) used the non-radial SBM directional distance function model to estimate the sulfur dioxide emission efficiency of 30 provinces in China and calculated their emission reduction potential from the perspective of energy-saving technologies and energy structure adjustment. Chen Shiyi et al. (2012) aimed to effectively evaluate the actual economic transition process after taking low-carbon factors such as energy and environmental pollution into account and used variables such as polluted gas emissions, solid waste, and wastewater as undesired outputs constructing a non-radial directional distance function of SBM and evaluating the environmental efficiency of 31 provinces in China from 1985 to 2010. The results show that according to the 2010 data, the top five regions for environmental efficiency are Shanghai, Jiangsu, Beijing, Guangdong, Tianjin, and Tibet. The remaining provinces are all inefficient regions. Wang Keliang et al. (2016) used a non-radial distance function to measure labor, capital, and energy as input factors in this model to allow input and output to increase or decrease according to different proportions to be closer to the actual situation measuring 30 provinces’ emission efficiency of sulfur dioxide, nitrogen oxides and soot in provinces in 2006-2013. The results show that the economic production efficiency of Beijing, Shanghai, and Guangzhou has always been at the optimal level, and the areas with higher levels of environmental efficiency include Tianjin, Fujian, Jiangsu, Zhejiang, and Hainan, Guizhou, Qinghai, and Ningxia are worse, which are summarized as that areas with higher levels of economic development go with higher environmental production efficiency, and areas with lower levels of development have lower production efficiency. In the context of more comprehensive research on environmental efficiency in various regions, more and more researches have begun to discuss the dynamic changes in regional environmental efficiency in different years, such as the direction or degree of regional environmental efficiency changes, etc [8].

3.2 Researches and Enlightenment of Environmental Performance Research

3.2.1 Discussion on Limitations of Production-Side Perspective Researches and Solutions
According to the analysis and calculation results of the environmental efficiency of various regions in the existing research, although the differences in calculation methods and model to design will lead to different rankings of cities in some provinces, Beijing, Shanghai, Guangzhou, Jiangsu and other regions with higher levels of coastal economic development remain ranking in the forefront [9]. The reason is that in the industrial structure of these regions, the tertiary industries are more developed and
the secondary industry has higher standards and stricter control. But this is only an analytical measurement from the perspective of the production side. If you try from the consumer side, the intermediate products produced by the discharge of pollutants will be consumed by other areas thereafter these pollutants should be borne by the consumption sites. For example, the intermediate products of coal products produced in Shanxi should be borne by other regions that consume this intermediate product. In this way, the balanced efficiency between energy and economy calculated from the perspective of input and output will provide new data basis and reliance for the formulation of local policies from a new perspective. It is expected that the environmental efficiency gap between various regions with miscellaneous economic level will be reduced, and even a ranking in a completely different order from the previous researches showed.

3.2.2 Discussion of Emission Inventory’S Uncertainty and Its Solution

The limitations caused by the establishment of various functional models and conditional assumptions will lead to systematic deviations of the calculation results, and the reliability of the data will greatly affect the calculation results. Waste pollutants include nitrogen oxides, carbon oxides, sulfides and other emissions data can be obtained from existing Chinese statistical yearbooks or Chinese environmental energy statistical yearbooks and other official databases. The bottom-up data collection method adopted firstly has the problem that when emission data is reported from factories with large pollutant emissions, such as chemical plants, they tend to avoid the constraints of related environmental policies, thereafter they will make more self-benefiting choices; Secondly, in addition to data acquisition situations with high availability of data like chemical plants, there are other situation that they can only rely on daily experience to estimate emissions data. The emissions data of pollutants generated by the combustion of agricultural waste can only be subjectively estimated which results in uncertainty. Finally, due to errors in the detection equipment during the data collection process, the lack of critical data, and the limitations of the sampling methods, the uncertainty of the emissions inventory data is inevitable. In comparison, the satellite data can obtain the pollutant emissions in various regions under different wind speeds by scanning the same area at different angles. Owing to the high wind speed, which will have a greater impact on its measurement results, hence when the wind speed is lower, the mean value of the scan results of the same area at various angles is more reliable and deterministic. Considering the original data of the satellite data is overly complicated and it needs to be analyzed and screened by spatial analysis methods and the data is only in recent years, in the existing studies, the emission inventory’s data is still used in the mainstream. With the improvement of calculation methods, satellite data will be more widely used in related environmental research in the future.

4. Conclusions

Issues such as climate warming and waste discharge are already unavoidable issues in the process of economic construction. In order to solve the trade-off between economic development and environmental pollution, two measures of energy efficiency and environmental production efficiency have emerged at the historic moment. Energy efficiency depends on energy consumption as well as environmental production efficiency relays on waste emissions which are both set to establish a relationship with economic construction to evaluate the comprehensive development level of a region or industry.

Existing study compares the results of pollution governance and economic construction in various regions through such indicators and corresponding function construction plans. Most of the results show that regions with better economic development status, such as Beijing, Shanghai, and Guangzhou, ranked upper. In these researches they use data from the production side, and the data from emission inventories. It is worth noticing that many industrial intermediate products will be transferred to other places instead of being supplied for local use. Consequently, when calculating the emissions of pollutants, the pollutants brought by this part of the industrial products should be included in the emissions place at their consumption area. If the research results show that the ranking
result of the environmental efficiency index of the economic development area changes greatly from the perspective of the consumption side, it should be considered whether there are technical issues such as low utilization of intermediate products, immature processing technology and other issues leading to greater energy demand. At the same time, comparing the bottom-up data collection method used in the emission inventory brings subjective errors and missing critical data which causes unavoidable uncertainty, satellite data is more reliable.

A general consensus is that the improvement and deterioration of the environment is not only a technical issue in physics or environmental science, nor is it a policy issue that can be resolved by administrative orders alone, more a comprehensively systemic issues of economic production, consumption, energy use and environmental change [10]. The research in this article provides new perspectives and insights on economic construction and pollution issues, and provides reference recommendations for future policy formulation and implementation.

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