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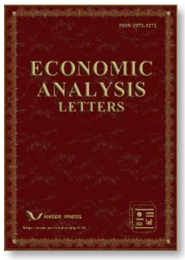

Spatial dynamic evolution of environmental infrastructure governance in China

Ke Guo [a]

[a] *School of Public Policy and Administration, Chongqing University, Chongqing, China*

ABSTRACT

The implementation of environmental protection strategy necessarily requires mapping the amount of capital stock of environmental infrastructure. Through the Weibull distribution function and hyperbolic age-decreasing efficiency model, the provincial environmental infrastructure capital stock in China from 1980 to 2018 is measured cautiously, and its spatial dynamics with the generated pollutants is analyzed using the center of gravity method. It is found that: the spatial distribution of environmental infrastructure capital stock is uneven, and the unevenness in the east-west direction is greater than that in the north-south direction, but the unevenness in the east-west direction is narrowing while the north-south direction is widening; the spatial and temporal distribution of environmental infrastructure capital and environmental pollution vary greatly, and the spatial management of environmental pollution is less accurate.

KEYWORDS

Environmental infrastructure; Capital stock; Governance; Dynamic evolution

*Corresponding author: Ke Guo
E-mail address: G_jpxykh@163.com

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1. Introduction

For more than 40 years of reform and opening up, China has created a miracle of world economic growth. While at the same time, it has also caused damage to the natural environment, and environmental problems have become increasingly prominent. The 14th Five-Year Plan proposes to resolutely fight the battle of pollution prevention and control, so that the ecological environment will be fundamentally improved by 2035 and the goal of beautiful China will be basically realized. It can be seen that the task of environmental protection is very arduous.

The capital theory of sustainable development argues that the long-term sustainability of development depends on the maintenance of natural capital (Pearce and Turner, 1990). Cai and Song (2011) point out that a certain proportion of investment in environmental protection must be maintained to achieve the goal of long-term sustainable development. According to international experience, pollution can be basically controlled when the proportion of environmental protection investment in GDP is 1%-1.5%, and environmental quality can be improved when it is raised to 2%-3%. Existing research on environmental investment has been very rich, but environmental investment does not fully reflect the scale of pollution control, so the issue of the stock of capital formation for environmental activities needs to be studied in depth. Gruver (1976) earlier proposed environmental capital and incorporated it into the neoclassical growth model, analyzing the investment allocation ratio of environmental capital to productive capital. Conrad and Morrison (1985), Karp and Zhang (2012) explored the quantitative study of environmental capital accounting using the perpetual inventory method. These provide good research ideas for this paper.

For this reason, this paper measures the capital stock of urban and industrial environmental infrastructure in China from 1980 to 2018, and examines the spatial evolution of the capital stock of environmental infrastructure and its spatial dynamic relationship with environmental pollution using the center of gravity method, and analyzes the existing problems to provide a theoretical basis for the design of environmental protection policies for the spatial management of regional pollution.

2. Methodology and data

2.1. Methods

The capital stock measurement uses the perpetual inventory method proposed by Goldsmith (1951), and referencing to OECD (2009), Guo et al., (2022), which states that the capital stock is accumulated from the capital flows in each period, and as long as the capital flow statistics are relatively sound, the capital stock can be extrapolated from year to year using the capital flow data. The basic formula is as follows.

$$\begin{cases} KE_t = \sum_{\tau=0}^{T} h_\tau EI_{t-\tau} \\ h_\tau = \sum_{\tau=0}^{Tmax} d_\tau(T) F_\tau \\ F_\tau = \alpha\lambda(\lambda\tau)^{\alpha-1} e^{-(\lambda\tau)^\alpha} \\ d_\tau = \dfrac{T-\tau}{T-\beta\tau} \end{cases} \tag{1}$$

Where t, τ and T is the year, service age of fixed asset and life of fixed asset respectively; EI is the environmental infrastructure investment in the specific time year; h, F and d respectively denote average age efficiency function, the weibull distribution retirement model and hyperbolic diminishing efficiency model, α and β take the values 1.49 and 0.6 respectively.

The center of gravity method connects the centers of gravity in different years to form a spatial-temporal evolution trajectory, which can be observed to understand the direction and balance of the variable in a country or economic region, as well as used to assess the effectiveness of spatial development policies (Wang et al., 2013). This paper applies the method to better understand the spatial dynamic relationship between environmental infrastructure capital and environmental pollutants. The specific calculation of the center of gravity is as follows:

$$X = \sum_{i=1}^{n} M_i X_i \Big/ \sum_{i=1}^{n} M_i \tag{2}$$

$$Y = \sum_{i=1}^{n} M_i Y_i \Big/ \sum_{i=1}^{n} M_i \tag{3}$$

Where i, n represent the province and the number of provinces, respectively. (X_i, Y_i) is the central coordinate, M_i can be denoted environmental infrastructure capital and environmental pollutants.

2.2. Data description

When using the perpetual inventory method to measure capital stock, the earlier the base year is chosen, the less the error in the base period capital stock estimate will affect the subsequent years. Considering the availability of data, the choice of the base period year is set at 1980. In this paper, the nominal fixed asset investment in environmental infrastructure is converted into real terms using the whole society fixed asset investment price index. Moreover, according to existing studies, the useful life of fixed asset investment in urban environmental infrastructure construction is set to 25 years, and the useful life of industry is set to 20 years.

Due to data limitations, Hong Kong, Macau and Taiwan are excluded from the study. The data of investment in environmental infrastructure construction are obtained from China Urban Construction Statistical Yearbook, China Urban Construction Statistical Annual Report, China Environmental Statistical Yearbook, and China Environmental Yearbook.

3. Research results

Overall, China's environmental infrastructure capital stock has shown rapid growth since 2000, with urban environmental infrastructure capital stock growing faster than that of industry, with urban environmental capital stock accounting for 30% in 1985 and reaching 60% in 2018. From the viewpoint of each region, the capital stock in North China and East China accounted for the largest share in 2018, 25% and 39% respectively, with a total of more than 60%; Southwest and Northeast regions accounted for the least, both at 6%; from the situation of each province, Jiangsu, Beijing, Shandong, Guangdong and Zhejiang had the most environmental capital stock, while Ningxia, Hainan, Qinghai and Tibet had a small environmental capital stock, and the largest environmental capital stock in Jiangsu Province is nearly 100 times that of the Tibetan region.

As shown in Figure 1-2, the center of gravity of urban and industrial environmental capital stock in China has always deviated from the geometric center of the country, and the center of gravity of both environmental capital stock is skewed to the southeast. Environmental capital stock density is higher in the east than in the west and in the south than in the north, and the imbalance in the east-west direction is much greater than in the north-south direction, but the dynamic trajectory shows that the imbalance in the east-west direction of capital stock distribution is narrowing, while the imbalance in the north-south direction is widening. During the whole sample period, the center of gravity of urban environmental capital stock moves repeatedly and faster at the head and tail, while the center of gravity of industrial environmental capital stock generally moves to the southwest; the imbalance of urban environmental capital stock first expands and then narrows, while the imbalance of industrial environmental capital stock basically narrows, and the imbalance of industrial environmental capital stock is generally smaller than that of urban environmental capital stock.

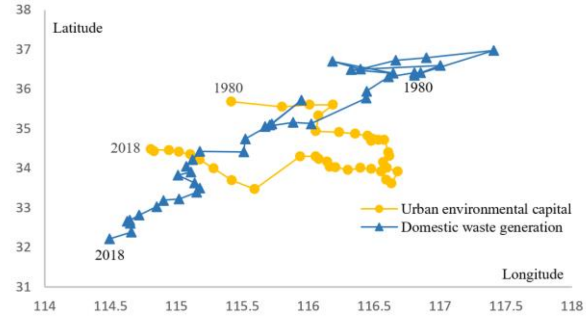

Figure 1. Spatial pattern of urban environmental pollution governance.

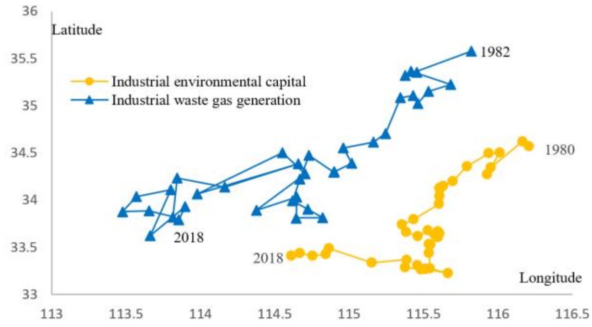

Figure 2. Spatial pattern of industrial environmental pollution governance.

From Figure 1-2, we can see that there is still a gap between the center of gravity of environmental capital stock and the center of gravity of environmental pollution in all years, and the spatial governance accuracy of environmental pollution is poor. There are obvious differences in the trajectory of the center of gravity movement of urban environmental capital stock and domestic waste generation, with urban environmental capital stock moving to the southeast from 1980 to 1997 and to the northwest from 1998 to 2018, while domestic waste generation is basically moving to the southwest. On the whole, industrial environmental capital stock and industrial waste gas generation center of gravity are generally moving to the southwest, and industrial environmental capital stock is always located in the southeast direction of industrial waste gas generation. From the perspective of longitude and latitude, the movement rate of industrial environmental protection capital stock is slower than that of industrial waste gas production. A comparative analysis of urban and industrial environmental management shows that the accuracy of urban pollution management after 2004 is better than that of industry, which is related to the faster growth rate of urban environmental capital stock and the fact that the total amount exceeding that of industrial environmental capital stock since 2000.

4. Research conclusions

Based on the existing studies, this paper measured the capital stock of environmental infrastructure in Chinese provinces from 1980 to 2018 by the perpetual inventory method, and made a spatial dynamic analysis of its relationship with environmental pollutants by using the center of gravity method. The conclusions of the study are as follows: first, the unevenness of spatial distribution of environmental infrastructure capital stock in China is large, and the unevenness between east and west is much larger than that between south and north. However, the unevenness between east and west is narrowing, and the unevenness between south and north is expanding, but in general the unevenness of environmental infrastructure capital stock in China is narrowing in recent years. Second, the accuracy of spatial governance of environmental pollution is poor, and the spatial and temporal distributions of environmental pollution and environmental infrastructure capital differ greatly, with urban environmental pollution governance being better than industrial pollution governance after 2004.

In view of the current serious situation of tightening resource constraints, serious environmental pollution and degradation of the ecosystem in China, vigorously promoting the construction of ecological civilization and ecological environmental protection is one of the important tasks to achieve the great rejuvenation of the Chinese nation. However, the current stock of environmental protection capital in China is not enough to manage environmental pollution and there is a large gap in environmental protection investment, so increasing environmental protection investment, improving the efficiency of environmental protection investment accumulation and the efficiency of environmental protection capital operation are the top priority of ecological civilization construction and ecological environment protection. In view of the outstanding problem of poor precision of spatial management of environmental pollution in China, environmental protection policy design deserves in-depth study, especially to develop a detailed and reasonable regional environmental protection investment plan, so that pollution management should be pre-layout and improve the precision of environmental management.

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Declaration of Competing Interest

All the authors claim that the manuscript is completely original. The authors also declare no conflict of interest.

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