Kuznets Curve Approach to Fertilizer Pollution-Economic Growth Nexus in China

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Abstract: The study applies the panel cointegration methods to empirically test the relationship between agricultural fertilizer pollution and economic growth. It is indicated that there is a significantly inverted U-shaped curve relationship between economic growth variables and agricultural environmental pollution variables, such as nitrogen pollution in fertilizer application, phosphorus pollution in fertilizer application. China is facing increasingly serious agricultural fertilizer environmental pressures. It is imperative to carry out an effective fertilization control policy, especially based on feasible testing soil and fertilizer reduction methods.

1 Introduction

The most classic study of the relationship between environmental pollution and economic growth is the environmental Kuznets curve (EKC) [1-3]. At present, most of the researches on China's Environmental Kuznets Curve focus on industrial and urban pollution, which mainly based on the empirical analysis of single individual time series and panel measurement [2]. Some literature analyzed the relationship between the total amount of environmental pollution and economic development [4, 5]. However, some of the studies do not consider the data stationary, so the estimation results need to be further considered, and due to the limitation of time series data acquisition, the data time period is shorter, and the cointegration relationship needs to be further analyzed [2-5]. At present, relevant researches based on panel data are still relatively insufficient [5]. There is little empirical analysis of the long-term cointegration relationship between environment and economy, and some studies only use time effects to represent the impact of technological advances on pollutant emissions, so the conclusions are still to be reconsidered [2-5]. For example, some studies have found that the EKC inflection point is at an impractical economic development level. At present, the EKC research on agricultural environmental pollution is still rare. Some have used the agricultural production data of Jiangsu Province to verify the EKC of agricultural non-point source pollution and found that there is a significant inverted U-shaped curve between per capita excess nitrogen emissions and economic growth. Some conducted an empirical study on the relationship between agricultural non-point source pollution and economic development in China using panel data of various provinces, indicating that China's agricultural non-point source pollution and economic growth shows a significant inverted "U" shape curve [2, 6, 7]. However, the above study did not consider the data stability test to evaluate the model, so the conclusion of the article remains to be discussed.

Considering the comprehensiveness of the study and the availability of data, this paper takes the per capita indicators of nitrogen pollution from fertilizer application and phosphorus pollution from

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fertilizer application as agricultural environmental pollution indicators, and takes the per capita agricultural gross product and per capita GDP as economic growth indicators. The original data came from the official statistical yearbook, including China statistical yearbook, China rural statistical yearbook, China agricultural yearbook and provincial statistical yearbook. In order to enhance the robustness of the metrological analysis and obtain a more powerful explanation, we use the longest time panel data from 1989 to 2017 of various provinces for analysis. Besides, the data of per capita GDP and per capita output value of agriculture, forestry, animal husbandry and fishery were calculated at constant prices. The data of Chongqing and Sichuan province were combined and processed, and all variables were taken as natural logarithms.

2 Methodology

2.1 Data

Total nitrogen application per capita from fertilizer (PN) is firstly estimated, according to the nitrogen content of chemical fertilizer application and the nitrogen content of compound fertilizer, where the total nitrogen amount of agricultural fertilizer applied in each region was calculated [6, 7]. Then, the total nitrogen amount per capita of chemical fertilizers based on the rural population is calculated by dividing the total nitrogen content of the area by the number of rural population.

Total phosphorus application per capita (PP): Similar to the calculation method of PN of fertilizer, firstly according to the amount of phosphate fertilizer in the application of chemical fertilizer and the amount of phosphorus in the compound fertilizer, the study calculates the total phosphorus amount of agricultural fertilizer applied in each region over the years. Phosphorus refers to the content of P2O5. Then the study divide the total phosphorus in the region by the number of rural population (person) to calculate the total phosphorus of chemical fertilizer applied per capita based on rural population.

2.2 Econometrics

The basic framework and regression model for analysis are as follows:

$$\begin{aligned} y_{it} &= \mathbf{x}'_{it}\boldsymbol{\beta} + \mathbf{z}'_i\boldsymbol{\alpha} + u_{it} \\ &= \mathbf{x}'_{it}\boldsymbol{\beta} + c_i + u_{it} \\ & i = 1, 2, 3, \ldots, n \qquad t = 1, 2, 3, \ldots, T \end{aligned} \tag{1}$$

Heterogeneity or individual influence contains a constant term and a set of variables that reflect the individual effects of the cross-section but do not change over time, all of which reflect only the individual characteristics of the cross-section and do not change over time.

In order to ensure the robustness of the conclusion, the following five panel unit root tests were used [2, 7, 8].

If the variables being tested are all homogenous processes, they need to be co-integrated to determine if there is a long-term relationship between the variables. Simply put, the panel co-integration test is to apply the co-integration test for a single individual to the panel data environment. It still adopts the test idea based on co-integration equation residual proposed by Engle and Granger [9]. This paper uses two kinds of residual-based test methods proposed by Pedroni to test [10]. The null hypothesis is that the residual is the unit root process, that is, there is no cointegration relationship in the panel data. If the null hypothesis can be rejected, it means that the panel data has a cointegration relationship. The cointegration method utilizes the residuals of the following cointegration equations:

$$y_{it} = \alpha_{it} + \boldsymbol{\delta}_{ti} t + x_{it}\beta_i + e_{it} \tag{2}$$

Among them, t=1，2，…，T；i=1，2，…，N； y_{it} and x_{it} are （N×T）×1 and（N×T）×m dimensional observable variables.

Under the finite sample, the OLS estimator has a non-negligible deviation. The FMOLS estimator does not improve the OLS estimator, which causes significant deviation under finite samples. For homogeneity panel data, the deviation even exceeds the OLS estimator. DOLS is a panel co-integration estimator with less deviation than OLS or FMOLS, so it is a relatively better estimation method [11, 12].

3 Results

The five panel unit root test methods mentioned above were used to conduct panel unit root test on the logarithmic values and first-order difference of agricultural environmental pollution variable and economic growth variable [5, 6, 8]. Regression is including only constant terms or including both constant and trend terms, to investigate the stationary of the data. It indicates that there is no unit root for the first order difference value of variables, and the natural logarithm of each time series data is a first-order process.

Due to the instability of the panel data, the direct application of the least squares method may lead to pseudo regression, so it is necessary to analyze the cointegration relationship of the relevant variables, and then analyze the long-term relationship of the theoretical model [10-12]. The results of the cointegration test are shown in Table 1. Panel ADF-Statistic, Group ADF-Statistic, Panel PP-Statistic, and Group PP-Statistic strongly reject the null hypothesis of "no co-integration relationship" at the 1% significance level. Therefore, the paper mainly uses the OLS and DOLS methods to estimate the cointegration equation [11-13]. The results are shown in Table 2.

There is a significant inverse U-shaped Environment Kuznets Curve relationship between nitrogen fertilizer pollution variable and per capita GDP. With the economic growth, the nitrogen pollution in this area will decrease correspondingly. The phosphorus pollution variable of chemical fertilizer application and per capita GDP also showed a significant inverse U-shaped Environment Kuznets Curve relationship. With the economic growth, the phosphorus pollution variable of chemical fertilizer application in the region will decrease correspondingly.

Table 1. Cointegration test results

	PN, A	PN, B	PP, A	PP, B
Panel v	-2.23, 0.70	-5.77, 1.00	-0.19, 0.67	-4.11, 0.99
Panel rho	-1.77, 0.04	0.27, 0.61	-4.91, 0.00	-2.40, 0.33
Panel PP	-6.49, 0.00	-9.52, 0.00	-8.23, 0.00	-7.97, 0.00
Panel ADF	-6.72, 0.00	-9.45, 0.00	-10.21, 0.00	-9.69, 0.00
Group rho	0.44, 0.82	5.25, 0.89	-0.96, 0.23	1.52, 0.77
Group PP	-6.34, 0.00	-7.89, 0.00	-7.54, 0.00	-7.85, 0.00
Group ADF	-10.42, 0.00	-6.27, 0.00	-8.99, 0.00	-6.93, 0.00

Note: (1) The first row value is the cointegration test statistic, and the second row value is the saliency level corresponding to the cointegration test statistic. (2) The optimal lag period is determined by the Schwarz evaluation standard (SIC), and the maximum lag order is 5. (3) Newey-West bandwidth uses the Bartlett core. (4) A is No trend item and B is Intercept and trend items.

4 Conclusion

The agricultural environment-economic spatial pattern in the eastern coastal areas can be judged, based on this empirical study. With the economic growth, the amount of nitrogen fertilizer application will continue to decrease. When the economic development level of a certain area exceeds the above-mentioned per capita GDP threshold level, the nitrogen emission in the area will decrease correspondingly with the economic growth, and for the areas where the per capita GDP is lower than the above-mentioned critical value, the amount of nitrogen fertilizer application will have an upward trend, that is, the nitrogen pollution increases with the increase of the per capita GDP. Three municipalities directly under the central government and Zhejiang, Jiangsu, Guangdong, Shandong provinces have passed the turning point of the curve, and their environmental and economic relations are located in the right half of the Environmental Kuznets Curve. In other words, with the development of economy and the per capita GDP rises, the fertilizer application of nitrogen pollution correspondingly decreases. The economic development level of the eastern region, such as Fujian province, is close to the critical value of transition, but it is still in the left half of the curve. There is still a large distance between the vast central and western provinces and the critical point. There is still a big gap between the central and western provinces and the critical point. With the development of economy, nitrogen pollution from fertilizer application is on the rise. For phosphorus pollution only three municipalities in the eastern coastal areas close to the critical level.

Table 2. Estimation results of cointegration relationship

PN	OLS	DOLS（1）	DOLS（2）	DOLS
C	-9.32 0.00	-6.34 0.00	-5.91 0.00	-6.11 0.01
GDP	3.55 0.00	1.65 0.00	2.00 0.00	1.91 0.00
GDP^2	-0.26 0.00	-0.12 0.01	-0.13 0.00	-0.11 0.00
PP	OLS	DOLS（1）	DOLS（2）	DOLS
C	-9.51 0.02	-4.43 0.00	-3.09 0.01	-7.97 0.00
GDP	4.57 0.00	1.47 0.00	1.26 0.00	1.96 0.00
GDP^2	-0.36 0.00	-0.05 0.00	-0.06 0.01	-0.08 0.00

Note: (1) The first row value is the cointegration coefficient value, the second row value is the saliency level. (2) The last column of DOLS (1) is estimated after adding weights.

The EKC results of economic growth and agricultural input pollution indicate that agricultural pollution is serious. At present, the use structure of nitrogen, phosphorus and potassium fertilizers in China is unreasonable. The production and application of chemical fertilizers are mainly based on nitrogen fertilizer, and farmer’s heavy nitrogen fertilizers, light phosphorus and potassium fertilizers. In China, N: P2O5: K2O was 1:0.34:0.24 in 2008, and a more appropriate ratio was 1:0.45:0.30. It can be predicted that if the use of agricultural resources by farmers is not controlled, the agricultural pollution will continue to rise for a long time as the agricultural and rural modernization process in the eastern coastal areas accelerates. At the same time, we should gradually change the traditional production mode of Chinese farmers through policies and subsidies, improve the use efficiency of agricultural resources, and realize the dual goals of economic growth and agricultural environment improvement.

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References

[1] Damme M, Clarisse L, Whitburn S. Industrial and agricultural ammonia point sources exposed. Nature. 2018, 564:99-103.

[2] Li F, Dong S, Li F, Yang L. Is there an inverted U-shaped curve? Empirical analysis of the Environmental Kuznets Curve in agrochemicals. Frontiers of Environmental Science & Engineering. 2016, 10(2): 276-287.

[3] Zheng J Y, Yin S S, Kang DW, Che W W, Zhong L J. Development and uncertainty analysis of a high-resolution NH3 emissions inventory and its implications with precipitation over the Pearl River Delta region. Atmospheric Chemistry and Physics. 2012, 12: 7041-7058.

[4] Chowdhury R R, Moran E F. Turning the curve: A critical review of Kuznets approaches. Applied Geography. 2012, 32(1): 0-11.

[5] Bergh J C, Savin I, Drews S. Evolution of opinions in the growth-vs-environment debate. Futures, 2019, 109: 84-100.

[6] Agboola M O, Bekun F V. Does agricultural value added induce environmental degradation? Empirical evidence from an agrarian country. Environmental science and pollution research international, 2019.

[7] Hou M, Yao S. EKC Retest of Fertilizer Non-Point Source Pollution Emission. Journal of Agrotechnical Economics. 2019, 4: 104-116.

[8] Kao C and Chiang M H. On the Estimation and Inference of a Cointegrated Regression in Panel Data. Advances in Econometrics, 2000, 15: 179-222

[9] Engle R, Granger C. Cointegration and Error Correction: Representation, Estimation, and Testing. Econometrica, 1987, 55: 257-276

[10] Pedroni P. Panel Cointegration: A Symptotic and Finite Sample Properties of Pooled Time Series Tests with an Application to the PPP Hypothesis. Economic Theory, 2004, 20: 597-625

[11] McCoskey S, Kao C. Comparing panel data cointegration tests with an application of the twin deficits problem, Mimeo, 1999

[12] Kao C, Chiang M H. On the Estimation and Inference of a Cointegrated Regression in Panel Data. Advances in Econometrics. 2000, 15: 179-222

[13] Smruti R B, Devi P D. The effect of urbanization, energy consumption, and foreign direct investment on the carbon dioxide emission in the SSEA (South and Southeast Asian) region. Renewable and Sustainable Energy Reviews. 2017, 70: 96-106