Environmental Kuznets Curve Analysis of Agricultural Pesticide and Film in China

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Abstract: The study analyzes the relationship between agriculture related environmental pollution and economic growth, in agricultural pesticide and film application, using the dynamic panel model and panel conintegration methods. It is shown that there a strong inverted U shaped Kuznets curve in agriculture pesticide, and agricultural film related Kuznets curve has no significant inverted U-type relationship, while it is an increasing linear relationship. Agricultural pesticide and agricultural film related pollution, to a certain extent, might continue to increase with economic growth. In the future, the focus of China's environmental pollution control need to be shifted from urban point source pollution to agricultural non-point source pollution, especially pesticides regulation as the main field urgently.

1 Introduction

Since the 21st century, China's agricultural environmental pollution problem has become increasingly serious and surpassed the industrial pollution problem, causing a widespread concern. For the agricultural environment, foreign scholars started research earlier. American scholars are at the forefront in the research and application of technical aspects of agricultural environmental pollution. The most widely used agricultural pollution analysis models are for soil erosion estimation simulation model, and model for estimating watershed erosion rate and nutrient loss from the basin, model for studying transfer process of nutrients such as N and P [1-3]. These models have been widely used in process simulation of non-point source pollution mechanisms, temporal and spatial distribution of pollutants, identification of key source areas, and simulation of non-point source management schemes. Domestic and foreign scholars have also conducted research on the relationship between agricultural environmental pollution and economic growth and its control measures. Foreign scholars have conducted many discussions on the policies and measures for agricultural environmental pollution control. Griffin and Bromley [4] explored the countermeasures for agricultural environmental pollution control earliest. They believed that there exist externality in agricultural environmental pollution. Farmers would not pay attention to the environmental pollution problems of production, and government should levy taxes on pollutant emissions or agricultural products and input factors. Shortle and Richard [5] believe that traditional policies based on environmental pollution may fail due to information asymmetry. It is recommended that taxes on farm production inputs and pollutants should be imposed, so that we can limit farm inputs and reduce pollutants. Some believed that incentive mechanisms could be used to influence the input of agricultural resources, and taxation and subsidy mechanisms were used to influence the concentration of agricultural environmental pollution, and shown that the taxes on nitrogen and

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phosphorus can allow farmers to grow crops that use less nitrogen, phosphorus and pesticides [6]. Some argues that it is difficult to enforce different tax and quantitative standards, so the uniform tax and quantitative standards should be adopted and found that the combination of economic instruments and standard management has a better effect than using economic means alone [7, 8].

Domestic and foreign scholars' research on agricultural environmental pollution began in the 1990s, but most of them are analyzed from the technical and engineering levels. The relevant research using the EKC curve from the perspective of environmental economy is scarce [3, 6]. In addition, most of the current research tend to apply the least squares estimation method to directly verify the Environmental Kuznets Curve. However, the test of the relationship between variables should base on a strict and prudent econometric system [6-9]. Direct regression will cause deviation of results. In addition, if neglected the stability of data, the estimation results may not be accurate. Therefore, this paper based on the environmental and economic data of 31 provinces for the longest time to analyze the co-integration relationship between the economic growth and agricultural environmental pollution in the eastern coastal areas. Besides, the dynamic least squares estimation model is used to compensate for the shortcomings of small sample time series analysis due to data acquisition. Compared with OLS and FMOLS, DOLS has less deviation and more applicability, and improves the accuracy of the test results [10, 11].

2 Methodology

2.1 Data

Taking into account the comprehensiveness of the research and the availability of data, this paper uses pesticide pollution intensity and agricultural film pollution intensity as the agricultural environmental pollution indicators, and uses per capita agricultural production value and per capita GDP as economic growth indicators. The original data comes from the "China Statistical Yearbook", "China Rural Statistical Yearbook", "China Agricultural Yearbook" and the statistical yearbooks of the provinces. In order to enhance the robustness of the analysis, the paper try to use the longest time series panel data from 31 provinces over the period of 1990-2017 in China. The data of per capita GDP and per capita agricultural production value are calculated. All variables are taken as natural logarithms. The pesticide application intensity (NY) (kg/ha) is the pesticide application amount (kg) in each region divided by the crop planting area (hectare), and the film application intensity (NM) (kg/ha) is the agricultural plastic film application amount (kg) in each region divided by crop area (hectare).

2.2 Econometrics

In general, regression of non-stationary time series data may cause pseudo regression. In order to avoid this phenomenon, it is necessary to perform a unit root test on the panel data to determine its stationarity. In order to ensure the robustness of the conclusion, the following five panel unit root tests were used: LLC test, IPS test, Fisher-pdf and Fisher-pp test [11, 12].

If the time series data is stationary, we need to perform a cointegration test to determine whether there is a long-term cointegration relationship between the variables. Pedroni [13] developed seven statistics to test cointegration relationship in panel variables, which are respectively recorded as Panel ν, Panelρ, Panel PP, Panel ADF, Group ρ, Group PP, and Group ADF statistics. The results of Pedroni [13] simulation experiment shows that Panel ADF and Group ADF statistics have better properties than other statistics under small sample conditions.

Finally, we need to estimate the parameters of the equation variables. Pedroni [13] proposed a comprehensive modified estimator (FMOLS) for estimating the heterogeneity panel cointegration equation. Kao and Chiang [11] proposed the panel dynamic least squares estimator (DOLS) and compared the finite sample features of the three estimators -OLS, FMOLS and DOLS. Monte Carlo simulation experiments show that the OLS estimators tend to inconsistent, and FMOLS and DOLS are better choices when estimating co-integration equations [10, 11].

The regression model of the paper is as follows:

$$E_{it} = a + b_1 Y_{it} + b_2 Y_{it}^2 + e_{it}$$

(1)

E_{it} represents the pollution status of pesticide and agricultural film of the i province in the t year. Y_{it} represents the per capita income level of the i province in the t year, including per capita GDP and the per capita agricultural output value based on the rural population. In practice, pollution variables and economic variables are logarithmic b_1 and b_2 are the parameter. e_{it} is the random error term.

3 Results

Table1. Cointegration test results

Estimator	NY	NY	NM	NM
	A	B	A	B
Panel v	-2.21 0.77	-5.97 0.98	5.11 0.27	-0.79 0.97
Panel rho	-3.75 0.00	-0.64 0.58	-3.92 0.09	0.98 0.91
Panel PP	-8.10 0.00	-11.43 0.00	-8.91 0.00	-10.34 0.00
Panel ADF	-5.38 0.00	-8.97 0.00	-7.45 0.00	-12.55 0.00
Group rho	-0. 94 0.25	2.68 0.87	1.98 0.76	5.79 0.94
Group PP	-4.08 0.00	-15.18 0.00	-9.21 0.00	-9.25 0.00
Group ADF	-7.61 0.00	-8.81 0.00	-8.92 0.00	-18.11 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.

First, the panel unit root test methods mentioned above were used to respectively conduct panel unit root test on the logarithm value and first-order difference of agricultural environmental pollution variable and per capita economic growth variable, so as to investigate the stationability of the data. It can be seen from Table 1 that when the original value of the variable is tested, the test result can basically not reject the null hypothesis of "the existence of the unit root". When the first-order difference value of the natural logarithm of each variable is tested, the test result can strongly reject the null hypothesis of "the existence of the unit root", indicating that each variable is the first-order process. Therefore, the cointegration method proposed by Pedroni [13, 14] can be used to test the long-term cointegration relationship between agricultural environmental pollution and economic growth. The result is shown in Table 1. As can be seen from Table 1, the logarithm of the agricultural environmental pollution variable, the logarithm of the economic growth variable and their squaredness tend to be consistent in the long-term, that is, there is a cointegration relationship between the variables. In this paper, OLS and DOLS methods are mainly used to estimate the parameters of the co-integration equation, and the results are shown in table1.

It can be seen from Table 2 that the pesticide pollution and per capita GDP show a significant inverse U-shaped curve, that is, the pesticide pollution in this area will decrease correspondingly with economic growth. There is no obvious inverse u-shaped relationship between the agricultural film pollution and per capita GDP, but the two are in an incremental linear relationship, with a slope of 0.66.

Table 2. Cointegration relationship estimation results

NY	RE	FE	DOLS(1)	DOLS(2)	DOLS
C	-9.12 0.00	-7.99 0.00	-4.37 0.00	-5.93 0.01	-5.11 0.00
GDP	2.14 0.00	2.37 0.00	1.51 0.00	1.11 0.01	0.97 0.0000
GDP^2	-0.09 0.00	-0.11 0.00	-0.07 0.00	-0.05 0.04	-0.03 0.01
NM	RE	FE	DOLS(1)	DOLS(2)	DOLS
C	-8.42 0.00	-7.91 0.00	-4.44 0.00	-5.48 0.00	-5.76 0.00
GDP	1.31 0.02	1.52 0.01	0.72 0.00	0.66 0.00	0.69 0.00
GDP^2	-0.05 0.52	-0.06 0.23	-	-	-

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.

4 Conclusions

Using panel data from various provinces in China, the paper empirically tested the relationship between agricultural film pollution, pesticide pollution and economic growth. There is still a big gap between the economic development level and critical level of each region, so pesticide pollution basically shows an upward trend with economic growth. Agricultural film pollution is also on the rise. Paper also test the relationship between two pollution variables and per capita agricultural output value, and found that there is no obvious inverted U-shaped curve relationship between pesticide pollution and per capita agricultural output value, instead showing an incremental linear relationship. The slope of the straight line is around 0.66, that is, the per capita agricultural output value changes by 1%, and the pesticide pollution has a variation of 0.66%. Similarly, there is no obvious inverted U-shaped Kuznets curve relationship between agricultural film pollution and per capita agricultural output value. The two also show a linear relationship, where the per capita agricultural output value changes 1%, and agricultural film pollution changes 1.2%. At present, the curve's inflection point of the pesticide pollution and per capita GDP are still at a high critical level. It can be predicted that if we can't vigorously control farmers' use of agricultural materials, with the acceleration of agricultural and rural modernization in the eastern coastal areas, the pollution from agricultural materials will continue to rise for a long time.

In the future, we should pay attention to the improvement of pesticide production and application technology, and accelerate the development and promotion of harmless pesticide technology [3, 6, 15]. At the same time, we can try using pesticides instead of fertilizers. Technological progress and related management measures will change the shape of the Environment Kuznets curve of pesticide pollution-economic growth and bring forward the inflection point.

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