

Research on Relationship between Agricultural Pollution and Economic Growth Based on the EKC in Chengdu

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Abstract: The relationship between agricultural environmental pollution and economic development has aroused the concern of theorists and practitioners, as it is directly related to agricultural economic growth and country's grain security. Based on the theory of environmental Kuznets curve, this paper studies the relationship between agricultural economic growth and agricultural non-point source pollution with the data of Chengdu from 1995 to 2012. The research results show that the relationship between per capita gross output value of agriculture (including farming, forestry, animal husbandry and fishery) and fertilizer input density reveals an N-shaped pattern. At the same time, there are 3 inverted U curves existing between per capita gross output value of agriculture and mulching input film density, pesticide input density and the number of slaughtered fattened hogs, and these pollutants have passed through the turning points of curves. Therefore, it is necessary to strengthen the management of chemical fertilizer, pesticide and mulching film, to increase the investment for new technology and the support of soil remediation technology and soil remediation industry, and to implement strict supervision to ensure the quality and safety of agricultural products.

Keywords: Chengdu, Agricultural Non-point Source Pollution, Agricultural Economic Growth, Environmental Kuznets Curve

INTRODUCTION

The relationship between environmental degradation and economic development has aroused the concern of theorists and practitioners. In the 1950s, American economist Kuznets put forward an inverted U curve in his study which dealt with the relation how income distribution changed with economic development [1]. Grossman and Kureger empirically researched that the relationship between environmental pollution and economic development revealed an inverted U firstly, that is, with the growing of economy, the degree of pollution would first increase but then decline gradually [2]. For the first time, Panayotou named the curve which reflected the relationship between environmental pollution and economic development as environmental Kuznets curve [3]. Since then, scholars from all over the world have shown a great passion for EKC researches.

Domestic scholars have carried out a large number of researches on EKC which focus on two main aspects. To begin with, according to the national or provincial level of economic development, researchers select different indexes to measure environmental quality for empirical studies, then to calculate the turning points, and to fit specific shapes which can be divided into linear, U, inverted U, N-shape and inverted N patterns [4-7]. Secondly, considering that economic development and environmental

pollution are interactional and causal, the simultaneous equations of economic growth and environmental pollution are established by calculating the comprehensive index of environmental pollution [8-9].

At present, researches on EKC are mostly concentrated on industry. The main index to reflect environmental pollution is the "three industrial wastes". And researches on agricultural non-point source pollution and agricultural economic growth are relatively less. Jia took Jiangsu province as an example and found that the inverted U curves significantly existed between the total output value of agriculture and the consumption of chemical fertilizer and plastic film. However, the inverted U relationship between the total output value of agriculture and pesticide was not obvious [10]. Wang studied Zhejiang's specific situation by using the panel data of 10 cities from 2000 to 2008 and indicated that the consumption of fertilizer, pesticide and plastic film, rural population and the number of livestock were in the left part of EKC, that is, environment would deteriorate gradually in the process of economic growth [11]. Li and Zhang used four indexes about the consumption of chemical fertilizer, pesticide, livestock excretion density and per unit area yield of straw to conduct the research and revealed that there was a stress relationship between agricultural non-point source pollution and agricultural

economic growth. But this relationship was weakening gradually [12].

In April 2014, China’s Ministry of Environmental Protection and Ministry of Land and Resources jointly issued the "National Survey Bulletin of Soil Pollution ". According to the survey, the quality of cultivated land in China is so inferior that over 16% of the soil has been polluted [13]. Chengdu is one of the largest central cities in the southwestern China. In 2012, Chengdu’s GDP ranked the third in the sub-provincial cities. But its agricultural non-point source pollution is quite serious in recent years. Therefore, it is of great significance to know the situation of agricultural non-point source pollution at present and to study the relationship between agricultural non-point source pollution and economic growth in the process of the construction of ecological agriculture in Chengdu.

METHODS AND MODELS

Variables and Data

Combing with the relevant researches and considering the availability of data, this paper selects Chengdu’s per capita gross output value of agriculture (namely, the ratio of the gross output value of agriculture to agricultural population) from 1995 to 2012 to measure the level of agricultural economic growth (the data are calculated at comparable prices based on the price of 1990). At the same time, other indexes, for example, fertilizer input density (the ratio of the consumption of fertilizer to total sown area),

mulching film input density (the ratio of the consumption of mulching film to total sown area), pesticide input density (the ratio of the consumption of pesticide to total sown area), the number of slaughtered fattened hogs and so on are used to measure agricultural non-point source pollution.

All data are derived from "Chengdu Statistical Yearbook". For simplicity, we use CZ (yuan) to represent per capita gross output value of agriculture, HF (kg/ hectare) to represent fertilizer input density, DM (kg/hectare) to represent mulching film input density, NY (kg/ hectare) to represent pesticide input density, and SZ (10000 heads) to represent the number of slaughtered fattened hogs.

Construction of Models

Domestic and foreign scholars on researches of EKC mostly adopt linear functions, quadratic functions, cubic functions and exponential functions. Because the fitting results are in the majority with quadratic functions and cubic functions, this paper builds the models as follows:

$$Y = \beta_0 + \beta_1 X + \beta_2 X^2 + \epsilon \quad (1)$$

$$Y = \beta_0 + \beta_1 X + \beta_2 X^2 + \beta_3 X^3 + \epsilon \quad (2)$$

Where, Y is expressed by the index of agricultural non-point source pollution; X is per capita gross output value of agriculture; $\beta_0, \beta_1, \beta_2, \beta_3$ are coefficients; ϵ is a random error term item. The operated results with Eviews7.0 are shown in table 1.

Table 1 Estimation results of models

Indexes	Models	β_0	β_1	β_2	β_3	R ²	F	P
Fertilizer input density	Cubic	-13.5694	0.2563*** (4.0454)	-8.06e-05*** (-3.0474)	7.62e-09** (2.2077)	0.8941	39.3879	0.0000
Mulching film input density	Quadratic	-5.7969	0.0086*** (7.4517)	-1.22e-06*** (-5.2102)	0	0.9504	143.6463	0.0000
Pesticide input density	Quadratic	4.3666	0.0024** (2.9250)	-4.40e-07** (-2.6109)	0	0.4555	6.2753	0.0105
The number of slaughtered fattened hogs	Quadratic	42.7833	0.5809*** (10.1102)	-7.99e-05*** (-6.8267)	0	0.9757	301.0408	0.0000

Notes: t values in parentheses; **, *** denote significance at 5%, 1% level, respectively.

RESULTS AND DISCUSSION

Per Capita Gross Output Value of Agriculture and Fertilizer Input Density

As shown in Fig. 1, per capita gross output value of agriculture increased year by year. The value reached 3918.75 yuan (the price of 1990) in 2012, while the value was 1152.94 yuan in 1995 (the price of

1990), increasing 239.89%. Fertilizer input density in 2007 was a turning point, rising at first but then decreasing gradually. Fertilizer input density increased from 185.01 (kg/hectare) in 1995 to 246.28 (kg/hectare) in 2007, and then dropped to 206.06 (kg/hectare) in 2012.

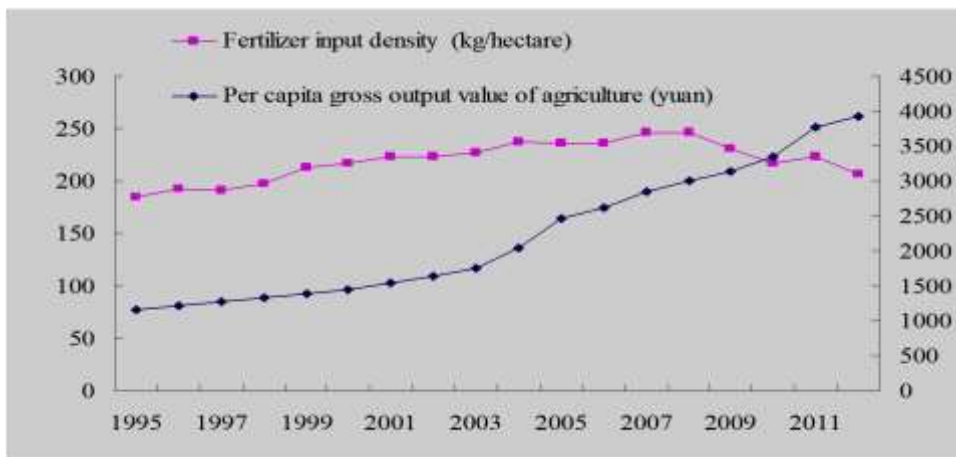


Fig-1: Changes in agricultural output value and fertilizer input density in Chengdu

Fig. 2 is the fitting curve that reflects the relationship between per capita gross output value of agriculture and fertilizer input density. The result shows that a clear N-shaped curve exists between them. R^2 is

0.89 and the adjusted R^2 is 0.87. The regression equation is $HF = -13.5694 + 0.2563CZ - 8.06e-05CZ^2 + 7.62e-09CZ^3$. The peak of this curve appeared, but its valley hasn't yet.

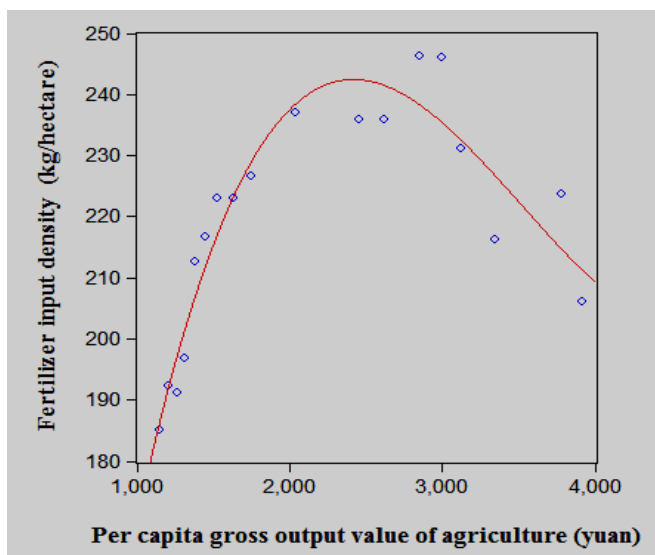


Fig-2: Fitting outcome of agricultural output value and fertilizer input density

Per Capita Gross Output Value of Agriculture and Mulching Film Input Density

As shown in Fig.3, mulching film input density increased from 1.78 (kg/hectare) to 9.29 (kg/hectare) steadily year by year during 1995-2006. Then it decreased during 2007-2008 and gradually rose to 9.56 (kg/hectare) in 2012. Overall, there were rising trends for per capita gross output value of agriculture and mulching film input density during 1995-2012. Fig. 4 is the fitting outcome of EKC that reflects the relationship between per capita gross output value of agriculture and mulching film input density. In this

figure, it reveals an obvious inverted U pattern. R^2 is 0.95 and the adjusted R^2 is 0.94. The regression equation is $DM = -5.7969 + 0.0086CZ - 1.22e-06CZ^2$. The turning point is 3524.59 yuan (the price of 1990), corresponding to the year of 2011.

At present, Chengdu is located in the right part of the curve that the slope is relatively smoother, having passed through the top of inverted U shape. It can predicate mulching film input density will decline with per capita gross output value of agriculture rising in future.

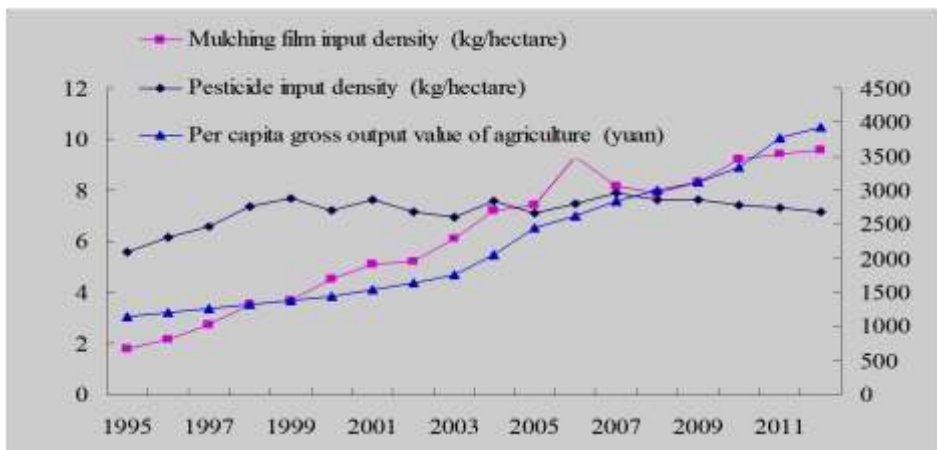


Fig-3: The changing trends of per capita gross output value of agriculture, fertilizer input density and mulching film input density from 1995 to 2012 in Chengdu

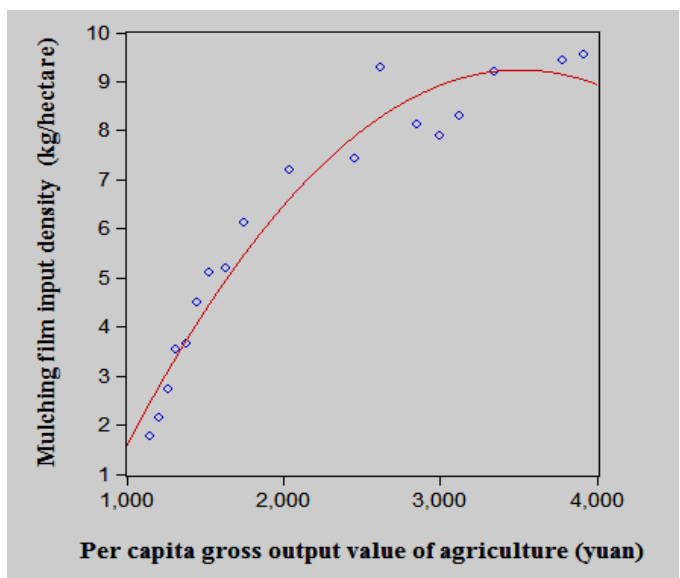


Fig-4: Fitting outcome of agricultural output value and mulching film input density

Per Capita Gross Output Value of Agriculture and Pesticide Input Density

As shown in Fig. 3, pesticide input density rose during 1995-1999 and declined during 2007-2012 clearly. There were more frequent fluctuations in the rest of years. As shown in Fig. 5, the fitting result on per capita gross output value of agriculture and pesticide input density is not very ideal. R^2 is 0.46 and the adjusted R^2 is only 0.38. The fitting equation is $NY=4.3666+0.0024CZ-4.40e-07CZ^2$ and its turning

point is 2727.27 yuan (the price of 1990), corresponding to the year of 2007.

The fitting model reveals an inverted U shape. Chengdu is located in the inverted U shape curve that the slope is relatively steeper position now. It can forecast that pesticide input density will decline greatly with per capita gross output value of agriculture increasing in the next years.

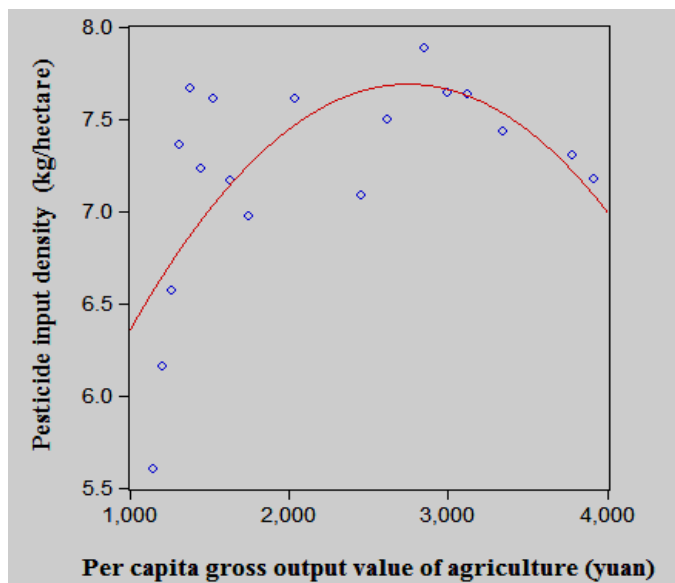


Fig- 5: Fitting outcome of agricultural output value and pesticide input density

Per Capita Gross Output Value of Agriculture and the Number of Slaughtered Fattened Hogs

Fig. 6 shows the changes in per capita gross output value of agriculture and the number of slaughtered fattened hogs in Chengdu from 1995 to 2012. Their trends are consistent roughly. As is shown in Fig. 7, the fitting model about per capita gross output value of agriculture and the number of slaughtered fattened hogs displays an inverted U shape clearly. R^2 is 0.98 and the adjusted R^2 is 0.97. The fitting equation is

$SZ=42.7833+0.5809CZ-7.99e-05CZ^2$. The turning point is 3635.17 yuan (the price of 1990), corresponding to the year of 2011.

Obviously, Chengdu lies in the right part of this EKC that the slope is relatively smoother. Thus, the number of slaughtered fattened hogs will decline gradually in the process of agricultural economic growth in future.

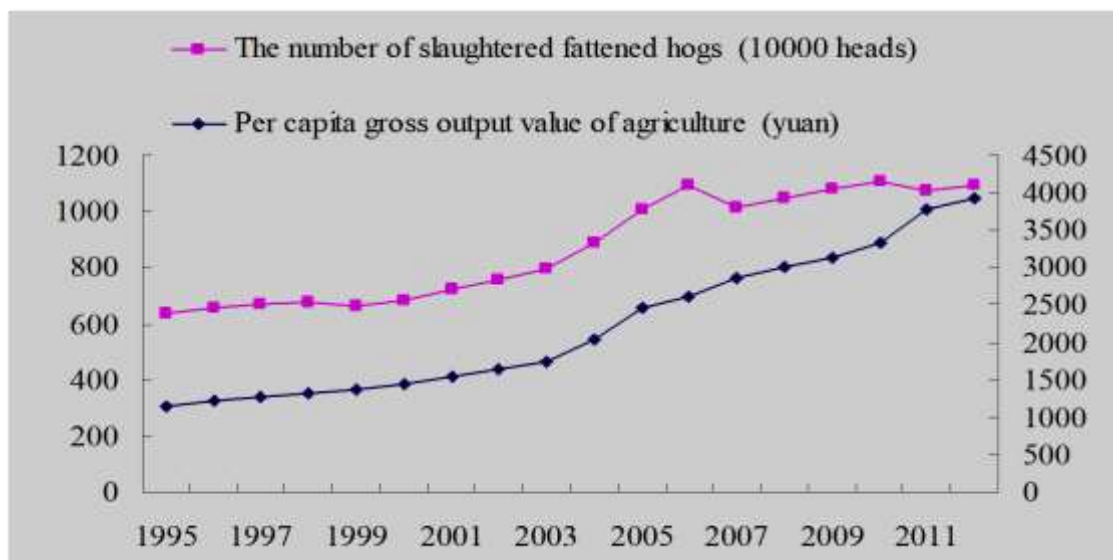


Fig-6: Changes in per capita gross output value of agriculture and the number of slaughtered fattened hogs from 1995 to 2012 in Chengdu

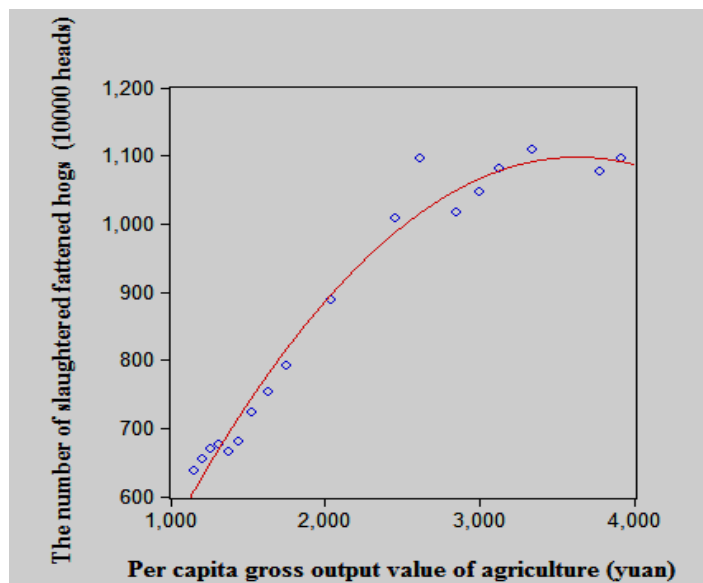


Fig.-7: Fitting outcome of agricultural output value and the number of slaughtered fattened hogs

CONCLUSIONS AND SUGGESTIONS

Conclusions

With the accelerating of industrialization and urbanization, the proportion of primary industry declined from 14.5% in 1995 to 4.3% in 2012. But at the same time, the harm caused by agricultural non-point source pollution is becoming increasingly serious. This paper uses the relevant data that reflect the relationship between the agricultural non-point source pollution and agricultural economic growth in Chengdu from 1995 to 2012 to test environmental Kuznets curve and the following conclusions can be drawn.

1. There is a clear N-shaped curve existing between per capita gross output value of agriculture and fertilizer input density. And per capita gross output value of agriculture and mulching film input density, pesticide input density and the number of slaughtered fattened hogs reveal inverted U-shaped curves that fit environmental Kuznets curve hypothesis very well. Among them, relationships between per capita gross output value of agriculture and fertilizer input density, mulching film input density and the number of slaughtered fattened hogs are especially significant because their R^2 is greater than 0.85.
2. Nowadays, Chengdu has passed through the turning points of inverted U models. Thus, it predicts Chengdu's agricultural non-point source pollution tends to reduce gradually with economy growing.
3. According to the fitting graph, Chengdu has passed through the valley of N-shaped pattern about per capita gross output value of agriculture and fertilizer input density, but it doesn't pass the peak. Therefore, we should notice that the extent of fertilizer pollution will decrease initially and increase then as economy develops.

Policy Suggestions

To Strengthen the Management of Fertilizer, Pesticide and Mulching Film Use

In 2014, China's No.1 central document "Opinions on deepening rural reform and accelerating the modernization of agriculture" points out that China should establish the long-term sustainable mechanism in agriculture, strengthen the prevention efforts of agricultural non-point source pollution, support the use of efficient fertilizer and low residual pesticide, reuse livestock manure in large-scale farms, use organic fertilizer by new agricultural main-scale operation and promote high-standard film [14].

According to its specific conditions, Chengdu should formulate reasonable management systems about fertilizer, pesticide and plastic film. It's almost impossible to prohibit the use of fertilizer, pesticide and plastic film under the current situation. Therefore, Chengdu could gradually control the consumption of these chemicals and adopt subsidies to promote the use of low-polluting and low residual pesticide. At the same time, the relevant departments should set a special fund to carry out the pilot work of film recycling.

To Increase the Support and Investment of New Technology

In order to alleviate the dependence on fertilizer, pesticide and mulching film, a new technology should be developed vigorously to increase agricultural products. Also, it's essential to develop low-polluting and degradable film.

To Strengthen the Support of Soil Remediation Technology and Soil Remediation Industry

In 2012, Chengdu began to conduct phytoremediation to remedy contaminated soil in

Pengzhou city. However, researches on soil remediation technology started late in China. Although the technology is not mature, soil remediation industry has huge potential.

To Implement Strict Supervision to Ensure the Quality and Safety of Agricultural Products

Quality and safety of agricultural products is closely related to people's health. To implement strict supervision and prevent agricultural products with excessive residues of heavy metal from entering market can encourage farmers to pay attention to food safety and avoid abusing fertilizer and pesticide.

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