Economic Growth and Agro-environmental Fragility

——Based on the Provincial Panel Data Analysis

XIONG Wen *

Key laboratory of Education Ministry of Geography Information Science, East China Normal University, Shanghai 200062, China

Abstract The agro-environmental fragility of 31 provinces and regions (except Hong Kong, Macao and Taiwan) of our country during the years 1978 -2004 is measured by adopting the method of principal component analysis. With the support of analytical model of panel data, regressive analysis is achieved from the aspects of introducing regional differences, not introducing regional differences, existing industrial differences and not existing industrial differences respectively. The conclusion points out that there are both industrial and regional differences in the economic growth effect on the environmental fragility; these differences are reflected on the industrial or regional development levels. The higher the development level it is, the less the effect it is when the economic growth effect on the environmental fragility is negative, the more when the effect is positive, and it will change from being negative to positive when on the critical point; and *vice versa*.

Key words Economic growth, Agro-environmental fragility, Principal component analysis, China

Man has achieved rapid economic development and the enhancement of welfare through exploiting the environment and resources after stepping into the 21st century. However, environmental damage caused by human beings' unrestrained exploitation of natural resources and environmental pollution caused by production and domestic wastes have been beyond the self-purification abilities of the environment, thus economic reproduction has begun to be under the threat of natural reproduction[1]. The relationship between economy and environment has been the top among man's concern. Researches on the relation between man's economic activities and environmental fragility in our country are mostly preliminary judgment according to current theories, or just some empirical analyses and simple statistical analyses at most[2-4]. Nevertheless, China is a country with obvious spatial and regional differences. So, more painstaking studies on the relation between the economy and environmental fragility should be done by further introducing spatial and industrial differences. Therefore, the writer firstly measured the agro-environmental fragility of each province from 1978 to 2004 by adopting principal component analysis, then analyzed the relation between economic growth and agro-environmental fragility with introducing spatial and regional differences and got relative conclusion.

1 Data sources, index measuring and method models

1.1 Data sources Research data are mainly from *China Statistical Yearbook*, *New China Fifty Years' Agricultural Statistics* and *New China Fifty-five Years' Statistics Compilation* from 2001 to 2005.

1.2 Index measuring Agro-environmental fragility in the research can be understood from the following two aspects. One is mutability which means environmental resource system can be easily changed under the influence of external disturbance or threat and this kind of change can be positive as well as negative and can be described by sensibility, instability and anti-interference ability. The other is probability which observes various potential risks in the environmental resource system and the possible responses of the system[5]. Therefore, according to the availability and operability of indexes, flood coverage rate, drought coverage rate, grain yield per unit area and farmland area per person are chosen to be the indexes of comprehensively measuring the dynamic changes of agro-environmental fragility[6].

The research chooses the panel data of 31 provinces and regions (except Hong Kong, Macao and Taiwan) in our country from 1978 to 2004 to analyze (data of Hainan and Chongqing are incorporated into those of Guangdong and Sichuan respectively). Then, relative indexes are standardized and agro-environmental fragility of each province is measured by using principal component analysis and SPSS11.0. Specific process and results are omitted.

GDP and three industrial added values are chosen to be indexes in economy. And to eliminate the effect of price changes, chain base index of total output value (the previous year =100) is adopted to adjust, regarding 1978 as annual base period.

1.3 Method models Panel data, which is also called parallel data or synthetic data, is a kind of comprehensive data information using time series and section data at the same time and an econometric model analyzing the interrelation among variables and predicting the changing trend. It can reflect the changing rules of research objects in time unit and section (spatial) unit as well as characteristics in different time and different units (regions)[7].

To study the relation between agro-environmental fragility and economic growth, a regression equation of agro-environmental fragility (*AEF*) and GDP is formulated with agro-environmental fragility as the dependent variable and GDP as the independent variable. Specific information is shown in equation (1).

Received: September 25, 2010 Accepted: October 16, 2010

* Corresponding author. E-mail: hsiongwell@gmail.com

$$AEF_{i,t} = \beta_0 + \beta_1 GDP_{i,t} + \varepsilon_{i,t} \quad (1)$$

In the equation, i stands for each municipality, province and region in the mainland of our country; t means year; β_0 is the constant term; β_1 is the influence coefficient on agro-environmental fragility (AEF); $\varepsilon_{i,t}$ is the residual.

Since the provincial differences of agro-environmental fragility changes in our country are probably be affected by regional differences of economic development, dummy variable D_i is introduced based on equation (1) to discuss the effect of regional differences and the specific information is shown in equation (2).

$$AEF_{i,t} = \beta_0 + (\beta_1 + \beta_1^* D_j) GDP_{i,t} + D_i + \varepsilon_{i,t} \quad (2)$$

In the equation, β_1 is the influence coefficient of economy on the environment; β_1^* is dummy variable coefficient; D_j is dummy variable; j = 1, 2 which means central area and western area respectively; meanings of other symbols are the same as those in equation (1).

When the dummy variable coefficient β_1^* is obvious, β_1, $\beta_1 + \beta_1^* D_j (j=1, 2)$ are the influence coefficients of variable GDP on variable AEF in eastern area, central area and western area respectively; When β_1^* is not obvious, there is no difference among the influence coefficients of different areas.

Since there are not only regional differences in the economic effect on the environment, industrial differences may also exist, industrial differences are introduced based on equation (1) and (2) to get equation (3) and (4).

$$AEF_{i,t} = \beta_0 + \beta_1 GDP1_{i,t} + \beta_2 GDP2_{i,t} + \beta_3 GDP3_{i,t} + \varepsilon_{i,t} \quad (3)$$

$$AEF_{i,t} = \beta_0 + (\beta_1 + \beta_1^* D_j) GDP1_{i,t} + (\beta_2 + \beta_2^* D_j) GDP2_{i,t} + (\beta_3 + \beta_3^* D_j) GDP3_{i,t} + D_j + \varepsilon_{i,t} \quad (4)$$

In the equations, β_1, β_2, β_3 are the influence coefficients of the primary, secondary and tertiary industry respectively; β_1^*, β_2^*, β_3^*, are dummy variable coefficients; $GDP1$, $GDP2$, $GDP3$ stand for the primary, secondary and tertiary industry respectively; meanings of other symbols are the same as those in equation (1).

The above 4 models are to be analyzed by using the analytical method of panel data and Eviews 5.0 so as to discuss the effect of regional differences and industrial developmental differences on the relation between economic growth and agro-environmental fragility.

2 Panel data analysis

2.1 Agro-environmental fragility and macro – economic growth First of all, the relation between the overall level of economic growth and agro-environmental fragility is analyzed. That is to estimate equation (1) and the result is shown in Table 1. The writer adopted methods of PLS, CSW, EGLS and PSUR and so on to estimate. The analysis shows that regression Ⅰ to regression Ⅲ can all be tested through F and t. However, the values of R^2 are relatively low and can not pass D – W test. Using period seemingly unrelated regression (PSUR) method (regression Ⅳ) can not only pass F and t test under the level of 1% but also greatly improve R^2 and serial correlation can be eliminated. Coefficients of regression Ⅰ to regression Ⅳ all passed t test under the level of 1% and are all negative, which indicates that the effect of overall economic growth level on agro-environmental fragility is negative.

2.2 Influence of regional differences Introducing regional differences to analyze the relation between overall economic growth level and agro-environmental fragility. That is to estimate equation (2) and the result is shown in Table 1. Analyses by PLS, CSW and EGLS find that the values of R^2 are lower with serial correlation. But, the effect can be optimum by adopting the method of PSUR (regression Ⅴ), passing F and t test under the level of 1%, improving R^2 and eliminating serial correlation. β_0, β_1, β_1^* all pass t test and present a stable characteristics with negative symbols. More importantly, both dummy variable coefficient β_1^* and intercept coefficient β_0 in different developmental stages are obvious, which indicates intercepts and influence coefficients in different regions are not the same. Additionally, values of R^2 are improved compared with those of not introducing regional differences (regression Ⅳ), which shows the estimating results of introducing regional differences are more practical.

Table 1 Regression results of economic growth level and agricultural environmental vulnerability

Item	Regression Ⅰ PLS	Regression Ⅱ CSW	Regression Ⅲ EGLS	Regression Ⅳ PSUR	Regression Ⅴ PSUR
C	0.114 7*** (3.083 1)	0.151 3*** (5.709 1)	0.084 6*** (3.262 0)	0.109 2*** (23.736 1)	0.117 3*** (10.756 9)
D_1					0.112 6*** (6.697 1)
D_2					0.102 7*** (6.919 0)
GDP	−0.081 4*** (−5.404 6)	−0.111*** (−9.815 5)	−0.073 4*** (−5.374 8)	−0.077 5*** (−22.061 5)	−0.051 6*** (−9.456 7)
$D_1 GDP$					−0.111 0*** (−9.201 8)
$D_2 GDP$					−0.358 0*** (−17.041 6)
R^2	0.036 1	0.109 9	0.035 7	0.429 8	0.551 2
F	29.209 4***	96.343 3***	28.898 9***	587.839 5***	190.585 5***
D-W	1.137 3	0.536 8	1.132 7	2.042 9	2.034 3

Note: T in the bracket is the statistics; * indicates significance level of 10%; ** indicates significance level of 5%; *** indicates significance level of 1%. Similarly hereinafter.

2.3 Influence of industrial differences The writer further introduced industrial differences to analyze the relation between economic growth and agro-environmental fragility. That is to estimate equation (3) and the result is shown in Table 2. The analysis shows values of R^2 from regression Ⅵ to regression Ⅷ are all relatively low and can not pass D-W test. However, regression Ⅸ, using method of PSUR, can not only pass F and t test under the level of 1% but also greatly improve the value of R^2 and eliminate serial correlation. β_1, β_2, β_3 from regression Ⅵ to regression Ⅸ all passed t test under the level of at least 5%. And they are stable with β_1 and β_3 being negative and β_3 positive. It indicates that economic growth levels of the first industry and the tertiary industry have negative impact on agro-environmental fragility, while that of the second industry has positive impact on agro-environmental fragility.

2.4 Interactive effect of industrial differences and regional differences Introducing regional differences to analyze the relation between the three industries and agro-environmental fragility. That is to estimate equation (4) and the result is shown in Table 2. Analyses by methods of PLS, CSW and EGLS find that values of R^2 are relatively low and can not pass D-W test. Regression Ⅹ using method of PSUR has improved effect and can pass F test under the level of 1% as well as t test mostly with values of R^2 improved and serial correlation eliminated. But, β_2, β_3 and $\beta_3^* D_2$ can not pass t test. Further calculation without public intercept β_0 got the result of regression Ⅺ. The analysis finds that the result has been further improved. For regression Ⅺ, β_2 did not pass the test and $\beta_3^* D_2$ just passed t test under the level of 10%, and all other coefficients passed t test under the level of at least 5%. This shows that intercepts and influence coefficients in different industries and regions are not the same. Besides, values of R^2 are considerably improved compared with those of not introducing regional differences (regression Ⅸ), which indicates the estimating results with introducing regional differences are more practical.

2.5 Comprehensive analysis Related analyzing results are integrated to get Table 3 for better analysis and comparison. Generally speaking, economic growth in our country has negative effect on agro-environmental fragility. And there are regional differences in these negative effects. The smallest effect is in eastern region, relatively big in central region and the biggest in western region. This kind of differences shows that the higher the economic developmental level, the less negative economic effect on the environment. Besides, there are industrial differences in these effects. The first and tertiary industry has negative impact on agro-environmental fragility and the second industry positive. Economic level of the second industry in our country is higher than those of the first and tertiary industry, which suggests that the higher industrial developmental level, the better the effect on the environment. Seen specifically from different industries and regions, for the first industry, western and eastern regions have negative influence with eastern region smaller, while central region positive; for the second industry, central and eastern region have positive influence with central region bigger, while western region negative; for the tertiary industry, central and eastern region have negative influence with eastern region smaller, while western region positive.

Table 2 Influence of three industries on agricultural environmental vulnerability

Item	Regression Ⅵ PLS	Regression Ⅶ CSW	Regression Ⅷ EGLS	Regression Ⅸ PSUR	Regression Ⅹ PSUR	Regression Ⅺ PSUR
C	0.159 8***	0.216 7***	0.135 0***	0.151 5***	0.127 7***	
	(4.038 8)	(7.867 9)	(4.827 8)	(17.558 6)	(8.782 7)	
D_1					0.069 9***	0.198 6***
					(3.101 8)	(13.417 6)
D_2					0.115 9***	0.243 9***
					(5.663 7)	(20.790 2)
$GDP1$	−0.592 0***	−0.853 0***	−0.648 0***	−0.574 0***	−0.241 0***	−0.127 0**
	(−3.233 7)	(−6.822 8)	(−4.192 5)	(−11.368 1)	(−3.375 6)	(−2.130 1)
$GDP2$	0.243 0**	0.288 0***	0.236 0**	0.132 0***	0.008 7	0.057 2
	(2.332 0)	(3.780 8)	(2.449 2)	(3.834 7)	(0.210 5)	(1.602 0)
$GDP3$	−0.375 0***	−0.411 0***	−0.318 0**	−0.214 0***	−0.088 4	−0.136***
	(−2.605 3)	(−4.154 5)	(−2.366 3)	(−4.164 7)	(−1.498 5)	(−2.886 9)
$D_1 GDP1$					0.398 0***	0.257 0**
					(3.008 8)	(2.243 3)
$D_1 GDP2$					0.370 0***	0.373 0***
					(4.054 3)	(4.870 9)
$D_1 GDP3$					−0.990 0***	−1.004***
					(−6.842 3)	(−7.818 7)
$D_2 GDP1$					−1.090 0***	−1.280 0***
					(−4.260 6)	(−5.667 3)
$D_2 GDP2$					−0.532 0***	−0.562 0***
					(−2.797 8)	(−3.399 2)
$D_2 GDP3$					0.401 0	0.457 0*
					(1.469 6)	(1.952 7)
R^2	0.054 1	0.163 8	0.061 6	0.295 0	0.437 0	0.514 3
F	14.835 2***	50.789 5***	17.035 6***	108.517 8***	54.342 5***	81.639 8***
D-W	1.165 1	0.568 0	1.157 5	2.065 0	2.066 7	2.057 4

Table 3 Influence of economy on agricultural environmental vulnerability in different regions

Item	Eastern China	Central China	Western China	Whole China
GDP	−0.051 6	−0.162 6	−0.409 6	−0.077 5
First industry	−0.127 0	0.130 0	−1.407 0	−0.574 0
Second industry	0.057 2	0.430 2	−0.505 0	0.132 0
Tertiary industry	−0.136 0	−1.140 0	0.321 0	−0.214 0

Note: The influence coefficients of three industries of eastern, central and western region on environment come from regression Ⅺ, the influence coefficients of GDP of eastern, central and western region on environment come from regression Ⅴ, the influence coefficients of national GDP on environment come from regression Ⅳ, the influence coefficients of three industries in whole China come from regression Ⅸ.

The analysis shows that the result is a verification of Environment Kuznets Curve Hypothesis in some sense. Environment Kuznets Curve Hypothesis holds that the relation between pollution level and economic growth presents an inverted curve. In the initial stage of economic development, the pollution level is low; pollution gradually increases with the economic development and will reach a turning point when the economy develops into a certain stage; pollution will decrease with further economic development after the turning point. To be specific in this research, generally speaking, the higher economic developmental level in the region, the less negative economic effect on the environment. For the first industry, central region has the best development with high technology, so economic effect on the environment is positive; eastern region is relatively advanced, the effect is relatively small thought it is negative; whereas some western areas are major provinces in agriculture but with backward agricultural technology, hence, the biggest negative effect on the environment. Seen from the second industry, central region is the traditional industrial advanced area with high technology and the biggest positive economic influence; eastern region has advanced economy and positive effect though it is smaller than that of central region; western region is backward in the second industry and many industries are resources-dependent with serious pollution, hence, negative effect; and for the tertiary industry, the fairly undeveloped western region is in the preliminary developmental stage, so economic effect on the environment is positive; central region has better development and negative effect; eastern region has the best development and smallest negative effect, but still pursuing the turning point.

3 Conclusion and discussion

Firstly adopting the method of principal component analysis, the research measured the agro-environmental fragility of each province in our country, and then analyzed the economic effect on agro-environmental fragility from four aspects of economic growth, namely on the whole, based on regional differences, based on industrial differences and based on industrial differences with introducing regional differences respectively through building panel data model. The result shows that developmental level has obvious effect on the environment from the aspects of both region and industry. If the initial effect on the environmental is negative, the lower industrial or regional developmental level, the bigger the negative effect on the environment. The negative effect will decrease with the improvement of industrial or regional development. And the effect may change from being negative to positive with certain developmental level. If the initial effect on the environment is positive, the positive effect will gradually grows with the improvement of industrial or regional development. Apparently, these characteristics are quite similar to the Environment Kuznets Curve Hypothesis. And in some sense, this is a kind of verification to the Environment Kuznets Curve Hypothesis.

References

[1] QU RX, ZHANG YR. The best way to coordinate trade and environment: internalization of environmental cost [J]. China Population Resources and Environment, 2006, 16(4): 17 –22. (in Chinese).

[2] LI B. An elementary analysis to environmental fragility and reasons for economics' lagging in the karst area of south China [J]. Carsologica Sinica, 1995, 14(3): 209 –215. (in Chinese).

[3] XIE B, YANG YG. Relationship between ecological environmental fragility and human activities in karst mountain areas of Guizhou Province—a case study at Xifeng County [J]. Bulletin of Soil and Water, 1998, 18(4):12 –16. (in Chinese).

[4] MA CH. On the relationship between poverty population distribution and ecological environment in our country [J]. Journal of Shaoxing University: Philosophy and Social Sciences Edition, 2003, 23(1): 92 –95. (in Chinese).

[5] WANG JY, ZHAO GX, WANG XF, *et al*. Discussion on environmental vulnerability and its evaluation [J]. Shandong Agricultural Sciences, 2004(2): 9 –11. (in Chinese).

[6] XIONG W, WU YM. Causality and impulse response on the relationship of China's economic growth and environment fragility [J]. Resources Science, 2006, 28(5): 17 –23. (in Chinese).

[7] WU YM. A panel data study on correlation mechanism between FDI and environmental regulations [J]. Economic Geography, 2007, 27(1):11 –14. (in Chinese).

(From page 45)

[2] FAN H. Economic analysis of inadequate investment on health in rural China[J]. China Rural Survey, 2001(6):38 –44. (in Chinese).

[3] ZHANG CW. Nutrition, health and productivity: evidence from poor areas of rural China[J]. Economic Research Journal, 2003(1):3 –12, 92. (in Chinese).

[4] CAI F, DU Y, WANG MY. The political economy of labor migration [M]. Shanghai:Shanghai People's Press, 2003. (in Chinese).

[5] ZHU N. Poverty, inequality and development of rural non-agricultural activities[J]. China Economic Quarterly, 2005(4):171 –192. (in Chinese).

[6] ZHANG YL, WANG WJ. The rural labour flowing and relieving the poverty[J]. Economy and Management, 2008(1):17 –22. (in Chinese).

[7] DU Y, PARK A. Migration, income transfer and poverty reduction [M]//CAI F, BAI NS. Labor flow in transitional China. Beijing: Social Sciences Academic Press, 2006. (in Chinese).

[8] GAO TM. Econometric analysis method and modeling—Eviews applications and examples [M]. Beijing: Tsinghua University Press, 2006. (in Chinese).

[9] SCHULTZ TW. Investment in human capital[M]. Beijing: Economic College Press, 1990. (in Chinese).