Urbanization, Water Pollution and Economic Growth--Analysis of Spatial Econometric Model Based on Inter-Provincial Data

Yunke Yuan*

Shanghai University, Shanghai, China

Email address:18535609416@163.com

Keywords: Urbanization; Environmental pollution; Economic growth; Kuznets curve; Spatial econometric model.

Abstract. Urbanization and ecological civilization construction are important goals of China's current economic development. This paper uses the panel data of 31 provinces in China from 2007 to 2016, and uses the spatial measurement model to empirically analyze the relationship between urbanization, environmental pollution and economic growth, and verify the environmental Kuznets curve from the perspective of urbanization. The results show that there is spatial correlation in China's environmental pollution; after expanding the basic environmental Kuznets curve, a spatial autoregressive model is formed to verify the binary relationship between environmental pollution and urbanization, which is inverted U-shaped. The urbanization rate at the turning point is 58.38%; the environmental pollution among the provinces in China is not only affected by the environment of the neighboring provinces, but also the economic development, industrial structure and technical level will also affect the environmental pollution. All provinces and municipalities must rationally control the scale of the city, optimize the industrial structure, and develop a circular economy.

Introduction

At present, China is in the rapid stage of urbanization development. The population agglomeration, industrial agglomeration and infrastructure construction brought about by urbanization have brought about earth-shaking changes. However, the extensive economic growth has caused serious environmental damage. So what is the relationship between urbanization and environmental pollution, especially water pollution? This paper studies this problem based on the environmental Kuznets curve.

Many scholars have studied the relationship between urbanization and environmental pollution. Here are four points. First, some scholars believe that urbanization will have a certain negative impact on the ecological environment, such as D.H. Meadows (1972)[1], Burak S(2004)[2], H. Wang (2011)[3], L.Y. Luo (2015)[4], B.C. Duan (2016)[5] , X.L. Deng (2017)[6]. Secondly, W.C. Du (2013)[7]believes that there is a U-shaped relationship between the two, that is, urbanization does not necessarily lead to deterioration of air quality. Thirdly, scholars generally believe that the impact of urbanization on water consumption is inverted U-shaped, in line with the Kuznets curve, such as Selden & Song (1994)[8], Grossman (1995)[9], S. MERRET (1997)[10],X.Y. Chen (2015) [11], W. Jin (2018)[12]. Finally, some scholars have subdivided urbanization, arguing that population urbanization can promote the construction of ecological civilization, while industrial urbanization and spatial urbanization are not conducive to the construction of ecological civilization, such as R. Li (2018)[13].

In summary, there are few articles on the relationship between urbanization and environmental pollution from the perspective of spatial measurement. This paper builds a spatial econometric model based on the Kuznets curve to verify the spatial correlation of environmental pollution, and uses the provincial panel data from 2007 to 2016 to analyze the inverted U-shaped relationship between urbanization and environmental pollution. The purpose is to find the turning point of urbanization and water pollution, judge the stage of the cities in China's provinces, and provide corresponding policy recommendations.

  DOI: 10.25236/icess.2019.164

Data

This paper selects 31 provinces and autonomous regions in China as samples. The data mainly comes from the 2007-2016 China Statistical Yearbooks and China Environmental Yearbook. This article uses Matlab and Stata software for data calculation.

In this paper, the total amount of wastewater discharge (Twwater) is selected as the explanatory variable in the model. This paper selects five variables of urbanization rate (U), urbanization rate (U^2), economic level (Pgdp), industrial structure (IS) and technological progress (Tec) as explanatory variables. 1) Urbanization rate. This paper uses the population urbanization index, which refers to the proportion of urban population in the total population among the provincial administrative regions. 2) The square of the urbanization rate. In order to illustrate the binary relationship between water pollution and urbanization, this paper introduces the dual form of urbanization in order to obtain the expected results. 3) The economic level is measured by the per capita GDP of the region. The rapid economic growth is at the expense of the environment, and environmental governance will also affect the speed and quality of economic growth. 4) Industrial structure, with industrial added value/GDP as an indicator of industrialization level. 5) Technological progress. Using capital labor is measured by this indicator. Technological progress leads to a decline in energy consumption per unit of GDP growth and reduces environmental pollution pressure. In order to eliminate the fluctuation of data, this paper has done a logarithmic processing of total wastewater discharge, per capita GDP, and technological progress. The descriptive statistics of the variables are shown in Table 1:

Table 1 Descriptive statistics after logarithm of each variable

Variable	Average	Sd	Max	Min	Sample
LnTwwater	11.86723	1.03671	13.75178	8.112396	310
U	0.5258769	0.1432725	0.8960662	0.2145329	310
U^2	0.2970073	0.1684271	0.8029347	0.0460244	310
LnPgdp	10.45197	0.5458814	11.68012	8.971829	310
IS	0.388366	0.098575	0.5303612	0.0680833	310
LnTec	12.92794	0.4797032	14.41768	11.86222	310

Source: China Statistical Yearbook

Before performing the model calculation, first check the stability of the panel data. The unit root test results are shown in Table 2. Each variable has passed the test. Secondly, the LSDV test is carried out on the total amount of wastewater discharge. According to the regression result of the least squares virtual variable estimation method (LSDV), most of the individual dummy variables are very significant (p value is 0.000), so rejecting "all individual dummy variables are The null hypothesis of 0". So there has an individual effect and does not use a mixed regression. Again, in the presence of individual effects, a total Hausman test is performed on the total amount of wastewater discharge. The P value in the test results is 0.0001. Therefore, a fixed effect model should be used instead of a random effect model.

Table 2 Panel unit root test results

Variable	HT test	Test result
LnWwater	-0.2029（0.0000）	pass
U	-0.0042(0.0000)	pass
U^2	-0.0237（0.0000）	pass
LnPgdp	0.3770（0.0000）	pass
IS	0.1468（0.0000）	pass
LnTec	0.1781（0.0000）	pass

Model Construction and Empirical Test

Spatial Autocorrelation Test. In order to determine whether to use spatial econometric method, we need to test the spatial dependence of the total amount of wastewater discharged. In this paper, Moran's I index is used to test the global spatial agglomeration. The Moran index I generally has a value ranging from -1 to 1, with greater than 0 indicating positive autocorrelation and less than 0 indicating negative autocorrelation. If the observed value and its spatial lag are transformed into a scatter plot, it is called the "Moran scatter plot" and the Morin index I is the slope of the regression line of the scatter plot. The calculative method of Moran index is:

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(X_i - \bar{x})(X_j - \bar{x})}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \quad (1)$$

In the formulation , w_{ij} is the spatial weight matrix, x_i and x_j is the observed value of the area i and j , $\bar{x}$ is the average of the sample, $S^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}$ is the sample variance, and n is the total number of regions.

Table 3 shows the results of global Moran's I test using stata12. During 2007-2016, the Moran's I values of total wastewater discharges in 31 provinces of China were positive and passed a significant test. There is a very significant spatial correlation and a spatial econometric model can be further constructed. The total amount of wastewater discharged in 2007 and 2016 is shown in Fig. 1. From all the above data test results, we can know that the influence of independent variables on the total amount of wastewater discharge should use the spatial measurement method and the fixed effect model.

Table 3 Total Wastewater Discharge Moran Test Results

year	Moran's I	Z statistic
2007	0.295^{***}	2.935
2008	0.284^{***}	2.842
2009	0.285^{***}	2.864
2010	0.288^{***}	2.883
2011	0.284^{***}	2.824
2012	0.274^{***}	2.752
2013	0.261^{***}	2.628
2014	0.259^{***}	2.608
2015	0.262^{***}	2.620
2016	0.249^{**}	2.510

Note: ***, **, and * indicate significant levels at 1%, 5%, and 10%, respectively.

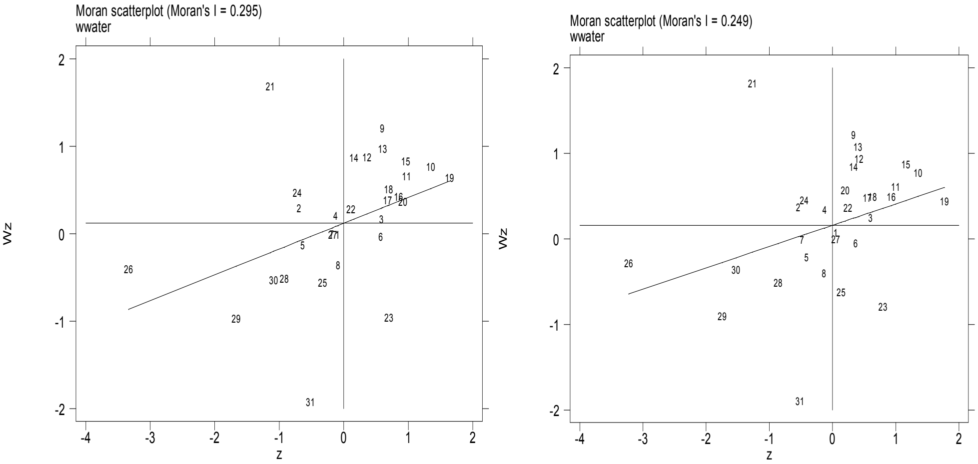

Figure 1. Moran scatter plot of total wastewater discharge in 2007 and 2016

Model Construction and Results Analysis. In order to illustrate the impact of urbanization on total wastewater discharge, this paper establishes two spatial models of spatial lag model and spatial error model to illustrate the problem. The spatial autoregressive model constructed is as follows:

$$\ln E_{it} = \rho W E_{it} + \beta_0 + \beta_1 U_{it} + \beta_2 (U_{it})^2 + \beta_3 \ln Pgdp_{it} + \beta_4 IS_{it} + \beta_5 lnTec_{it} + \varepsilon_{it}. \quad (2)$$

Where $\varepsilon_{it} \sim N(0, \sigma_{it}^2)$, W is a spatial weight matrix, and ρ is a spatial autoregressive coefficient.

If the spatial dependence is achieved by the error term, the spatial variables that are not included in X but have an effect on y have spatial correlation, or the spatial impact of unobservable random shocks, the spatial error model constructed as follows is introduced:

$$\ln E_{it} = \beta_0 + \beta_1 U_{it} + \beta_2 (U_{it})^2 + \beta_3 \ln Pgdp_{it} + \beta_4 IS_{it} + \beta_5 lnTec_{it} + \mu_{it}. \quad (3)$$

$$\mu_{it} = \lambda W \mu_{it} + \varepsilon_{it}. \quad (4)$$

λ is the spatial error coefficient, revealing the degree of spatial autocorrelation between regression residuals; W is the spatial weight matrix.

This paper use the fixed effect model. The results of OLS mixed regression, SAR model and SEM model estimated by Matlab2012 are shown in Table 4. By comparing R^2, the significance degree of each index, the log-likelihood function value and the LM test results, it can be seen that the spatial autoregressive model (SAR) under the double fixed effect is superior to other analytical models, so this paper will follow this result to analyze.

Table 4 SAR model and SEM model regression results

variable	OLS mixed regression	SAR-model Fixed effect			SEM—model Fixed effect		
		Space fixed	Time fixed	Double fixed	Space fixed	Time fixed	Double fixed
U	6.647*** (2.649)	3.015*** (3.100)	1.205 (0.538)	4.583*** (4.383)	2.749*** (3.073)	5.022** (2.249)	4.118*** (4.176)
U^2	-6.157*** (-3.201)	-2.988*** (-3.327)	1.654 (0.888)	-3.925*** (-4.261)	-2.813*** (-3.332)	-1.385 (-0.755)	-3.637*** (-4.069)
LnPgdp	1.104*** (6.514)	0.385*** (6.281)	-0.032 (-0.146)	0.188 (1.525)	0.335*** (6.176)	-0.015 (-0.072)	0.150 (1.283)
IS	5.042*** (8.845)	-0.493** (-2.504)	6.826*** (12.079)	-0.668** (-2.342)	-0.371** (-2.022)	5.800*** (10.714)	-0.569** (-1.955)
LnTec	-0.256** (-2.312)	-0.057 (-1.639)	-0.891*** (-7.534)	-0.090** (-2.498)	-0.043 (-1.293)	-0.837*** (-7.714)	-0.072** (-2.063)
rho	/	-0.181** (-2.256)	0.306*** (6.108)	-0.325*** (-3.969)	-0.209** (-2.497)	0.384*** (5.896)	-0.293*** (-3.481)
R^2	0.431	0.991	0.596	0.991	0.990	0.532	0.991
log likelihood	/	270.453	-314.113	282.433	270.669	-317.794	281.517

Note: ***, **, and * indicate significant levels at 1%, 5%, and 10%, respectively.

According to the results, we can see that the coefficient of urbanization rate is 4.583, the coefficient of squared urbanization rate is - 3.925, and both are significant at the level of 1%, indicating that urbanization shows the total amount of wastewater discharged. It is an inverted U-shaped relationship that verifies the existence of an environmental Kuznets curve. That is, with the advancement of urbanization, the total amount of wastewater discharge is rising, but when it exceeds a certain value, the total amount of wastewater discharge begins to decline. According to the calculation results, this inflection point value is 58.38%. That is, when the urbanization rate is less than 58.38%, urbanization promotes wastewater discharge and aggravates environmental pollution; when the urbanization rate is greater than 58.38%, urbanization has an inhibitory effect on total wastewater discharge.

From the results of the control variables, it can be seen that the impact of industrial structure on environmental pollution is negative, that is, for every unit change of industrial structure, the total amount of wastewater discharge is reduced by 0.668 units, indicating that when the proportion of industrial added value to GDP gradually rises, it will reduce the total amount of wastewater discharge to a certain extent. It shows that China's original extensive economic growth mode has improved, and the situation of economic construction and environmental considerations has achieved initial results. The impact of technological progress on the total amount of wastewater discharge is negative. For every unit change in technological progress, the total amount of wastewater discharge is reduced by 0.09 units. On the one hand, the improvement of the technical level in production activities can improve the efficiency of resource utilization. It is conducive to the realization of the "high energy consumption, high pollution" extensive production mode to the conservation-oriented production mode, reducing the demand for natural resources and pollution of the ecological environment. On the other hand, the advanced technology level can be directly used in the ecological environment governance, alleviate the deterioration of the ecological environment and improve the ecological environment.

Conclusions and Policy Recommendations

Conclusion. Based on the environmental Kuznets curve, this paper uses the panel data of 31 provinces in China from 2007 to 2016 to construct a spatial econometric model, and verify the existence of the environmental Kuznets curve from the perspective of urbanization, and obtain the following conclusions:

First, there is a significant spatial correlation between the total amount of wastewater discharge in China. It is more appropriate to use spatial measurement methods to study the relationship between the two variables. Second, there is an inverted U-shaped relationship between the total amount of wastewater discharge and the level of urbanization, which verifies the EKC hypothesis and conforms to the environmental Kuznets hypothesis. In the process of urbanization development, the degree of environmental pollution has intensified, and then with the further development of urbanization level, the technical level has been continuously improved, the degree of environmental pollution has decreased year by year, and the regional ecological efficiency has been increasing year by year. The inflection point of the inverted U-shaped curve is 58.38%. At present, 12 provinces in China have reached this inflection point, indicating that most cities are still in the stage of positive development of urbanization and environmental pollution. Third, environmental pollution is not only affected by the environment of the surrounding provinces, but also by the impact of structural differences between regions, such as economic level, industrial structure, technological progress and other factors. Economic development will lead to an increase in environmental pollution, and industrial upgrading and technological advancement can improve energy efficiency and reduce environmental pollution.

Recommendation. Urbanization construction and environmental protection are two development goals of China. In order to achieve urbanization development, coordinated development and win-win between economic growth and environment, this paper proposes the following suggestions:

First, reasonable control of the scale of the city, the decline of environmental pollution is not the inevitable result of urbanization reaching a certain level, but the need to raise awareness of environmental protection and the public's joint efforts. While promoting urbanization, we cannot develop the economy at the expense of the environment. We must do a good job in supporting environmental sewage treatment, better provide excellent public services for the urbanized population, and reduce environmental pollution and wastewater discharge.

Second, optimize the industrial structure and develop a circular economy. Improve the technological innovation level of each enterprise, adopt technology to drive the transformation of energy consumption structure, adopt more advanced emission reduction technologies, transform economic growth mode, realize industrial structure re-optimization, and promote sustainable urban development.

References

[1] D.H. Meadows, Meadows D L, Randers J, et al: The Limits to Growth (Universe Books, New York 1972).

[2] S. Burak, E. Dogan, C and Gazioglu: Ocean & Coastal Management, Vol. 47 (2004) No.9-10, p.515-527.

[3] H. Wang and Q. Wang: Chinese Journal of Population Science, Vol. (2011) No.5, p.57-66.(In Chinese)

[4] L.Y. Luo and Z.L. Wei: Journal of Industrial Technological Economics, Vol. (2015) No.6, p.59-66. (In Chinese)

[5] B.C. Duan and X.D. Sun: Statistics & Decision, Vol. (2016) No.22, p.102-105.(In Chinese)

[6] X.L. Deng, M.H. Che and B.D. Chen: Inquiry into Economic Issues, Vol. (2017) No.1, p.31-37. (In Chinese)

[7] W.C. Du and K. Feng: Comparative Economic & Social Systems, Vol. (2013) No.5, p.91-99. (In Chinese)

[8] T.M. Selden and D. Song: Journal of Environmental Economics and Environmental Management, Vol. (1994) No.27, p. 147-162.

[9] G.M. Grossman and A.B. Krueger: The Quarterly Journal of Economics, Vol. (1995) No.110, p. 353-378.

[10] S. MERRET: Introduction to the economics of water resources ： an international perspective (UCL Press, London 1997).

[11] X.Y. Chen: China Economic Studies, Vol. (2015) No.3, p.51-62. (In Chinese)

[12] W. Jin, H.Q. Zhang and H. Wang: Journal of Beijing Institute of Technology (Social Sciences Edition), Vol. 20 (2018) No.3, p. 42-50. (In Chinese)

[13] R. Li, T. Liu and Y.S. Zhang: Urban Problems, Vol. (2018) No.4, p. 12-17. (In Chinese)