THE IMPACT OF URBANIZATION AND INDUSTRIAL STRUCTURE ON ENVIRONMENTAL POLLUTION IN CHINA

[1]FEIHONG WANG, [2]SONGSAK SRIBOONCHITTA, [3]WORAPHON YAMAKA, [4]PARAVEE MANEEJUK

[1,2,3,4]Faculty of Economics, Chiang Mai University
E-mail: [1]798892063@qq.com, [2]songsakecon@gmail.com, [3]woraphon.econ@gmail.com, [4]mpravee@gmail.com

Abstract - The economic growth has promoted the development of China's urbanization as well as optimizing and upgrading its industrial structure. However, the situation of environmental pollution has become increasingly severe. This study thus examines the relationship between urbanization and industrial structure in China considering 30 provinces from the period 2005-2017. This study uses the panel kink regression model to find two threshold points of urbanization and industrial structure and thereby 3-regime model is considered. Several estimations, namely pooling, within, and random, are considered an the Akaike information criterion (AIC) method is used to select the best fit model. According to the empirical test, we find that: (1) The relationship between industrial structure and environmental pollution is nonlinear and shown as an inverted N-shaped. When the industrial structure has upgraded to a certain degree, it can reduce wastewater discharge from environmental pollution. (2) Urbanization is positively related to environmental pollution in three different regimes. Owing to the mode of urbanization development in China, the continuous process has brought more and more pollution to the environment. (3) This paper also considers three control variables, namely trade openness, environmental investment, and technology. Among them, environmental investment and technology has a negative relationship with environmental pollution, while the trade openness has a positive relationship with pollution.

Keywords - Environmental pollution, Industrial structure and Urbanization, Panel Kink regression.

I. INTRODUCTION

According to official statistics from UNHVR, the World Bank, and the World Health Organization, as the world's most polluted country, China also has a significant proportion of deaths caused by environmental pollution. As the world's second-largest economy, China's urbanization rate has increased by nearly 49% from 10.64% in 1949 to 59.58% in 2018.At the same time because of the continues development of urbanization, the industrial structure is also constantly optimized, and the added value of the tertiary industry continues to increase, which reduces the proportion of heavy industry to a certain extent and has a certain mitigating effect on environmental pollution. However, with the continuous development of the city, there are still many problems, the most serious of these is the problem of environmental pollution.

Many scholars have studied the relationship between economic growth and environmental pollution, most of which are non-linear relationships such as inverted U-shaped curves [10,11].Controversial studies on the economy and the environment continue to emerge. Some scholars believe that the relationship between economic growth and environmental pollution is an inverted U-shape, and some scholars believe that the two are an N-type relationship. Inverted U-shape EKC for 9 Latin American countries was found by Culas [13]. The paper based on 74 countries finds evidence for the N-shaped EKC in all income groups, except for the upper-middle-income countries [14].

As the world's second-largest economy, China has the largest proportion of environmental pollution in the world. Many scholars have researched China's environmental pollution issues. China's economic growth and environmental pollution not only has a linear relationship with a U-shape [9,12] but also has a relationship with an inverted U-shape [10,15].China is a country with many provinces, and the development degree of each region is different. Therefore, the economy of environmental pollution also exists inverted N-type. Yi [16] finds the environmental pollution index and per GDP of Yunnan province showed an inverted-N curve in China. Dan and Shuiping [6] also finds Hunan province exists inverted-N curve between urbanization and environmental pollution. Therefore, will urbanization and industrial structure presents an inverted N-type nonlinear relationship to environmental pollution? In this article, we study the impact of urbanization and industrial institutions on environmental pollution based on the panel kink regression model on 3 different regimes.

Many articles focus on the relationship between economic growth and environmental pollution, and most of the relationships are inverted U-shaped non-linear relationships, but this article studies the impact of urbanization and industrial structure in China on environmental pollution. This paper we pay attention to inverted-N curve with two kink points.

II. LITERATURE REVIEW

2.1. The relationship between urbanization and environmental pollution

The relationship between urbanization and environmental pollution has attracted more attention around the world. More and more scholars at domestic and foreign have studied the relationship between the

two, and there are linear relationships as well as nonlinear relationships. Applying the Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) found that urbanization and environmental pollution exhibit a non-linear relationship of inverted U-shaped. Before reaching the inflection point, Malaysia's carbon dioxide emissions will increase with the increase of urbanization. After crossing the inflection point, a negative relationship will follow [1]. This article examines the relationship between urbanization and coal consumption in Indonesia from 1970 to 2015. Coal consumption will bring pollution to the environment. The results show that urbanization will increase coal consumption. Therefore, urbanization is a vital reason for coal consumption[2].Therelationship between urbanization and environmental pollution in China also has a linear relationship and non-linear relationship of inverted N-type. The paper combines the threshold regression model and the mediating effect model to find out that urbanization can contribute to decreasing in carbon emission scale, however, the harmonious relationship between urbanization and the environment can be further achieved at a highly urbanized level [3]. Based on China's panel data from 2001 to 2012, the rapid progress of urbanization is accompanied by the increase of energy demand [4]. To explore the relationship between urbanization and residential CO2 emissions apply fixed effects two stage least squares (2SLS), with the results It is found that the carbon dioxide emissions of residents will increase with the increase of urban population [5]. In 2014, Dan and Shuiping [6] combined a fixed-effect model and a random-effect model and found that there is a non-linear relationship of N-type between urbanization and industrial wastewater in Hunan Province of China, and a non-linear relationship of inverted N-type also appears in other regions of the province.

2.2. The relationship between industrial structure and environmental pollution

According to most of the literature on industrial structure and environmental pollution, the relationship between them is not only linear but also non-linear.

The heavy industry exerts a significant negative effect on economic growth using system generalized methods of moments (GMM-sys) estimation methods [4]. Continuously optimizing China's industrial structure can enable China to achieve the goal of reducing carbon emissions by 2020, and the current adjustment of the industrial structure has greatly reduced COD and SO2 emissions [7]. Xiaole [8] found through the threshold model that the industrial agglomeration formed from the development of the industrial structure to a certain stage has an inverted U-shaped nonlinear relationship between environmental pollution and environmental pollution. Jiyang [9] found a positive linear relationship between industrial structure and energy consumption using a dynamic panel model based on EKC theory. From the above literature, it can be concluded that there are different relationships between urbanization and industrial structure and environmental pollution. Linear and non-linear relationships with threshold points. In this article, two threshold points will be considered to study the impact of urbanization and industrial structure on environmental pollution.

III. METHODOLOGY AND DATA

3.1. Panel Kink Regression

According to the kink regression developed by Yonghui, Qiankun, and Li [17], and is extensively used as a significant method to explain the non-linear feature of a wide range of economic phenomena. The panel kink regression model takes the following form:

$$y_{pt} = \beta_1^- \left(x_{1,pt} - \gamma_1\right)_- + \beta_1^+ \left(x_{1,pt} - \gamma_1\right)_+ +,...,+\beta_Q^- \left(x_{Q,pt} - \gamma_Q\right)_- + \beta_Q^+ \left(x_{Q,pt} - \gamma_Q\right)_+ + \phi Z_{pt} + \alpha_p + \varepsilon_{pt} (1)$$

where P =1,..., N represents the provinces and t =1,..., T represents the year, y_{tp} represent the independent variable, x_{tp} is the dependent variable.

γ_Q is the threshold point. β_Q^-, β_Q^+ represent the regime-dependent coefficients for $x_{Q,pt}$. The negative side means β_Q^- less than the corresponding kink parameter γ_Q, and the positive side means β_Q^+ greater than the corresponding kink parameter γ_Q. α_p is the unobservable individual effects of each province that can be correlated with independent and dependent variables. ε_{pt} refers to the random standard error.

This article studies the impact of urbanization and industrial structure on environmental pollution based on the panel kink regression model. The Panel kink with 2 kink points takes as the following form:

$$y_{pt} = \beta_1^{(1)} \left(x_{1,pt} - \gamma_1\right)_1 + \beta_2^{(2)} \left(x_{1,pt} - \gamma_1\right)_2 + \beta_3^{(3)} \left(x_{1,pt} - \gamma_1\right)_3 +,...,+\beta_{Q-2}^{(1)} \left(x_{Q,pt} - \gamma_{1Q}\right)_1 + \beta_{Q-1}^{(2)} \left(x_{Q,pt} - \gamma_{1Q}\right)_2 + \beta_Q^{(3)} \left(x_{Q,pt} - \gamma_{1Q}\right)_3 + \phi Z_{pt} + \alpha_p + \varepsilon_{pt} (2)$$

where $x_{Q,pt}$ are departed into 3 regimes, depending on the kink parameter γ_Q. Regime 1 means $\beta_1^{(1)} < \gamma_1$, Regime 2 means $\gamma_1 \le \beta_2^{(2)} \le \gamma_2$, and Regime 3 means $\beta_3^{(3)} < \gamma_2$.

Based on the function (2), the independent variable y_{pt} represents environmental pollution and is expressed by the discharge of wastewater (W). The threshold variable is urbanization (Ur) and industrial structure (IS). The control variable represents Technology (Te),

Environmental Investment (EI) and Trade openness (To).

$$W_{pt} = \beta_1^{(1)}\left(IS_{1,pt} - \gamma_{IS1}\right)_1 + \beta_2^{(2)}\left(x_{1,pt} - \gamma_{IS2}\right)_2 + \beta_3^{(3)}\left(x_{1,pt} - \gamma_{IS2}\right)_3 + \beta_4^{(1)}\left(Ur_{pt} - \gamma_{Ur1}\right)_1 + \beta_5^{(2)}\left(Ur_{pt} - \gamma_{Ur2}\right)_2 + \beta_6^{(3)}\left(Ur_{pt} - \gamma_{Ur2}\right)_3 + \phi To_{pt} + \phi EI_{pt} + \phi Te_{pt} + \alpha_p + \varepsilon_{pt} (3)$$

3.2 Data and Variables Description

This research intends to analyze the impact of urbanization and industrial structure on Environmental pollution, over the period from 2005 to 2017 applying the secondary data from China Statistics Yearbook.

The 30 provinces and municipalities include Beijing, Tianjin, Hebei, Shanxi, Neimenggu, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang.

The dependent variable is represented by the amount of wastewater discharged. Industry structure is represented by the sum of the secondary and tertiary industries as a percentage of GDP. (Unit:%). Urbanization is represented by population ratio of urban to the total population (Unit:%). Technology is represented by the sum of the number of domestic patent applications (Unit: pieces).

Environmental investment accounted for GDP (Unit:%). Trade openness is represented by total import and export volume as a share of GDP (Unit:%). These variables are comes from China Environmental Statistics Yearbook and China Statistical Yearbook.

Variable	*Mean*	*Median*	*Max*	*Mini*	*Std.Dev*
LnW	11.952	12.023	13.752	9.625	0.839
LnIs	-0.119	-0.117	-0.004	-0.410	0.066
LnUr	-0.668	-0.677	-0.110	-1.314	0.253
LnTo	-1.654	-1.931	0.568	-4.086	0.975
LnEI	-4.410	-4.419	-3.161	-5.809	0.460
LnTe	9.185	9.217	12.715	4.369	1.613

Table1. Data Statistics Description

Table 2 provides the statistical description of Wastewater (W), Industry structure (IS), Urbanization (Ur), Technology (Te), Environmental Investment (EI), Trade openness (To).

This article based on a panel data set of 390 observations. We presents mean, median, maximum and minimum, standard deviation values of dependent, independent, and control variables.

IV. EMPIRICAL RESULTS

4.1. unit root test

Variables	Level	Result
lnW	-6.339***	Stationary
lnIS	-6.122***	Stationary
lnUr	-5.782***	Stationary
lnTO	-3.044***	Stationary
lnEI	-5.384***	Stationary
lnTe	-8.052***	Stationary

Table 2：Unit root test（LLC test）

Note: "*", "", "***" indicates significant at 10%, 5% and 1% level**

7 variables are selected in China from 2005 to2017.it is important to test whether variables are stationary before estimating the panel kink regression model. Thus, in this study, we apply the Levin-Lin-Chu to test the unit root of each variable. The result of table 2 reveals that all variables reject the null hypothesis that there is a non-stationary data, all panel variables are stationary at 1% so the data can undertake further study on the impact of urbanization and industrial structure on environmental pollution.

Model	1 Regime	2 Regime	3 Regime
pooling	-268.079 (74.630)	-341.628 (47.214)	-338.514 (48.090)
Within	-742.563 (4.5858)	-761.792 (3.998)	-763.794 (3.859)
Random	-691.585 (6.124)	-688.823 (6.079)	-695.433 (5.709)

Table 3：Model Selection AIC

Note: The parentheses ( ) is RSS.

The residual sum of squares (RSS) is a measure of the discrepancy between an estimation model and data. The smallest RSS can be used as an optimality criterion in parameter and model selection. From Table 3, we can see the RSS values of the models pooling, within and random under three different regimes. Among them, the smallest value of RSS is regime3 under the within model which is 3.859.

Giving a collection of three models for the RSS, Akaike information criterion (AIC) estimates the quality of these 3 models. The optimal model is selected according to the value of AIC, where the smaller value of AIC, the better model is chosen. Therefore, the size of the AIC is calculated based on the RSS value in Table 4. From the calculation results in Table 3, it can be seen that the smallest value of AIC is regime3 under the within model is -763.794. Therefore, this paper uses regime3 under the within model to explore the impact of urbanization and industrial structure on environmental pollution.

4.3. Impact of industrial structure and urbanization on environmental pollution

Table 4 shows the impact of the three models on environmental pollution in the urbanization and industrial structure for regime 3. According to the results in Table 3, the Within model is the optimal model in the case of regime3, so here we evaluate the Estimated results of the Within model in regime 3.

Variable	Within	Pooling	Random
$\beta^1_{\ln IS}$	-1.570*** (0.563)	0.773 (0.466)	-1.591* (0.710)
$\beta^2_{\ln IS}$	0.296*** (0.090)	0.349*** (0.150)	-0.894*** (0.180)
$\beta^3_{\ln IS}$	-6.879 (9.728)	-5.4237*** (1.6370)	-0.531 (0.447)
$\gamma^1_{\ln IS}$	-0.198*** (0.009)	-0.067 (0.055)	-0.255** (0.009)
$\gamma^2_{\ln IS}$	-0.017*** (0.002)	-0.095*** (0.007)	-0.215*** (0.005)
$\beta^1_{\ln Ur}$	1.248*** (0.177)	-0.272 (0.199)	0.933*** (0.229)
$\beta^2_{\ln Ur}$	0.005 (0.018)	0.002 (0.035)	-0.024 (0.019)
$\beta^3_{\ln Ur}$	2.206** (1.056)	-1.514*** (0.317)	-0.153 (0.206)
$\gamma^1_{\ln Ur}$	-0.946*** (0.284)	-0.377*** (0.008)	-0.977*** (0.075)
$\gamma^2_{\ln Ur}$	-0.321 (44.251)	-0.777** (0.318)	-0.643*** (0.077)
lnTo	-0.027 (0.020)	0.295*** (0.030)	0.022 (0.022)
LnEI	0.081*** (0.019)	-0.139*** (0.045)	0.047** (0.022)
lnTe	0.123*** (0.008)	0.470*** (0.016)	0.174*** (0.013)

Table4. Estimated results from the Panel kink regression: Three Regime of 3 model
Note: "*", "", "***" indicates significant at 10%, 5% and 1% level**

Table 4 shows the impact of urbanization and industrial structure on environmental pollution for regime3.According to the results in table3, within model is the optimal model in the case of regime3,so we evaluate the estimated results of within model in regime3. (1) Regime 1 represents the region of $\ln IS < \gamma^1_{\ln IS}$ and $\ln Ur < \gamma^1_{\ln Ur}$.(2) Regime 2 represents the region of $\gamma^1_{\ln IS} \le \ln IS \le \gamma^2_{\ln IS}$ and $\gamma^1_{\ln Ur} \le \ln Ur \le \gamma^2_{\ln Ur}$. (3) Regime 3 represents the region of $\ln IS > \gamma^2_{\ln IS}$ and $\ln Ur > \gamma^2_{\ln Ur}$.

It can be concluded from the results that lnIS has negative coefficients in both regime 1 and regime 3, but the coefficients of regime2 are positive and significant. This paper studies the situation of the industrial structure under three different regimes as well, it is divided into two threshold points which are $\gamma^1_{\ln IS} = -0.198$ and $\gamma^1_{\ln IS} = -0.017$ .The coefficients for three different regimes are different, with the largest coefficient being regime2, followed by regime1, and the smallest coefficient being regime 3 is -6.879. The estimated result shows that if lnIS is less than -0.198, it has a significant negative effect on wastewater, a 1% increase in lnIS can contribute to a 1.570% decline in the discharge of wastewater. This is because, in the regime1 stage, the proportion of the secondary and tertiary industries that have a relatively serious impact on the environment is not large. However, if $-0.198 \le \ln IS \le -0.017$, it has a significant positive impact of wastewater, a 1% increase in lnIS can contribute to a 0.296% increase in the discharge of wastewater. At this stage, the proportion of the secondary industry gradually increasing and the number of heavy industries pollute the environment increasing. In particular, the increase in the number of heavy industries has discharged a large amount of wastewater, which has aggravated environmental pollution. if lnIS is larger than-0.017, it has a negative effect on wastewater, a 1% increase in lnIS can contribute to a 6.879% decrease to the discharge of wastewater. In the case of regime3, China attaches great importance to the development of the tertiary industry. Although it has reduced the discharge of wastewater to a certain extent, the development of the tertiary industry in China is mainly concentrated in the service industry and tourism, so the effect on wastewater pollution is not significant. The results show that China's industrial structure is gradually rational, and it can be seen that the optimization of the industrial structure is constantly upgrading, which has a certain effect on improving environmental pollution. Ln Ur contributes a positive impact on waster water in 3 regimes but the effect is significant only in regime 1 and regime 3. Comparing the coefficients of three different regimes of wastewater, the smallest is regime2, the second is regime1, and the largest is regime3 is 2.206.

We find a significant and positive impact of the urbanization on wastewater when lnUr is less than -0.946. An increase of one percentage point in the comprehensive level of urbanization will promote an increase in wastewater discharge by 1.248 percentage points. Under the phase of regime2, if $-0.946 \le \ln Ur \le -0.321$, it has a positive impact of wastewater, a 1% increase in lnUr can contribute to a 0.005% increase to the discharge of wastewater. The result reveals that the positive influence of the urbanization on wastewater after its kink points $\gamma^2_{\ln Ur} = -0.321$.This result means that the increase of urbanization in these three stages will aggravate environmental pollution. The continuous advancement of urbanization has led to the expansion of the city scale and the urban population has skyrocketed. To solve the employment problem of the new urban population, industrial agglomeration becomes more and more serious and worsening industrial pollution has made China's ecological environment worsen continuously. The coefficients of environmental investment and technology are both significant and

have a positive impact on environmental pollution. 1% increase in lnEI can contribute to a 0.081% increase in the discharge of wastewater.Environmental investment has not played a role in restraining environmental pollution, and environmental governance has not been effective enough to achieve the effect of environmental pollution. The main reason is that China executive the measure of "Treatment After Pollution" The amount of investment in environmental pollution treatment is mainly used for the recovery and treatment of pollutants, such as the reuse of industrial wastewater and the recovery and utilization of solid waste. An increase of one percentage point in the comprehensive level of technology will promote an increase in wastewater discharge by 0.123percentage points. China's science and technology are still in the development stage, mainly due to the negative impact caused by excessive dependence on science and technology, which has aggravated environmental pollution. While the improvement of science and technology has improved human life and production efficiency, it has ignored sustainable green development.

Trade openness can restrict environmental pollution, but the impact is not significant. For each percentage point increase in trade openness, the level of environmental pollution will drop by 0.027 percentage points. This conclusion is completely contrary to the "pollution paradise hypothesis" theory, that is, trade opening will not only increase the environmental pollution but will also improve the quality of the environment. This is mainly because the signing of environmental protection-related trade agreements has indirectly promoted the exploitation and utilization of environmentally-friendly technologies in developing countries. At the same time, the technological spillover effect of open trade has also indirectly increased the factor productivity and technological level of developing countries.

V. CONCLUSION

The result of panel kink regression indicates that industrial structure has negative coefficients in both regime 1 and regime 3, but the coefficients of regime2 are positive and significant to environmental pollution. Urbanization in these three stages has exacerbated environmental pollution. The continuous advancement of urbanization has led to the expansion of the city scale and the urban population has skyrocketed. Environmental investment and technology has a negative relationship with environmental pollution, while the trade openness has a positive relationship with pollution. The following recommendations can be made based on the primary estimation results:

(1) In the secondary industry, we must optimize the industrial structure and vigorously develop high-end manufacturing and high-tech industries with low energy consumption. (2) According to the size of the city, it is necessary to construct basic supporting facilities for sewage treatment and living garbage treatment that match the city and develop into a circular and cost-saving city. (3) By increasing investment in science and technology, focusing on improving self-innovation capabilities, speeding up the development and using of clean technologies, replacing traditional technologies with clean technologies gradually.

REFERENCES

[1] Robi Kurniawana, Shunsuke Managi. Coal consumption, urbanization, and trade openness linkage in Indonesia. Energy Policy 121 (2018) 576–583.

[2] Muhammad Shahbaz, Nanthakumar Loganathan, Ahmed Taneem Muzaffar, Khalid Ahmed, Muhammad Ali Jabran. How urbanization affects CO2 emissions in Malaysia? The application of the STIRPAT model. Renewable and Sustainable Energy Reviews 57 (2016) 83–93.

[3] Xilong Yao, Dong Kou, Shuai Shaob, Xiaoyu Li, Wenxi Wang, Chentao Zhang Can urbanization process and carbon emission abatement be harmonious? New evidence from China. Environmental Impact Assessment Review 71 (2018) 70–83.

[4] Wei Zheng, Patrick Paul Walsh. Economic growth, urbanization and energy consumption — A provincial level analysis of China. Energy Economics 80 (2019) 153–162.

[5] Yuping Bai , Xiangzheng Deng , John Gibson, Zhe Zhao, He Xu. How does urbanization affect residential CO2 emissions? An analysis on urban agglomerations of China. Journal of Cleaner Production 209 (2019) 876e885.

[6] zhang dan, Li shuiping（2014). Kuznets curve of urbanization and environmental pollution in Hunan Province. China Academic Journal Electronic Publishing House

[7] Shiwei Yua,, Shuhong Zheng, Xuejiao Zhang, Chengzhu Gonga, Jinhua Cheng. Realizing China's goals on energy saving and pollution reduction: Industrial structure multi-objective optimization approach. Energy Policy 122 (2018) 300–312.

[8] Li Xiaole（2014). Empirical analysis of marketization, industrial agglomeration and environmental pollution. Statistical Research,1002-4565(2014)08-0039-07.

[9] Bai Jiyang (2015). Economic Growth, Urbanization and China's Energy Consumption: An Empirical Study Based on EKC Theory. China Environmental Science 2015,13(6)：580~588.

[10] Li Guozhi, Li Zongzhi (2011). EKC test for the relationship between carbon dioxide emissions and economic growth-comparison of eastern, central and western regions of China. China Environmental Science 2011,29(7)：443-448

[11] Wei Liang, Ming Yang Urbanization, economic growth and environmental pollution: Evidence from China. Sustainable Computing: Informatics and Systems 21 (2019) 1–9

[12] Yang Hao（2018). Research on Threshold Effect of Environmental Management Based on Industrial Structure on Carbon Emissions. Finance Theory and Teaching,1004- 9487（2018）04- 0094- 03.

[13] Culas RJ (2012). REDD and forest transition: tunneling through the Environmental Kuznets curve. Ecol Econ79:44–51.

[14] The N-shaped environmental Kuznets curve: an empirical evaluation using a panel quantile regression approach. Environmental Science and Pollution Research (2018) 25:5848–5861

[15] Zhang hongxu (2012). Study on the Relationship of Economic Growth and Environmental Quality in Hefei:Based on Environmental Kuznets Curve.（Master Thesis,Department of environment and science), Hefei University of Technology.

[16] Lu Yi (2013). Study on EKC Curves of Yunnan Province and Each City. (Master Thesis, Department of Economic) ,Yunnan University of Finance and Economic.

[17] Yonghui Zhang, Qiankun Zhou, Li Jiang. Panel kink regression with unknown threshold. Economic Letter 157 (2017) 116-121.

★★★