Research on the Impact of Economic Growth of the Northeastern Old Industrial Base on Environmental Pollution—Taking Liaoning Province as an Example

Pang Lei (the first author)\textsuperscript{1} *,\textsuperscript{2}

School of Economics & Management, Yunnan Normal University, Kunming, 650500
Email: 160025@ynnu.edu.cn; panglei719@126.com

Abstract. This paper takes the impact of economic growth on environmental pollution in Liaoning Province as the research object. After analyzing the status quo of economic growth and environmental pollution in Liaoning Province, four environmental pollution indicators (industrial wastewater discharge, industrial waste gas emissions, industrial sulfur dioxide emissions, and industrial dust emissions) and an economic growth indicator (per capita GDP) are selected. After an economic model is established to focus on the real impact of Liaoning’s economic growth on environmental pollution, it is found that the impact of Liaoning’s economic growth on environmental pollution does not conform to the traditional Environmental Kuznets Curve. Through analysis, it is concluded that economic growth has affected the four environmental indicators to varying degrees. Among them, industrial wastewater discharge, industrial sulfur dioxide emissions, and industrial dust emissions drop after rising, and industrial dust emissions have been on the rise all the time. Considering the realities and characteristics of Liaoning Province, the author has proposed five countermeasures and suggestions for coordinating the relationship between economic growth and environmental protection in Liaoning Province, which are, optimize the industrial structure to promote economic development in the direction of environmental protection; focus on pollution prevention to take a new road to industrialization of circular economy; tap the full potential of market mechanism to realize the innovation of environmental protection system; actively promote the application of low-carbon energy to increase its proportion in total energy consumption; increase investment in environmental protection to improve investment structure and efficiency of environmental protection.

1. Introduction
With the progress of economic growth and industrialization, resources and environment problems are increasingly severe. The debate on whether economic growth is the cause of environmental problems or the driving force to solve environmental problems has caused a boom in the research on the relationship between economy and environment. The most representative one is the Environmental Kuznets Curve (EKC) hypothesis. However, the current research on EKC is mainly based on economically developed areas, and it fails to reflect the real relationship between economic growth and environmental pollution. Therefore, this paper takes Liaoning province as an example to verify the Environmental Kuznets Curve. Liaoning as the pioneer for the revitalization of northeast China is a representative province of the northeastern old industrial base. This paper takes Liaoning province as an example to analyze the relationship between economic growth and environmental pollution. The purpose is to verify the realization of the Environmental Kuznets Curve hypothesis in provinces of...
developing countries where the level of economic development is not high and the economic and environmental contradictions are prominent. At the same time, it aims to determine which environmental indicators are affected by the economic growth of Liaoning Province and the degree of impact.

Since the reform and opening up, China’s economy has experienced a stage of sustained rapid growth. However, rapid economic growth inevitably intensifies the consumption of resources and piles pressure on environmental protection. Thus the contradiction between economic growth and environmental pollution has become increasingly prominent. Therefore, this paper, by exploring the relationship between economic growth and environmental pollution in Liaoning province, has found out the suggestions to promote the economic development in the direction of environmental protection, focus on pollution prevention to take a new road to industrialization of circular economy, tap the full potential of market mechanism to realize the innovation of environmental protection system, actively promote the application of low-carbon energy to increase its proportion in total energy consumption, increase investment in environmental protection to improve investment structure and efficiency of environmental protection and promote the coordinated development of economy and environment in Liaoning province.

2. Theoretical Foundation

2.1. System Theory of Environmental Economics

The system of environmental economics is a combination of environmental system and economic system. These two systems interact and interrelate with each other through exchanges of materials, energy and information. The environmental system serves as the material basis for the economic system, and provides resources and energy for the human production and life. It is the resource pool for human beings. At the same time, the environmental system receives waste from the economic system and serves as waste disposal sites for humans, namely the so-called sinking service. The economic system is the product of the environmental system, and the product when humans take advantage of and transform the natural environment for survival. However, economic growth has posed negative impacts on environmental quality in two ways: on the one hand, economic growth requires increased investment, which in turn increases the use of resources; on the other hand, increasing output also raises pollution emissions. Buoyant economic growth is closely related to technologies of environmental protection and high efficiency. Therefore, during the process of a country’s economic growth, R&D expenditure should be increased at the same time to promote technological progress, which may lead to two results: one is that when other things remain constant, technological progress increases productivity, improves the efficiency of resources, decreases the factor inputs per unit of output and reduces the impact of production on nature and the environment; second, clean technologies which continue to be developed and replace dirty technologies, effectively recycle resources, and reduce pollution emissions per unit of output.

2.2. Environmental Kuznets Curve

In 1991, considering that Americans worried that free trade would worsen the environment of Mexico and impact the local environment of the United States in the North American Free Trade Area negotiation, the American economist Grossman for the first time studied through empirical research the relationship between environmental quality and per capita income, and pointed out that the relationship between pollution and per capita income is “pollution rises with the increase of GDP per capita at low levels of income, and decreases with GDP growth at high levels of income.” The World Bank’s World Development Report themed with “development and the environment” has extended the influence of research on the relationship between environmental quality and income. Kuznets defines the relationship between per capita income and income inequality as an inverted U-shaped curve which for the first time is used to describe the relationship between environmental quality and per capita income and is called Environmental Kuznets Curve (EKC). EKC reveals that at the beginning
environmental quality decreases as income increases. After the levels of income rose to a certain level, it improves as income increases, that is, the relationship between environmental quality and income presents an inverted U-shaped curve.

3. Statistical Analysis

The author presents the statistical data of per capita GDP and various pollutant emissions (including industrial wastewater discharge, industrial waste gas emissions, industrial sulfur dioxide emissions and industrial dust emissions) in Liaoning province over the years, as shown in the following table:

Table 1 Per capita GDP and various pollutant emissions in Liaoning Province from 2000 to 2019

| Year | Industrial wastewater discharge (10,000 tons) | Industrial waste gas emissions (100 million SCM) | Industrial sulfur dioxide emissions (10,000 tons) | Industrial dust emissions (10,000 tons) | per capita GDP (yuan) |
|------|---------------------------------------------|-----------------------------------------------|-----------------------------------------------|----------------------------------------|---------------------|
|      |                                             |                                               |                                               |                                        |                     |

Source: China Statistical Yearbooks Database

Over the past 20 years, the industrial wastewater discharge has continuously declined from 1,637.14 million tons in 2000 to 1,090.44 million tons in 2010, and then fluctuated, but the overall trend is downward. In 2019, it fell to the historic low of 751.59 million tons. The total industrial waste gas emissions have generally maintained a growth trend, rising from the historic low of 783 billion standard cubic meters in 2001 to the all-time high of 4,021.9 billion standard cubic meters in 2018, an increase of 4.14 times. Although there was a decline in 2019, it exceeded 100 million tons since 2011. The industrial sulfur dioxide emission has fluctuated greatly. It has a gradual downward trend from 2000 to 2019, and an upward trend annually from 2012 to 2018. Although industrial dust emissions fluctuate to varying degrees, the overall trend is downward, from 1,051 million tons in 2000 to the historic low of 390,000 tons in 2014. Despite a sudden increase from 573,000 tons in 2007 to 751,000 tons in 2008, it has shown a decreasing trend in slight fluctuations since 2009.

With the development of economy, the environment is also experiencing changes. The total industrial wastewater discharge and industrial dust emissions are decreasing, the total industrial waste gas emission is increasing, and the industrial sulfur dioxide emission rises after declining progressively. Generally speaking, the realities of environment development are varied. The relationship between economic growth and environmental pollution needs to be further studied.

Meanwhile, based on the above-mentioned statistical data, the author concludes through regression analysis that since the environmental pollution indicators selected are limited, the regression curve of the impact of Liaoning province’s per capita GDP on environmental pollution indicators is in an inverted N shape, U shape and continuous decline in fluctuations, and no evidence is found to prove that the impact of Liaoning province’s per capita GDP on environmental pollution indicators is an inverted U-shaped EKC. Thus it is sufficient to show that the impact of Liaoning province’s economic growth on environmental pollution does not completely conform to the traditional Environmental Kuznets Curve. The general analysis of the impact of economic growth on environmental pollution in Liaoning Province is as follows:

Table 2 General analysis of the impact of economic growth on environmental pollution in Liaoning Province

| Environmental pollution indicators | The model selected | Curve type | Curve trend |
|-----------------------------------|--------------------|------------|------------|
| Industrial wastewater discharge   | Cubic              | Inverted N-type | Down, up and down |
| Industrial waste gas emissions    | Cubic              | U-type     | Up         |
| Industrial sulfur dioxide emissions| Cubic              | Inverted N-type | Down, up and down |
| Industrial dust emissions         | Logarith            | Decrease progressively | Down |
At present, the regression curve between the total industrial waste gas emissions, an environmental pollution indicator and per capita GDP presents an upward trend, indicating that this indicator may be worse. The regression curves between per capita GDP and industrial wastewater discharge, industrial sulfur dioxide emissions and industrial dust emissions all show a trend of downward after upward, indicating that it may get better.

The established form of the Environmental Kuznets Curve (EKC) reflects the economic, political and technical conditions in a particular time period, which is not static, but a dynamic process. In different countries or regions, EKC has different forms of expression, different turning points, and time spans to reach turning points. Although EKC theory indicates that economic growth will ultimately improve environmental quality, the environmental quality does not improve automatically with the increase of levels of income. The negative correlation between income growth and environmental degradation is actually achieved through policy responses. In addition to income levels, environmental quality in Liaoning province is also affected by factors such as national or regional environmental policies, industrial structure, and the process of industrialization.

4. Countermeasures & Suggestions
Liaoning province is still in the intermediate stage of industrialization, and it is its primary task to promote the process of industrialization and increase income currently. Although the importance and urgency of environmental protection in Liaoning province have long been recognized, developing industrial economy always comes before protecting the environment. The environmental pollution of Liaoning province is getting worse, and there is no evidence showing that Hubei has the phenomenon conforming to Environmental Kuznets Curve. Economic growth will not improve the environment automatically. The Environmental Kuznets Curve can only be achieved through policy responses. Without policy intervention, environmental quality cannot be automatically improved with economic growth. In order to promote the coordinated development economy and environment in Liaoning province, the following suggestions are now put forward: first, optimize the industrial structure to promote economic development in the direction that contributes to the ecological environment. Second, focus on pollution prevention to take a new road to industrialization of circular economy. Pollution prevention is more cost-saving than pollution control. Third, actively promote the application of low-carbon energy to increase its proportion in total energy consumption. Low carbon energy is clean energy that is highly efficient, renewable, and sustainable. Fourth, increase investment in environmental protection to improve investment structure and efficiency of environmental protection.

Author
Pang Lei, male, (1987-), associate professor of School of Economics and Management of Yunnan Normal University, engaged in research on world economy and technological innovation.

References
[1] Ma Yanjun, Cui Jinsong, Liu Xiaomei, et al. Analysis on Variation Characteristics of Atmospheric Pollutant in a Group of Cities in Central Liaoning from 1987 to 2002. Plateau Meteorology. 2007, 24 (3), 428-435.
[2] Du Qiugen. Research on the Sustainable Development Strategy for Environmental Protection in Liaoning Province. Beijing: Science Press. 2004: 202-215.
[3] Zhang Meng, Lin Lin, Zhang Ziyi. Characteristics of Air Pollution and its Countermeasure Changchun, China. Journal of Meteorology and Environment. 2009, 25 (3): 57-61.
[4] Buckley. The Future of the Multinational Enterprise[M]. Holmes and Melers, 1976.
[5] Tsui, Auch, LS.International production relationships and developmental impacts. International Journal of Urban & Regional Research1999, 23(2): 345-359.
[6] J Cantwell. Technological globalization and innovation caners: the role of technological leadership and location hierarchy [J]. Research Policy, 1999, 28(7): 119–144.
[7] Jeffrey Henderson, Peter Dicken, Martin Hess, Global production networks and the analysis of economic development[J]. Review of International Political Economy 9:3 August 2002: 436-464.

[8] Bruce A. Blonigen, A Review Of The Empirical Literature On FDI Determinants. NBER Working Paper No 11299, 2005.

[9] Alder, M., B. Dumas, 1983, “International portfolio choice and corporation finance: A synthesis”, Journal of Finance, 38 (3): 925-984.

[10] Elhanan Helpman, Trade, FDI, And The Organization Of Firms. NBER Working Paper No 12091, 2006.