Water Pollution and Economic Growth

in Western China

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⟨Contents⟩

Ⅰ. Introduction

Western China, which has mountains, hills and plateaus more than 90% of its land area, including Tibetan Plateau known as the "roof of the world",

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is the backbone of the Eurasian Continent and also the upriver region of Eastern China. It has 355 million population accounts for 28% and its land area for 71% of China's total, while the region's share of the national GDP fewer than 20% in the last two decades. China's western inland region has largely been left out of the nation's economic boom, and poverty and environmental degradation are common in Western China. Therefore, the government has implemented the West Development Strategy since 1999 to boost the region's growth and prevent the environmental degradation, for harmonious development coordinated with Eastern and Western China, economy and environment.

The Western China has become a new hotspot of development and investment since the West Development Strategy implementation. The economic growth and living standard has improved greatly. Meanwhile, the ecological environment in Western China becomes weak and deteriorative. As the upper reaches of Yangtze River, Yellow River and Lancang River, water pollution-especially industrial wastewater pollution is not only aggravates the degradation of the water quality, but also influences the residents' lives in the western China. So the State Council declares that the ecological environment partly improved while the total deteriorative trend stayed and the pressure of water shortage increased in *Some Opinions of Further Improving Western Development* by the State Council.

In this paper we set 12 provinces as research objects including Chongqing, Sichuan, Shanxi, Ningxia, Gansu, Guangxi, Qinghai, Guizhou, Tibet, Yunnan, Xinjiang and Inner Mongolia. Then we chose two indexes – GDP per capita and the Volume of Industrial Waste Water Discharge-to analyze the relationship of industrial waste water condition and economic indexes per capita in those 12 provinces and cities. Through this we try

to find out the problems in harmonious development of economic growth and environmental protection in Western Development.

Ⅱ. Western Economic Growth and Water Pollution

Since the implement of Western Development Stratagem, the Western economic growth has increased rapidly and the growth rate has gradually chased the domestic level. According to the General Programming Group in Western Development office, the GDP of Western China increased 8.5%, 8.8%, 10.0%, 11.2% and 12.7% respectively during the year 2000 to 2004 with a 10.2% annual increase averagely in five years. The GDP increasing rate in Western China is 0.7% less than that of other area with same calculated standard in China compared with 2.8% in the Eighth Five-Year Plans and 1.3% in Ninth Five-Year Plans.

However, the economic growth in Western China mainly depends on the energy and mineral resources too much, and exploration of these resources is in a wasteful mode. These two reasons made great pressure to the weak ecological environment in Western China. Environmental statistic data in 2004 showed that the Volume of Industrial Waste Water Discharge in Western China was 22.1% of the whole country, while the Percentage of Industrial Waste Water Meeting Discharge Standards was only 83.2%. According to the data on *China Environmental Quality Gazette 2004*, The water quality of the trans-boundary of Yangtze River at the borderline of Sichuan-Chongqing and Gansu-Sichuan deteriorated to Grade Ⅳ

from Grade II, III that shown in 2003. There were 2 trans-boundaries which water quality fell into Grade below IV compared with one in 2003.

The National Survey of Domestic Water Resource shows that the northwestern region of China lacks 5 billion ton water every year at leas. Water pollution, especially the industrial pollution will increase the shortage of clean water resources in Western China.

III. Econometrics Model on Economic Growth and Water Pollution

1. Environmental Kuznets Curve and its Further Model

The Environmental Kuznets Curve (EKC) has been proved by many statistic analysis and fieldworks in developed countries and new industrialized countries. In China, there are also many researches in these years which not only prove the EKC but also constitute different further models according to diverse area situation in China. Considering the fluctuant effects the further model changes the quadratic equation into cubic to reflect the mode which adopted by government to avoid the "Pollution First and Control Afterwards" mode more correctly.

2. Index and Data Select

In this paper we collected 12 provinces' data of GDP per capita

calculated by 1978 comparable price and regional Volume of Industrial Waste Water Discharge from 1989 to 2004. A special situation happened that Chongqing became a city directly under the jurisdiction of central government since 1997 but we collected data from the year 1989. In order to keep the same calculative standard, Chongqing city was calculated into Sichuan Province so there are only 11 provinces in this paper. The data mainly collected from regional statistic yearbook, *China Statistic Yearbook* and *China Environment Yearbook*. The max possible error of the data proved to be less than 6%.

3. Regression Equation

Tests show that, the correlations between the volume of industrial wastewater discharge and GDP per capita are rejected in Sichuan and Xinjiang Province at 10% significance level, while in other GDP per capita provinces are not. Make the volume of industrial wastewater discharge dependent variable, GDP per capita independent point. From the scatter graph we can find these provinces have different wave styles, so the regression model chosen in the paper is cubic, as equation (1).

$$Y_t = \beta_1 X^3_{i,t} + \beta_2 X^2_{i,t} + \beta_3 X_{i,t} + \beta_4 \qquad (1)$$

Y : the volume of industrial wastewater discharge

X : GDP per capita

i : denotes province

t : denotes time

β : parameter
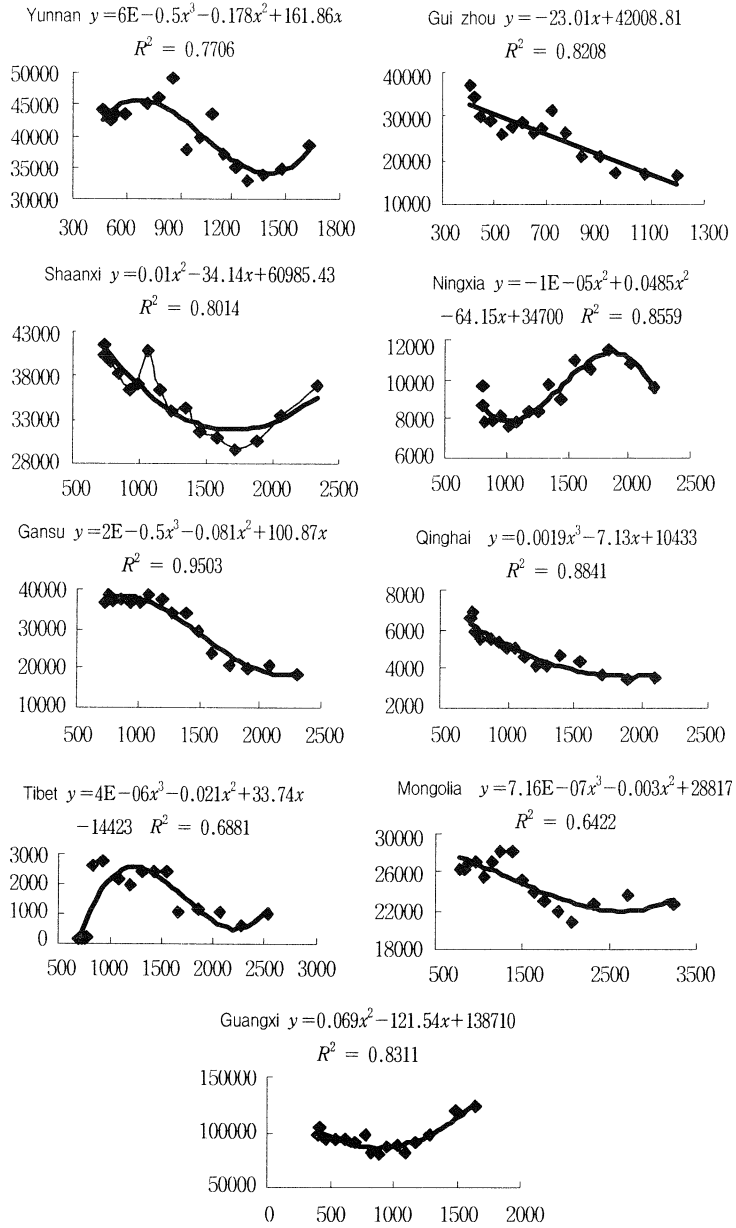
4. Results and Discussion

The results show in <Table 1>. To set adjusted R^2 is 0.5, the results of Sichuan and Xinjiang are not acceptable, which are in accord with former correlation tests. Three form of regression model in the other 9 provinces: linearity (Guizhou), quadratic model (Shaanxi, Qinghai and

<Table 1> Regression Results of Industrial Wastewater Discharge and GDP Per Capita

Provinces	Parameter Estimation				Adjusted R^2
	β_1	β_2	β_3	β_4	
Sichuan	−636.85***	−0.438***	−8.99E−05**	450376.8***	0.48
Yunnan	161.86***	0.178***	5.72E−05***	−	0.74
Guizhou	−23.01***	−	−	42007.81***	0.81
Shaanxi	−34.14***	0.010***	−	60985.43***	0.77
Ningxia	−64.16***	0.049***	−1.12E−05***	34699.68***	0.82
Gansu	100.89***	−0.080***	1.76E−05***	−	0.94
Qinghai	−7.13***	0.0019***	−	10433.45***	0.87
Xinjiang	34.21***	−0.021***	4.07E−06***	−	0.28
Tibet	33.74***	−0.021***	4.10E−06***	−14422.86***	0.61
Inner Mongolia	−	−0.003***	7.16E−07**	28816.58***	0.59
Guangxi	−121.54***	0.069***	−	138710.1***	0.80

Note : *, **, *** denotes 1%, 5%, 10% significance level;−denotes coefficient is no significance and is excluded; value of F are of significance in all regression model.

⟨Figure 1⟩ Fitted Curve of Industrial Wastewater Discharge in Relation to GDP Per Capita in the West

Yunnan $y=6E-0.5x^3-0.178x^2+161.86x$
$R^2 = 0.7706$

Gui zhou $y=-23.01x+42008.81$
$R^2 = 0.8208$

Shaanxi $y=0.01x^2-34.14x+60985.43$
$R^2 = 0.8014$

Ningxia $y=-1E-05x^2+0.0485x^2$
$-64.15x+34700$ $R^2 = 0.8559$

Gansu $y=2E-0.5x^3-0.081x^2+100.87x$
$R^2 = 0.9503$

Qinghai $y=0.0019x^3-7.13x+10433$
$R^2 = 0.8841$

Tibet $y=4E-06x^3-0.021x^2+33.74x$
-14423 $R^2 = 0.6881$

Mongolia $y=7.16E-07x^3-0.003x^2+28817$
$R^2 = 0.6422$

Guangxi $y=0.069x^2-121.54x+138710$
$R^2 = 0.8311$

Guangxi), cubic model (Yunnan, Ningxia, Gansu, Tibet and Inner Mongolia). They indicate different development modes exit in the relationship between the GDP per capita and industrial wastewater discharge. Meanwhile, development gap among these provinces may cause the difference, and small time dimension may also be a reason.

The results of regression are shown in figure1, abscissa denotes GDP per capita (RMB, 1978 price), and ordinate denotes industrial wastewater discharge (10,000 ton). No adjustment of R^2 in figure, so the value is slightly higher than it is in <Table 1>.

The relationship between the GDP per capita and industrial wastewater discharge could be reflected in <Figure 1>. Generally speaking, there are two kinds of relationships between industrial wastewater discharge and GDP per capita-downward and upward.

In the downward category are Yunnan, Guizhou, Gansu, Qinghai, Tibet and Inner Mongolia; and Yunnan, Guizhou, Tibet and Inner Mongolia have experienced the max/min value of industrial wastewater discharge which have still maintained lower level by now.

In the upward category are Shaanxi, Ningxia and Guangxi; there are "U" curves in Shaanxi and Guangxi, where the volume of industrial wastewater discharge is increasing after experienced the lowest value; while Ningxia is in the double peak mode, and its volume of industrial wastewater discharge has fallen followed the maximum value. One reason for it is the heavy industry in these provinces, and the other is that they are in the upper or middle reaches of some great rivers and have abundant water passing through. The rivers dilute the local water pollution, and on the other hand, bring the pollutants to the lower reaches.

〈Table 2〉 GDP Per Capita Corresponding to the Extremum
of Industrial Wastewater Discharge

(Unit : yuan)

Trend	Province	GDP Per Capita Corresponding to Peaks	
Downward	Yunnan	670 (↑)	1400 (↓)
	Tibet	1250 (↑)	2250 (↓)
	Gansu	900 (↑)	2140 (↓)
	Inner Mongolia	0 (↑)	2800 (↓)
	Qinghai		1880 (↓)
Upward	Ningxia	1020 (↓)	1860 (↑)
	Shaanxi	1710 (↓)	
	Guangxi	880 (↓)	

Note : (↑) or (↓) means the trend followed the extremum; the value of 0 for Inner
Mongolia is excluded from the analysis.

In the calculation of GDP per capita corresponding to the turning
points, it's found that provincial economic difference may bring some
departure of the value. Details are in <Table 2>. It's mainly at 1000 and
2000 yuan per capita for the turning points of Tibet, Gansu, Qinghai,
Ningxia and Guangxi; while for Yunnan it's lower probably because
Yunnan has the lowest GDP per capita in the eight provinces and the
higher value for Inner Mongolia probably because it has the highest GDP
per capita in recent years. The illustration may also prove that EKC is
just a representation of given span; when the span expanded, the style
and turning point we now obtain may be no longer the style and turning
point we will get.

5. Comparison with Other Regions in China

According to other researches, such as Manhong SHEN (2000) found the discharge of industrial wastewater in Zhejiang from 1981 to 1998 had a "N" style of the GDP per capita and the turning points were respectively about 3,000 and 8,000 yuan per capita; Liu (2005) and Gao (2004) found both Guangdong and Jiangsu have not achieved the peak value of industrial wastewater discharge; Liu (2003) considered the relationship of industrial wastewater discharge and GDP per capita in Wuhan City has a reverse "N" shape, and the turning point would occur at 12,000 yuan per capita in 2009; Li (2002) compared the EKCs among the East, Middle and West of China and came to the conclusion that the turning point in the west would be obviously later than those in the East and Middle of China, we believe that the discharge of industrial wastewater in the West will has a increase trend in the long term.

Though many understand the EKC as the environmental situation will be promoted with the economic growth after the peak, the lack of awareness and governance will probably lead to irreversible damage to the environment. And whats more important, as the upper reaches of Yangtze River, Yellow River and Lancang River, water pollution is not only aggravates the environmental degradation of the West, but also influences the water security of the Middle and East of China.

Ⅳ. Conclusions

The authors analyzed the relationship between the GDP per capita and industrial wastewater discharge by EKC in the western provinces, China. The results of regression model validated the EKC and its expanded model basically. With the rapid economic development in the process of western China development, there are two trends in industrial wastewater discharge-increasing and falling. And most of western provinces' industrial wastewater discharge have fallen observably, which maybe benefited by a series of environmental protection policies implementation a coupled with process of western development.

With the rapid economic development in the process of western China development, western China will face increasing environmental pressure. To achieve a harmonious development between economic growth and environmental protection, the central and local government should adopt integrated policies to cease the environmental pressure. Firstly, it should be increasing environmental investment, reinforcing environmental protection infrastructure, and making environmental protection as a long-term project. Secondly, the central and local should change the traditional development pattern, which is characteristic of high consumption of resources and energy, wasteful processing operations, low benefits and serious pollution, strengthen environmental management and improve industrial structure, enforce circular economy and cleaner production, to achieve win-win goal.

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Water Pollution and Economic Growth in Western China

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Chinese government has implemented the West Development Strategy since 1999 to boost the region's growth and prevent the environmental degradation. Until now, the regional economy and living standard in Western China have been greatly improved, while it also indicated by the State Council that the ecological environment still deteriorated with part improvement, and pressure of water shortage increased. The paper focus on the relationship of GDP per capita and the volume of industrial waste water discharge of all the 12 provinces in Western China from 1989 to 2004, by the expanded EKC model in the cubic form. Results show that they mainly have down trend in the whole sample space but small up trend in the recent years. That means controlling of industrial wastewater discharge is still an important task to be insisted in the Western China.

Keywords : Western China, water pollution, economic growth,
           industrial wastewater discharge, Environmental Kuznets Curve