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The Impact of Environmental Regulation on High Energy-consuming Enterprises Competitiveness in Zhejiang Province

Based on Heavy Chemical, Medicine, Chemical Fiber, Plastics Industry Data Research

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***Abstract*—The output value of high energy-consuming industries is the main source of economic growth in various provinces. The economic growth of high-energy-consuming industries is slowing down under environmental regulations. Appropriate relaxation of environmental regulations by the government can significantly increase the output of high-energy-consuming industries in the region and accelerate economic growth. At the same time, the government faces the dilemma of environmental pollution. This paper studies the impact of environmental regulation on the competitiveness of high-energy-consuming industries in Zhejiang Province under low-carbon economy based on the panel data of high energy-consuming industries in Zhejiang Province from 2012 to 2016. It focuses on the research of heavy chemical, pharmaceutical, chemical fiber, and plastic industries. The relationship between the treatment of pollutant emissions and economic growth shows that environmental regulation can inhibit pollution, but there are differences in the effects of different industries and different pollutants. The discharge of pollutants is positively related to economic growth. The relationship proposes countermeasures for the differential regulation of pollutants produced by different industries.**

Keywords—low carbon economy; environmental regulation; high energy-consuming industry; pollution control; industrial competitiveness

I. INTRODUCTION

The National 13th Five-Year Plan outlines the goal of improving the overall quality of the ecological environment and achieves green ecological and lifestyle, a higher level low carbon. The efficiency of energy resources development and utilization has been greatly improved, energy and water consumption, construction land and carbon emissions have been effectively controlled, and the total discharge of major pollutants has been greatly reduced. The period of "13th Five-Year Plan" is the stage of decisive completion of a well-off society. At this stage, the development environment and conditions in China and western countries have undergone new profound changes, and economic development has entered a new normal state. The environmental protection objectives have initially achieved the expected results under the strict conditions of comprehensive environmental regulation. The output value of high-energy-consuming industries is the main source of economy growth in many provinces. Due to the pressure of competition between the local governments for economic and environmental protection, the economic standards adopt the standards of benchmark, and their environmental standards are more consistent with the bottom line standards of their neighboring provinces. Because environmental pollution is not a regional problem, it needs to be dealt with jointly to achieve significant results. The stricter the environmental protection regulation carries, the more obvious the inhibition of economic growth turns. The increase the cost of pollution control also increases the cost burden of enterprises. In 2018, the economic situation is very severe, and the economic benefits of enterprises are declining. They are faced with the situation of shutting down and turning to bankruptcy, and thus they are even more powerless for pollution control. Premier Li Keqiang pointed out in the 2019 government work report "China's development environment is more complicated, difficult and challenging in this year. The downward pressure on the economy is mounting, and the government faces arduous work."

In this context, this project uses the panel data of the four high-energy-consuming industries of heavy chemical, pharmaceutical, chemical fiber and plastic in Zhejiang Province from 2012 to 2016. It uses the econometric method

and the Spss12.0 software to analysis the relationship between environmental regulation and economic growth under different environmental regulations in different high-energy-consuming industries. This paper has further revealed the interrelationship between pollution emissions and economic growth of high-energy-consuming industries in Zhejiang Province. The study found that structural adjustment measures can be implemented across the board under the premise of environmental regulation. How to achieve environmental protection while promoting economic growth is the purpose of this paper.

II. LITERATURE REVIEW

A. Research Status in China and Western Countries

Traditional economic theory holds that strict environmental regulation will lead to a decline in industrial competitiveness, because the social benefits generated by environmental regulation will inevitably increase the private cost of enterprises and reduce their competitiveness. It means that excessive economic costs will hinder enterprises. The growth of productivity affects its competitiveness in the international market.

Michael ·Porter (1991) first proposed a different point of view that companies should abandon the "near-sighted idea that environmental regulation will inevitably lead to increased costs". It believes that environmental regulation will not only cause the increase in corporate costs, but also brings technological innovations. These innovations can partially or completely offset the cost of environmental regulations for companies (Porter and Linde, 1995) which makes companies more competitive. This view is called Porter hypothesis.

Portney (1994), Jaffe (1995) and other scholars insist that new environmental regulations will always bring some costs to the enterprise, and these costs will be offset by the social benefits of reducing pollution.

Some scholars have tested the relationship between environmental regulation and industrial competitiveness. A study researched by Brannlund (1995) and other scholars in the Swedish which takes pulp and paper industry as examples shows that strict environmental regulations can lead to a decline in corporate competitiveness. Gray and Shadbegian (1995) researched on pulp and paper, petroleum refining and steelmaking in the United States showed that there is a negative correlation between regulated corporate pollution control costs and productivity. The improvement of environmental performance does not bring enough benefits for enterprises to cover their costs up for the cost of its benefits.

Simpson & Bradford (1996) and Ulph (1996) theoretically prove that in the case of only one company in each of the two countries, the new regulations can not only improve the environmental quality, but also increase the profits of enterprises, which mainly come from tapping the market potential.

Local governments have competition in the field of environmental regulation (Fredriksson & Milimet, 2002; Levinson, 2003; Woods, 2006). These studies are based primarily on two assumptions. First, there is a spillover effect between pollution in the region. It means that the pollution has the characteristics of free flow across regions, such as cross-regional pollution of the atmosphere and water resources. This shows that even if a region increases its investment in public goods of environmental pollution control, the environmental quality of the region will not necessarily be improved due to the spillover effect of pollutants in the neighboring regions (Anselin, 2001). Therefore, the optimal strategy of local governments is to take competitions to reduce their investment in environmental protection, use limited resources in the field of industrial economic development, and let neighboring governments share the losses caused by environmental pollution. In recent years, Chinese scholars have also conducted tentative research on this issue.

As for the impact of environmental regulation on industrial development, Wang Yanli and Zhong Ao (2016) explored the study of local government competition, environmental regulation, and high energy-consuming industry relations. Zhong Maochu (2015) and other scholars discussed the impact of environmental regulation on the evolution of industrial space. The research conclusions verified the "pollution paradise hypothesis" and the effect of government environmental regulation was greater than that of non-government environmental regulation. Some studies have also shown that environmental regulation can promote inter-regional industrial transfer in China, but the promotion of industrial upgrading is not obvious.

The inverted U-shaped relationship between economic development and environmental quality is the focus of scholars in China and western countries. The collaborative treatment of smog pollution areas and the introduction of pollutant standards Liu Huajun (2019) have derived from the industrial development and environmental quality turns into an inverted U-shaped relationship.

B. Evaluation of Related Literatures

An empirical study of whether Potter's hypothesis is validated begins in the United States. Whether the impact of environmental regulation on industrial competitiveness is positive or negative has become a hot topic in current academic circles. Chinese scholars have also done some verification in recent years, but there is no conclusion. The conclusions of the study can be roughly divided into three cases: First, the traditional view has been partially confirmed, and environmental regulation has led to a certain degree of decline in industrial competitiveness, resulting in negative effects; second, there is a "Porter hypothesis" positive correlation among environmental regulation and enterprise technological innovation and enhance industrial competitiveness; third, the impact of environmental regulation on industrial competitiveness is uncertain.

The research in China mainly focuses on the national provincial panel data, the eastern, central or individual

enterprises to establish an econometric model for empirical research. There is no empirical analysis of single-column data in Zhejiang Province, especially the competitiveness of high-energy-consuming industries under low-carbon pressure. The impact has not been fully justified. The output value of high energy-consuming industries is the main source of economic growth in Zhejiang Province. Zhejiang Province is also facing the pressure of low-carbon demand while maintaining economic growth under the background of low-carbon economy. Therefore, the research on this topic will be helpful in environmental regulation. Considering of the impact on economic growth to choose whether to relax or strictly control in the process of implementing the policy.

III. THE RESEARCH CONTENT DESIGN

A. Data Sources

This topic is based on the panel data of the high energy-consuming industry in Zhejiang Province from 2012 to 2016. The data comes from China Statistical Yearbook, China Industrial Statistical Yearbook, China Environmental Statistics Yearbook, Zhejiang Statistical Yearbook and "Zhejiang Natural Resources and Environment Statistical Yearbook". It has comprehensively calculated and compiled, focusing on the data of heavy chemical, pharmaceutical, chemical fiber, plastics industry. Econometric method is used to analyze the mechanism and possible influence of environmental regulation on the competitiveness of energy-consuming industries through technological innovation.

B. Establishment of Environmental Regulation Evaluation Index System

1) Studying the technological innovation of high energy-consuming industrial enterprises R&D and industrial output value: It's necessary to select enterprise R&D expenditure as an evaluation index of technological innovation.

- The cost of technological innovation of enterprises research and development expenditure (R&D) among them: The capital investment is the basis for technological innovation activities, and the level of technological innovation must be improved rapidly, so it must have strong capital investment for protection. Therefore, R&D expenditure is an important indicator of the level of technology innovation.
- Gross outputs: The total industrial output value of high energy-consuming industries under environmental regulations.

2) Studying the impact of environmental protection on the competitiveness of high-energy-consuming industries in Zhejiang Province under environmental regulations: Studying the relationship between environmental protection investment, environmental regulation intensity E and enterprise production output T. Using the technological innovation output function T= f (E, G) to measure the technological innovation output is affected by environmental regulation and industrial output value G. Among them, the intensity of environmental regulation (E): For the evaluation of Environmental Regulation Intensity, this paper uses the pollution control facility operating cost, it means the per thousand industrial output value pollution control cost is taken as the evaluation index of environmental regulation intensity. Environmental investment is I (investment), pollution emissions are D (discharge).

T= f (E, G) Formula (a)

Environmental Investment = Pollution Control Cost + T (output) Industrial Gross Output Value Formula (b)

Industrial output value T (output) = Gross Output Industrial output value + pollution discharge Discharge, Formula (c)

3) The impact of studying the relationship between pollutant discharge and industrial output value: This paper selects pollutant emissions as exhaust gas, sulfur dioxide, wastewater, and solid waste as representatives of environmental pollutants. The greater the proportion of pollution control costs is, the smaller the proportion of industrial output and the smaller the emissions are.

IV. DATA ANALYSIS AND EMPIRICAL RESULTS

A. Analysis of the Relationship Between Technological Innovation and Industrial Output Value

The data are the R&D expenditure of Zhejiang Province from 2012 to 2016, which represents the investment of technological innovation of enterprises. (As shown in "Table I") It is based on the regression analysis of the contribution of R&D expenditure to the total output value.

TABLE I. COMPARISON OF R&D EXPENDITURE AND TOTAL OUTPUT VALUE OF ZHEJIANG PROVINCE IN 2012-2016 UNIT: 10,000 YUAN

Years	R&D expenditure	Gross output value	Environmental protection investment / total output value (%)
2012	7225900	347391300	2.08%
2013	8172700	377565800	2.16%
2014	9078500	401730300	2.26%
2015	10111800	428864900	2.36%
2016	11306300	472513600	2.39%

[a.] Note: Data Source 2013-2017 *Zhejiang Statistical Yearbook and Zhejiang Natural Resources and Environment Statistical Yearbook*

B. Zhejiang Environmental Protection Investment (2012-2016), Analysis of the Relationship Between the Intensity of Environmental Protection Investment and Total Output Value

As shown in "Table II", the greater the environmental regulation intensity of the region for high-energy-consuming industries is the greater investment in environmental protection and the greater the rate of treatment of environmental pollutants or the rate of compliance with standards are. The higher the environmental cost payment rate is, the greater the environmental regulation intensity of

the high energy-consuming industries in the region and the lower the total industrial output value are.

TABLE II. COMPARISON OF ENVIRONMENTAL PROTECTION INVESTMENT AND TOTAL OUTPUT VALUE OF ZHEJIANG PROVINCE IN 2012-2016 UNIT: 10,000 YUAN

Years	Environmental investment	Gross output value	Environmental protection investment / total output value (%)
2012	1349000	347391300	0.39%
2013	1762447.6	377565800	0.47%
2014	2318539.7	401730300	0.58%
2015	2409762.2	428864900	0.56%
2016	4480932.4	472513600	472513600

a. Note: Data Source 2013-2017 *Zhejiang Statistical Yearbook and Zhejiang Natural Resources and Environment Statistical Yearbook*

TABLE III. REGRESSION ANALYSIS OF ZHEJIANG R&D, ENVIRONMENTAL PROTECTION INVESTMENT AND TOTAL OUTPUT VALUE IN 2012-2016

	Multiple R	R Square	Correlation
R&D	0.997971103	0.995946322	Highly positive correlation
Environmental Investment	0.944689881	0.892438972	Highly positive correlation

As shown in "Table I", "Table II", and "Table III ", the improvement of technological innovation and increase of environmental protection investment in Zhejiang Province are highly correlated with the increase of Zhejiang's industrial output value, which has obvious promotion effect.

C. Analysis of the Relationship Between Pollution Emissions and Industrial Output Value of High Energy-consuming Industries

1) Environmental pollution index: Waste water, waste gas and solid waste discharge are the main sources of environmental pollution in China, and they are also commonly used indicators to measure environmental pollution (Liu Huajun 2019). Therefore, the selection of environmental pollution indicators mainly includes wastewater discharge, exhaust emissions and solid waste discharge. Among them, the discharge of urban industrial wastewater by waste water discharge indicates that the exhaust gas emissions are characterized by the emission of industrial sulfur dioxide and the industrial waste of solid waste discharge emissions are characterized and sulfur dioxide is listed separately.

2) Classification of four different types of heavy chemical, pharmaceutical, chemical fiber and plastic

a) Heavy chemical: Using the regression analysis of the data of each pollution discharge and total output value, the relationship between pollutant emissions and total industrial output value is a positive correlation with a promotion effect, and vice versa. And the regression analysis was carried out for the relationship among wastewater, waste gas (non-SO_2), solid waste discharge, SO_2 emissions and industrial output value. (See "Table IV "and "Table V")

TABLE IV. DATA OF VARIOUS POLLUTANT EMISSIONS AND TOTAL OUTPUT VALUE OF ZHEJIANG HEAVY CHEMICAL MANUFACTURING INDUSTRY IN 2012-2016

Years	Production value (ten thousand tons)	Waste water (ten thousand yuan)	Exhaust gas (100 million cubic meters)	Solid waste (10,000 tons)	SO_2 (ten thousand tons)
2012	1357.78	17738.7	460.27	85.32	2. 095648
2013	1367.26	19330.6	485.55	84.32	1. 88705
2014	1340.01	21841.6	471.85	84.02	1. 661429
2015	1355.26	19684	470.82	81.11	0.879408
2016	1260.24	18897.3	461.18	81.38	0.874983

a. Note: Data Source 2013-2017 *Zhejiang Statistical Yearbook and Zhejiang Natural Resources and Environment Statistical Yearbook*

TABLE V. REGRESSION ANALYSIS OF TOTAL OUTPUT VALUE OF HEAVY CHEMICAL INDUSTRY AND POLLUTANT DISCHARGE

	Multiple R	R Square	Correlation	Future environmental regulation trends
Wastewater discharge	0.330254726	0.109068184	Low positive correlation	↑
Exhaust emissions (non-SO_2)	0.845272647	0.714485847	Highly positive correlation	↓
Solid waste discharge	0.510616912	0.26072963	Positive correlation	—
SO_2 emissions	0.583409034	0.340366101	Positive correlation	—

The analysis results in "Table IV "and "Table V" show that the higher the emission of waste gas from heavy chemical industry is, the higher the total output value is. The environmental protection regulation standards can be appropriately relaxed, and technological innovation is also needed. The discharge of wastewater is related to the low total industrial output value, and the environmental protection control standards are raised, which has a general impact on economic growth. Solid waste emissions, SO_2 emissions and medium industrial output are moderately correlated; indicating that moderate environmental regulation policies can be applied. The symbol "↓" means that the environmental regulation standard should be relaxed, which can increase the total industrial output value; the symbol "↑" means that the environmental regulation standard can be improved, and the industrial output value has little effect, and the environmental indicator can be improved; the symbol "—" represents the environmental regulation standard can be adjusted and refer to the standards of neighboring provinces.

b) Medicine: The analysis results of "Table VI "and "Table VII" show that the higher is the pollution discharge of wastewater, solid waste discharge and SO_2 emissions of pharmaceutical manufacturing industry, the higher is the total output value. The environmental protection regulation standards can be appropriately relaxed, and technological innovation needs to be increased. Exhaust gas (non-SO_2) emissions are associated with low industrial output values, which can raise environmental regulations and have little impact on economic growth and improve environmental quality.

TABLE VI. DATA OF VARIOUS POLLUTANT EMISSIONS AND TOTAL OUTPUT VALUE OF ZHEJIANG PHARMACEUTICAL MANUFACTURING INDUSTRY IN 2012-2016

Years	Production value (tons)	Waste water (ten thousand yuan)	Exhaust gas (100 million cubic meters)	Solid waste (10,000 tons)	SO_2 (ten thousand tons)
2012	19894	26238.2	227.62	21.74	0.494077
2013	21167	28677.5	230.66	21.91	0.511076
2014	25950	33141.9	260.39	19.27	0.466256
2015	33217	38027.1	237.08	16.02	0.401422
2016	36352	50104.9	235.7	12.65	0.149998

a. Note: Data Source 2013-2017 Zhejiang Statistical Yearbook and Zhejiang Natural Resources and Environment Statistical Yearbook

TABLE VII. REGRESSION ANALYSIS OF TOTAL OUTPUT VALUE AND POLLUTANT EMISSIONS OF PHARMACEUTICAL MANUFACTURING INDUSTRY

	Multiple R	R Square	Correlation	Future environmental regulation trends
Wastewater discharge	0.92871383	0.862509378	Highly positive correlation	↓
Exhaust emissions (non-SO_2)	0.122789747	0.015077322	Low positive correlation	↑
Solid waste discharge	0.986716349	0.973609154	Highly positive correlation	↓
SO_2 emissions	0.868021346	0.753461058	Highly positive correlation	↓

c) Chemical fiber: The analysis results of "Table VIII "and "Table IX" show that the higher is the pollution discharge of chemical fiber industrial wastewater, solid waste discharge and SO_2 emissions, the higher is the total output value. The environmental protection regulation standards can be appropriately relaxed, and technological innovation needs to be increased. Exhaust gas (non-SO_2) emissions are associated with low industrial output values, indicating that environmental regulations can be raised and have little impact on economic growth.

TABLE VIII. DATA OF VARIOUS POLLUTION DISCHARGES AND TOTAL OUTPUT VALUE OF CHEMICAL FIBER MANUFACTURING INDUSTRY IN ZHEJIANG PROVINCE IN 2012-2016

Years	Production value (ten thousand tons)	Waste water (ten thousand yuan)	Exhaust gas (100 million cubic meters)	Solid waste (10,000 tons)	SO_2 (ten thousand tons)
2012	1677.27	8521.5	271.66	27.02	1.169074
2013	1839.31	8685.2	344.03	31.39	1.034459
2014	1987.97	8830	218.61	29.57	1.086977
2015	2186.42	10820.3	272.27	41.15	1.317082
2016	2106.42	11704.2	357.04	0.904425	0.904425

a. Note: Data Source 2013-2017 Zhejiang Statistical Yearbook and Zhejiang Natural Resources and Environment Statistical Yearbook

TABLE IX. REGRESSION ANALYSIS OF TOTAL OUTPUT VALUE AND POLLUTANT EMISSIONS OF CHEMICAL FIBER INDUSTRY

	Multiple R	R Square	Correlation	Future environmental regulation trends
Wastewater discharge	0.826278505	0.682736167	Highly positive correlation	↓
Exhaust emissions (non-SO2)	0.16889521	0.028525592	Low positive correlation	↑
Solid waste discharge	0.729246824	0.53180093	Highly positive correlation	↓
SO2 emissions	0.410700047	0.168674529	Positive correlation	—

d) Plastic: The data analysis results in "Table X "and "Table XI" show that the plastics industry consumes energy in four industries in a general level, and the discharge of wastewater pollution is related to the low total industrial output value. The higher is the pollution discharge, the lower is the total output value, and the improvement of environmental protection standards has little impact on economic growth. Exhaust gas (non-SO_2), solid waste discharge, SO_2 emissions are moderately related to industrial output value, and environmental protection control standards are appropriate.

TABLE X. DATA OF VARIOUS POLLUTANT EMISSIONS AND TOTAL OUTPUT VALUE OF PLASTICS MANUFACTURING INDUSTRY IN ZHEJIANG PROVINCE, 2012-2016

	Production value (ten thousand tons)	Waste water (ten thousand yuan)	Exhaust gas (100 million cubic meters)	Solid waste (10,000 tons)	SO_2 (ten thousand tons)
2012	948.54	5966.2	1119.07	38.16	2.215768
2013	940.38	6147.9	1246.38	36.58	2.215376
2014	1054.85	6359	1247.3	40.03	2.032016
2015	1041.17	7264.1	1290.28	35.05	1.845044
2016	1072.97	6036.3	500.52	23.53	0.763116

[a.] Note: Data Source 2013-2017 Zhejiang Statistical Yearbook and Zhejiang Natural Resources and Environment Statistical Yearbook

TABLE XI. REGRESSION ANALYSIS OF TOTAL OUTPUT VALUE AND POLLUTION DISCHARGE OF PLASTICS INDUSTRY

	Multiple R	R Square	Correlation	Future environmental regulation trends
Wastewater discharge	0.162409387	0.026376809	Low positive correlation	↑
Exhaust emissions (non-SO_2)	0.491830688	0.241897425	Positive correlation	—
Solid waste discharge	0.409034589	0.167309295	Positive correlation	—
SO_2 emissions	0.657953069	0.432902241	Positive correlation	—

V. CONCLUSION

This project uses the panel data of four high-energy-consuming industries in Zhejiang Province from 2012 to 2016, taking econometric methods to empirically analyze the environmental regulation industry in Zhejiang Province. Under the current "new normal" economic environment, it's necessary to maintain growth, also consider the low carbon ecology, which has a certain reference role for the formulation of environmental protection policies in the "13th five-year plan". The improvement of technological innovation and increased investment in environmental protection in Zhejiang Province is highly correlated with the increase in the total industrial output value of Zhejiang Province, which has a significant role in promoting.

Both technological innovation and environmental protection investment have a highly positive correlation with the total industrial value, and different wastes have different correlations with industrial output values. It also shows the reason why local governments are in a dilemma between the choice of environmental standards and the completion of economic performance indicators. The output value of high energy-consuming industries is the main source of economic growth in Zhejiang Province. Zhejiang Province has a huge pressure on low-carbon requirements, and in-depth study of the impact of its environmental regulation on the competitiveness of high-energy-consuming industries under the background of low-carbon economy. Adopting a one-size-fits-all environmental regulation policy will not necessarily have obvious effects; on the contrary, it will reduce economic growth.

It should be treated differently in the environmental regulation policies of heavy chemical industry, pharmaceutical, chemical fiber and plastics manufacturing industries in high energy-consuming industries in Zhejiang Province.

Relaxing the environmental regulation of waste gas in heavy chemical industry and improving the environmental regulation standard of waste water. Appropriate environmental regulation policies can be adopted for the discharge of solid waste and SO_2.

In view of the three waste environmental protections regulation standards of pharmaceutical manufacturing industry can be appropriately relaxed, and technical innovation needs to be increased. Raising environmental control standards for emissions of waste gas (non-SO_2) has little impact on economic growth.

The three waste environmental protection regulatory standards can be relaxed for the chemical fiber industry, need to increase technological innovation. Raising environmental control standards for emissions of waste gases (non-SO_2) will have little impact on economic growth.

Considering that the plastic industry consumes only half of the energy in the four industries, it has little impact on economic growth to improve environmental regulation standards for the discharge of waste water pollution. The environmental protection control standard of other three wastes should in a moderate level.

Under the pressure of competition in economic and environmental assessment, the provincial government adopt the scale standard in economic standard, while adopt bottom line standards for environmental standards. The environment pollution is not a regional problem; it needs to deal with the linkage to achieve the apparent effect. The stricter the environmental regulations are, the more obvious the inhibiting effect on economic growth will be, and the higher the cost of pollution control is, the heavier the cost burden of enterprises will be, and the lower the economic benefit of enterprises will turn to. For pollution control, the government can increase the investment in environmental protection through government procurement to reduce the burden of enterprises.

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