Study on Environmental Pollution and Regulatory Effects in China’s Manufacturing Industry

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Abstract. Based on the factual data of various pollutants discharged from the manufacturing industry from 2003 to 2015, the current situation of environmental pollution in China’s manufacturing industry is described; and the evaluation index of administrative order type and market incentive type environmental regulation tools is constructed to measure the environmental regulation intensity of manufacturing industry. On this basis, this paper puts forward targeted recommendations for policy to provide valuable reference for the green development of the manufacturing industry and ecological environment protection.

1. Introduction
Since the Reform and Opening up, especially since China’s accession to the WTO, with the deepening of economic globalization and the accelerating industrialization process, China’s manufacturing industry has gradually developed into the world’s largest manufacturing country from the recovery to the rise, and has profoundly driven the scale of China’s economic development. At the same time, however, China’s manufacturing industry has been in the middle and low-end segments of the world’s value chain division of labor. The problems caused by low-end manufacturing, such as massive consumption of resources, severe environmental pollution, and degradation of ecosystems, have become an obvious bottleneck, constraining the high quality of manufacturing development. Industrial pollution is a major component of China’s environmental pollution, and manufacturing pollution is the top priority of the manufacturing industry. Therefore, it is necessary to implement effective environmental regulation measures for the manufacturing industry. At present, China’s environmental regulation methods are mainly based on administrative orders and market incentives. Based on the factual data of various pollutant emissions in the manufacturing industry from 2003 to 2015, this paper describes the actual situation of environmental pollution in China’s manufacturing industry, and selects appropriate indicators to measure the environmental regulation intensity of manufacturing industry.

2. Analysis of Current Situation of Environmental Pollution in China’s Manufacturing Industry
Among the published materials, the environmental data from industry statistics has a time span from 2003 to 2015. Therefore, this paper selects some data of 27 manufacturing industries during this period as research sample. The sample data mainly comes from China Statistical Yearbook, China Statistics Yearbook of Environment, China Environmental Statistics Bulletin, etc. 27 manufacturing industries and 2-digit code industries are C01(Agricultural and Sideline Food Processing Industry), C02(Food Manufacturing Industry), C03(Beverage Manufacturing), C04(Tobacco Product Industry), C05(Textile
Industry), C06(Textile Clothing, Shoes, Hats Manufacturing Industry), C07(Leather, Fur, Feather (Velvet) and Its Products), C08(Wood Processing and Wood, Bamboo, Rattan, Palm, Grass Products Industry), C09(Furniture Manufacturing), C10(Papermaking and Paper Products), C11(Printing and Record Medium Reproduction), C12(Cultural Educational and Sports Goods), C13(Petroleum, Coking and Nuclear Fuel Processing), C14(Chemical Raw Materials and Chemical Products Manufacturing), C15(Pharmaceutical Industry), C16(Chemical Fiber Manufacturing), C17(Plastic and Rubber Products), C18(Nonmetal Mineral Products), C19(Ferrous Metal Smelting and Rolling Processing Industry), C20(Nonferrous Metal Smelting and Rolling Processing Industry), C21(Metal Products Industry), C22(Ordinary Machinery Manufacturing), C23(Special Equipment Manufacturing), C24(Transportation Equipment Manufacturing), C25(Electrical Machine and Appliance Manufacturing), C26(Communication Equipment, Computers and Other Electronic Equipment Manufacturing), C27(Instrument, Meter and Cultural And Office Machinery Manufacturing).

2.1. Overall Environmental Pollution Situation of the Manufacturing Industry

2.1.1. Wastewater and its Pollutants Discharge. Wastewater and its pollutants (chemical oxygen demand, ammonia nitrogen) discharge are an important source of industrial water pollution and an important part of China’s environmental regulation. According to figure 1, the wastewater discharge of manufacturing industry has approximately experienced a downward “U” process of rising and falling. The discharge intensity of wastewater (the ratio of wastewater discharge from industrial enterprises above designated size to the income from main operations) has shown a rapid decline during the sample period. The overall decline was 83.32%, indicating that the comprehensive treatment and reuse capacity of wastewater from Chinese manufacturing companies has been greatly improved.

From the perspective of chemical oxygen demand and ammonia nitrogen emissions from wastewater (figure 1), except for a slight increase in a few individual years, the two maintained a downward trend in other years, with an overall decline of 43.11% and 47.87%, indicating that the chemical oxygen demand and ammonia nitrogen emissions in industrial wastewater are greatly reduced, and the water pollution problems caused by these two sources are partly controlled. From the perspective of chemical oxygen demand and ammonia nitrogen emission intensity in wastewater, both of them showed a rapid decline trend, which decreased by 91.45% and 90.26% respectively, indicating that the comprehensive treatment capacity of wastewater of Chinese manufacturing enterprises was greatly improved, and the removal effect of chemical oxygen demand and ammonia nitrogen was greatly enhanced.

![Figure 1. Manufacturing Industry’s Wastewater Discharge and its Pollutants Discharge from 2003 to 2015.](image_url)
2.1.2. Exhaust Gas And its Pollutants Emissions. The emission of exhaust gas and its pollutants (sulphur dioxide, smoke (powder) dust, etc.) is an important source of air pollution in our country. The air pollution issue has received great attention from the government in recent years and has become the top priority of China’s current environmental regulation. According to figure 2, the emissions of manufacturing industries are generally on the rise, with a nearly four-fold increase during the sample period. The current air pollution problem is already very serious. From the perspective of exhaust emission intensity, the emission per unit of the manufacturing sector has been declining year by year in other years except seeing a short increase in 2011. The overall decline is 51.52%, indicating that the comprehensive treatment capacity of Chinese manufacturing enterprises has been greatly improved.

From the amount of emission of sulfur dioxide and smoke (powder) dust from exhaust gas (figure 2), the overall emission of sulfur dioxide is fluctuating, with an average annual growth rate of 3%. The resulting air pollution problem cannot be ignored; the emissions of smoke (powder) dust were also generally fluctuating, with a total decrease of 18.46% during the sample period. The problem of air pollution caused by smoke (powder) dust emissions was to some extent controlled. From the emission intensity of sulfur dioxide and smoke (powder) dust in the exhaust gas, both of them showed a rapid decline trend, with the overall decline of 79.63% and 89.92%, indicating that the removal rate of sulfur dioxide and smoke (powder) dust in the exhaust gas of China’s manufacturing industry has been greatly improved.

2.2. Environmental Pollution from Subdivision Industries in Manufacturing Industry

The above analysis of the overall pollution emissions of China’s manufacturing industry from 2003 to 2015 is carried out from vertical views. The following is a comparative analysis of the wastewater, exhaust gas and pollutant emissions of 27 manufacturing industries from a horizontal perspective.

2.2.1. Wastewater and its Pollutant Discharge. According to figure 3, in 2015, the top five rankings of wastewater discharge intensity in the 27 manufacturing industries were C10, C05, C16, C03, and C13, and the total discharge intensity accounted for 61.3% of the industry as a whole. The top five industries in the discharge of chemical oxygen demand in wastewater are C10, C16, C03, C01 and C02, with a total proportion of 62.1%. The top five industries in the wastewater discharge intensity of ammonia nitrogen are C10, C14, C13, C16 and C03, with a total proportion of 55.4%. The above data shows that China’s manufacturing wastewater and its pollutant emissions have a high degree of industry concentration. Reversely, the industries with low chemical waste and chemical oxygen demand and ammonia nitrogen emission intensity in 27 industries are very concentrated, including the following 10
industries: C09, C12, C25, C23, C22, C11, C27, C04, C24 and C26. The total pollution accounted for only 4.1%, 2.8%, and 2.5% of the industry as a whole.

2.2.2. Exhaust gas and its Pollutant Emissions. According to figure 4, in 2015, the top four exhaust gas emission intensity rankings in the 27 manufacturing industries are C19, C18, C20, and C13, which accounted for 69% of the industry as a whole. The top six industries in the sulfur dioxide emission intensity are C18, C20, C13, C10, C19, C14, with a total proportion of 74.5%. The top seven industries in the exhaust gas’ smoke (powder) dust emission intensity are C19, C18, C13, C08, C20, C10, C14, and the total emissions of C19 and C18 alone account for 53.4% of the industry as a whole. The above data shows that China’s manufacturing exhaust gas and its pollutant emissions have a high degree of industry concentration. Reversely, in the 27 manufacturing industries, the industries with low emission intensity of sulfur dioxide and smoke (powder) dust are mainly C12, C27, C26, C25, C22, C23, C11, C24, C04, C09, C07, C06. The total emissions accounted for only 4.8%, 2.9%, and 2.6% of the industry as a whole.

3. Measurement of Environmental Regulation Intensity of Manufacturing Industry
This paper estimates the intensity of manufacturing environmental regulation by constructing evaluation indicators of administrative order type and market incentive type environmental regulation tools.

3.1. Construction of Evaluation Indicators
(1) Administrative order type environmental regulation. This tool emphasizes the government’s mandatory intervention in enterprises. When enterprises face the government’s mandatory environmental regulations, they must comply with the requirements of pollution control. The stronger
the regulation is, the higher the cost of enterprises to invest in pollution control [1]. Thus the pollution control operation cost can be used as a proxy indicator for administrative order-type environmental regulation. The pollution control costs mainly include two aspects, industrial wastewater and waste gas. The calculation formula is: (industrial wastewater treatment operation cost + industrial exhaust gas treatment operation cost)/main business income.

(2) Market-incentive environmental regulation. This tool emphasizes the rational allocation of environmental resources through market and price mechanisms, and selects the comprehensive energy prices of various industries as the proxy indicators for market-incentive environmental regulation [2]. The specific calculation method is as follows: First, calculate the relative price of energy in various industries. Using the ratio of the energy price index to the ex-factory price index of industrial production, the energy price index is replaced by the fuel and power kinds of price index, and the entire price index is converted into the base price index for 2003. Price index can be obtained from the China Statistical Yearbook over the years. Secondly, the China Energy Statistical Yearbook publishes the energy consumption of various industries over the years and weights them according to the relative price of energy to estimate the energy costs of various industries. Finally, the energy costs of various industries are divided by the total energy consumption of various industries to obtain the comprehensive energy prices of industries [3].

3.2. Analysis of the Results of Measuring the Environmental Regulation Intensity of Manufacturing Industry

According to figure 5, the intensity of administrative order-based environmental regulation declined during the period 2003-2012, but began to turn upward after 2013. 2003-2012 is the golden age of China’s economic development. Since China officially joined the WTO in 2002, the rapid development of economic globalization has brought great opportunities for the development of China’s manufacturing industry. Manufacturing trade and direct investment from abroad have risen sharply, but some pollution industries and products gradually transferred to China and spread along with the transmission path of trade and direct investment from abroad. Meanwhile, driven by the accelerated development of industrialization and urbanization, China’s heavy chemical industry has grown rapidly, and high-pollution and high-energy consumption projects have emerged. Under the extensive development model, the government departments have placed greater emphasis on the glorious achievements of economic development, but have paid insufficient attention to the deterioration of the ecological environment. In many cases, the formulation of environmental protection policies lags behind or even gives way to economic development policies, and the environmental problems caused by them are serious. A clear turning point in the intensity of environmental regulation appeared in 2013. In the increasingly severe environmental pollution situation, the government attaches great importance to ecological and environmental issues. To accelerate the green transformation of the manufacturing industry, the government has promulgated a series of environmental policies, laws and regulations to strengthen the environmental regulation of manufacturing enterprises. For example, the government has stopped the approval, forced the closure, stop, merging and transformation of some highly polluting and inefficient manufacturing enterprises to control environmental pollution, so the intensity of the administrative order-type environmental regulation began to strengthen.

According to figure 5, the intensity of market-incentive environmental regulation is generally on the rise. Since the beginning of the 21st century, with the continuous advancement of Reform and Opening Up in various fields, the market economic system has been increasingly fulfilled, and the ability of the market to allocate resources has been greatly improved. These have provided conditions for the government to adopt market-based means to solve ecological and environmental problems. The market-incentive environmental regulation tools represented by environmental protection fees (taxes), emissions rights trading have been rapidly developed, and the intensity of environmental regulation has been continuously elevating.
Figure 5. Intensity Change of Administrative order-type Environmental Regulation and Market-Incentive Environmental Regulation on Manufacturing Industry from 2003 to 2015.

4. Conclusions and Recommendations
Based on the above research, the following conclusions can be drawn: (1) China’s manufacturing industry’s wastewater, exhaust gas and its pollutant emissions showed a downward trend, indicating that the comprehensive treatment and reuse capacity of wastewater and exhaust gas of manufacturing enterprises is largely improved. (2) Wastewater, exhaust gas and its pollutant emissions have a high degree of industrial concentration. (3) The intensity of administrative order-type environmental regulation gradually weakened and it was not strengthened until 2013. The intensity of market-incentive environmental regulation gradually increased, indicating that the government pays more attention to ecological environmental protection and green transformation of manufacturing industry, and the capacity of comprehensively using administrative, economic, legal and other means to carry out environmental governance has improved. In the future, we should further strengthen the overall application of these two environmental regulation tools, improve existing legal regulations related to environmental protection, continuously innovate law enforcement methods, improve law enforcement supervision mechanisms, strengthen market-oriented environmental regulation means, and promote the construction of sewage market in an orderly manner; strengthen the support of fiscal and taxation policies for environmental protection, formulate reasonable environmental protection tax standards, and guide enterprises to actively fulfill their environmental responsibility through direct subsidies, tax incentives, and tax refunds.

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