



Status of Environmental Pollution Caused by Heavy Pollution Industries and Environmental Regulation Measures in China

Liuxin Chao

Zhengzhou Tourism College, Zhengzhou, Henan, 450009, China

Corresponding author: Liuxin Chao

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ABSTRACT

Most of the heavy pollution enterprises in China are industrial enterprises. These enterprises not only facilitate rapid economic development but are also the main sources of environmental pollution. Therefore, strengthening the environmental regulation on heavy pollution enterprises is the key to enhance sustainable environmental development in China. By using the enterprise data from 2000-2015, we analyzed the characteristics and status of environmental pollution caused by heavy pollution industries in China to put forward specific environmental regulation measures. Results showed that the number of heavy pollution enterprises in China increased continuously from 2000 but decreased slightly after 2005. The environmental pollution caused by heavy-pollution enterprises in China has three characteristics: externality, substantivity, and persistence. The status of enterprise environmental pollution in heavy pollution industries in China is mainly indicated by increasing environmental protection inputs and steady rise of environmental performance; gradual increase in control rate of industrial waste discharge and large regional difference in environmental performances; lack of internal environmental management mechanism of industrial enterprises and poor implementation of environmental management theory; and low level of enterprise environmental management and serious violation of environmental laws. Finally, specific control measures were put forward from the perspective of environmental regulation. Research results can provide reference and suggestions for the improvement of environmental management standards for heavy pollution enterprises, promote reform in heavy pollution enterprises, offer technological and policy supports, and establish an environmental protection information platform.

INTRODUCTION

Resource exhaustion, environmental pollution, and ecological damages are increasingly intensified by rapid economic development in China. Thermal power and steel and metallurgical industries greatly promote China's economic development. The number of enterprises in 16 heavy industries, such as thermal power, steel, coal, cement, metallurgy, chemical engineering, petrifaction, paper-making, brewery, pharmacy, fermentation, textile industry, leather industry, mining, building material industry, and electrolytic lead industry, increased continuously since 2000 (Fig. 1). However, with the industrial restructuring in China, the number of heavy pollution enterprises decreased slightly after 2005. The environmental pollution caused by these heavy pollution industrial enterprises cannot be ignored. Environmental pollution has recently become the most highlighted problem in China. Environmental agencies in different regions have released policies related to environmental management. Although related departments have enacted strict environmental regulation system to restrict environmental protection behaviours of enterprises, pollutant gas emission has long been increasing, accompanied by intensify-

ing water pollution and heavy metal pollution, indicating that the environmental regulation has not achieved its goal. One of the reasons for this failure is that the government has focused more on direct correlation between policies and environmental protection behaviours of enterprises during formulation of environmental regulations, whereas the other factors that will directly or indirectly influence environmental protection behaviours of enterprises were overlooked. Enterprises in heavy pollution industries not only facilitate rapid economic development in China but are also the main sources of environmental pollution. Thus, sustainable environmental development is closely related to the production and management of enterprises. Positive environmental protection behaviours of enterprises are keys in strengthening sustainable environmental development in China. Traditionally, enhancing environmental protection behaviours of enterprises and fulfilling environmental responsibilities are considered to surely increase cost, reduce economic benefits, and add burden to enterprises, preventing maximization of their profits and even weaken their influences. The environmental protection behaviour and competitiveness of enterprises is a pair of opposite-acting

forces. Subsequent studies have reported that the environmental protection behaviours of enterprises do not always increase the burden of enterprises but rather are conducive for the development of enterprises. Therefore, perfecting the environmental regulations and guiding the enterprises to positively implement environmental protection behaviours by analysing enterprise environmental pollution status of heavy pollution industries and giving suggestions from government and enterprises are beneficial.

EARLIER STUDIES

Numerous studies worldwide have been reported on the status of environmental pollution caused by enterprises in heavy pollution industries and the corresponding environmental regulatory measures. With respect to types, causes, and status of environmental pollution caused by these enterprises, Clarke-Sather divided China into three regional units (east China, central China, and west China) based on Theil index and then analyzed the regional difference in CO₂ emission in China from 1997-2007 (Clarke-Sather et al. 2011). Srinivas evaluated the environmental air quality indexes in industrial regions in Andhra Pradesh, India and proposed corresponding pollution control measures (Srinivas et al. 2013). Ezeilo speculated that the rapid development of industrial enterprises causes severe heavy metal (Pb, Zn, Cu and Cd) pollution in soil (Ezeilo & Agunwamba 2014). Gao evaluated the status of heavy metal pollution caused by industrial enterprises in China Bohai (Gao et al. 2014). Hu speculated that with the rapid economic development in China, the energy consumption of industrial enterprises increases, and these enterprises cause serious environmental pollution. Heavy metal pollution has become one of the major environmental problems in China (Hu et al. 2014). Choubisa contested that with the rapid industrialization in India, many industrial activities, such as coal-fired power generation, cause heavy environmental pollutions (Choubisa & Choubisa 2016). Many foreign studies on environmental regulatory measures have demonstrated that controlling environmental pollution via strict environmental regulatory measures can improve management performance of enterprises, realizing the goal of environmental protection. Specifically, Murty analyzed the relationship between performance of sugar industry in India and environmental regulation through DEA (Data Envelopment Analysis) model, and the results demonstrated that environmental regulation increases DEA efficiency in sugar industry in India (Murty & Kumar 2003). By analysing several heavy pollution enterprises in Britain, Salama concluded that environmental regulation is strongly positively correlated with enterprise performance (Salama 2005). Ciocci demonstrated the influences of environmental regulation

on power enterprises in America, Japan, and European Union. He believed that environmental regulation not only increases service efficiency of energy sources but also promotes growth of industrial performance (Ciocci & Pecht 2006). Chintrakarn discovered that implementation of environmental regulation policies increases the technological efficiency and industrial performance of manufacturing industry in America (Chintrakarn 2008). Ramanathan believed that environmental regulation can cause technological innovation in the industrial sector in Britain, improving industrial performance (Ramanathan et al. 2010). On the basis of oligopoly model of two departments, Roy found that strict environmental regulation will promote technological innovation, resulting in increased industrial performance and industrial competitiveness (Roy & Das 2011). Thomas analyzed the influences of air quality management in the coastal region of District of Southern California from 1982-2006 on local electroplating industry; the result showed that they have a potential win-win relationship (Thomas 2009). Studies have demonstrated that heavy pollution enterprises cause great environmental pollution caused by pollutants including soil heavy metals, waste gas, waste residues, and wastewater. With the gradual perfection of environmental regulation and increasing consciousness of social environmental protection, these heavy pollution enterprises formulate guidelines on emission levels and technological standards to reduce environmental pollutions. In guiding enterprises in operation reform and technological innovation, pollution control is run throughout the production chain, resulting in reduced environmental pollution.

CHARACTERISTICS OF ENVIRONMENTAL POLLUTION CAUSED BY HEAVY POLLUTION ENTERPRISES IN CHINA

China's "11th Five-Year Plan" and "12th Five-Year Plan" have put forward clear requirements on environmental protection. Major government departments, including the Ministry of Environmental Protection of China, have formulated specific laws and regulations for management and control of environmental pollution.

Externality: Externality refers to the influences of the behaviours of economic subjects on external environment. Economic subject may cause advantageous and disadvantageous influences on external environment; these influences are referred to as positive externality and negative externality, respectively. The production and management activities of heavy pollution enterprises will significantly influence the external environment, and most of such influences are disadvantageous. The production behaviours of thermal power, coal, and chemical enterprises will discharge abundant pollution gases into the air, causing serious air

Table 1: Classification of heavy pollution industries in China.

Industry	Types of Enterprise
Thermal power	Thermal power generation (including thermoelectricity, electricity generation based on comprehensive use of gangue, and garbage power)
Steel	Iron-making, pelletizing, and sintering; steel-making; ferroalloy metallurgy; steel rolling processing; and coking
Cement	Cement manufacturing (including clinker manufacturing)
Electrolytic aluminium	Whole-scale and whole-process productions
Coal	Coal mining and washing; underground coal gasification; and coal chemical industry
Metallurgy	Non-ferrous metal metallurgy and non-ferrous alloy manufacturing; nonmetal metallurgy; non-ferrous metals; rolling processing; and metal finishing and thermal processing
Building materials	Glass and glass product manufacturing; glass fiber and glass fiber-reinforced plastic product manufacturing; ceramic product manufacturing, asbestos product manufacturing; refractory ceramic product and other fireproofing material manufacturing; graphite and carbon product manufacturing
Mining	Oil exploitation; natural gas exploitation; non-metallic mines; black metal mining; and non-ferrous metal mining
Chemical engineering	Basic chemical raw material manufacturing and fertilizer manufacturing; manufacture of coating, dye, pigment, printing ink, and other similar products; manufacture of qualified chemical product; chemical pesticide manufacturing and biological chemical pesticide and microbial pesticide manufacturing; daily chemical product manufacturing and rubber processing; tire manufacturing; and regenerated rubber manufacturing
Petrifaction	Crude oil processing; natural gas processing; petroleum product manufacturing; crude oil extraction from oil shale; and biological oil extraction
Pharmacy	Chemical medicine manufacturing; manufacture of chemical medicine and preparations; biological and biochemical manufacturing; Chinese patent medicine manufacturing
Light industry	Wine and beverage manufacturing; soda manufacturing; bottle (tank) drinking water manufacturing; fruit and vegetable juice manufacturing; milk beverage and vegetable protein drink manufacturing; solid drink manufacturing; and tea manufacturing. Paper-making and pulp manufacturing; paper making (waste paper making); condiment manufacturing (monosodium glutamate, citric acid, and amino acids); fermented food and feed processing; sugar production; and vegetable oil processing
Textile Industry	Chemical fiber manufacturing; cotton and chemical fiber textiles, dyeing finishing; wool manufacturing and dyeing finishing; tiffany textile and finishing; chemical fiber pulp manufacturing; and cotton pulp manufacturing
Leather industry	Leather tanning; fur tanning and product processing

pollution. Wastewater and sewage discharged by pharmacy, textile, and paper-making enterprises during production flow into nearby water systems, causing serious water pollution. Metallurgy industry will discharge massive amount of harmful substances during metallurgy process, causing heavy metal pollution and land-based sources of pollution. To relieve pressures from government or from the public, enterprises will adopt corresponding environmental protection behaviours to avoid or reduce pollution of the external environment as much as possible. Therefore, environmental protection behaviours of heavy pollution enterprises demonstrate evident externality.

Substantivity: Most heavy pollution enterprises directly acquire raw materials for production from nature; in the process, they discharge toxic harmful substances directly into air, water, or soil, causing pollution in atmosphere, water, or land. Coal enterprises exploit coals from the nature directly, generating abundant dusts and thus causing air pollution. Therefore, heavy pollution enterprises directly influence the environment. By contrast, some environmental protec-

tion behaviours of enterprises directly reduce pollution. For example, some heavy pollution enterprises improve their production technologies and use clean energy sources to avoid discharge of harmful substances directly into the atmosphere and water bodies. Some heavy pollution enterprises that use non-renewable resources for production resort to alternative resources as their raw materials for production, which is directly beneficial to the environment. The environmental protection behaviours of these heavy pollution enterprises demonstrate substantivity.

Persistence: Production and management activities of enterprises are harmful to the environment. Enterprises must display appropriate environmental protection behaviours in order to survive. Production and management activities of heavy pollution enterprises definitely exert disadvantageous influences on the environment. Additionally, environmental pollution caused by one heavy pollution enterprise may involve many aspects. Given the severity and complexity of environmental pollution, a heavy pollution enterprise experiences difficulty in implementing environ-

mental management. Environmental management could not be accomplished by one or several strategies but rather requires long-term control of different pollution aspects with the activity of enterprises. Providing guidance to heavy pollution enterprises in improving their environmental protection behaviours has become extremely important. Therefore, environmental protection behaviours of heavy pollution enterprises are a long-term process.

STATUS OF ENVIRONMENTAL POLLUTION CAUSED BY HEAVY POLLUTION ENTERPRISES

The economic development in China has been consistently high. However, the environmental pressure caused by previous industrial development idea of pollution first and then control cannot be ignored. Control of pollution caused by heavy pollution industries shall be reinforced to promote change in the mode of economic development. This approach has been the key in environmental protection in China.

Increasing environmental protection inputs and steady increase in environmental performance: After more than 10 years of continuous exploration and improvement, evaluation of environmental management and environmental performance of listed companies classified under heavy pollution industries in China became well established and has achieved some results. China increasingly provides financial and policy supports in the control of environmental pollution caused by heavy pollution industries (Fig. 2). The total investment for environmental pollution control in China at the least doubled in 10 years, creating a sound environmental and solid basis for national environmental protection. Heavy-pollution industries are important in national economy. They are the subjects of environmental pollution when making great economic contributions. Under the guidance of a supervising government unit, industrial enterprises pay more attentions to environmental management when pursuing economic benefits and they increase their capital and equipment investments related to environmental protection. Given that heavy pollution industries are pillar industries in China's economy, environmental performance has become an important component of the comprehensive performance evaluation of enterprises. The influence of environmental performance on the overall competitiveness of enterprises increases continuously, which is related to profitability and financial performance of enterprises. Therefore, environmental performance evaluation and standard implementation of environmental protection of heavy pollution enterprises are important in facilitating steady transition and rapid growth of China's economy.

Gradual increase in the control rate of industrial waste

discharge and large regional difference in environmental performances: With the gradual increase in the number of heavy pollution enterprises and the increase in investments for research and development of clean production technologies and green products, increase in the investment on pollution control technologies can effectively mitigate environmental pollutions caused by production behaviours. Some capitals are used for regular maintenance and in updating of production equipments to prevent environmental pollution caused by equipment as much as possible. The control rate of industrial waste emissions increases continuously (Fig. 3). Limited by the fundamental realities of the country and influenced tendency of policies in different development stages, industrialization and urbanization process in China lay the keynote of developing east China priori in the beginning of reform and opening-up policy. After more than 30 years, considerable industrial development occurred in coastal regions in east China. Moreover, these regions are the first to experience the disadvantageous influences of environmental pollution and to implement environmental protection and enterprise environmental performance evaluation. In recent decades, China began to pay attention to China Western Development and coordinate the national economic structure. Middle and western China, which are resource-rich regions, are the raw material base for traditional energy, chemical engineering, and metallurgy industries. Moreover, coastal provinces and cities in eastern China not only formulate more perfect and stricter environmental protection laws and regulations but also put forward higher requirements on enterprise environmental performance evaluation and environmental management information disclosure. Many heavy pollution enterprises began to migrate from coastal regions into the central and western China, consequently intensifying environmental pollution and increasing environmental protection pressure in central and western China. In China, environmental protection and environmental performance of heavy pollution enterprises are high in east and low in west. An increasing number of heavy pollution enterprises showing high resource consumption, high pollution emission, and low technological level migrate to western regions. Environmental protection behaviours and environmental performance of these enterprises must be improved.

Lack of internal environmental management mechanism of industrial enterprises and poor implementation of environmental management theory: Early in the environmental performance evaluation of heavy pollution industries, enterprise managers and stakeholders pay more attention on pollutant emission but neglect environmental management in production and management process. Many enterprises have not integrated environmental objectives

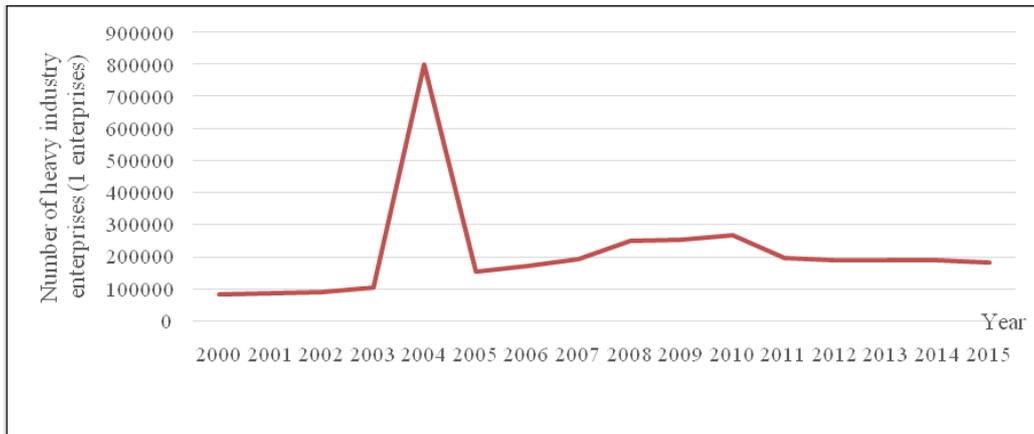


Fig. 1: Number of enterprises in heavy pollution industries in China.

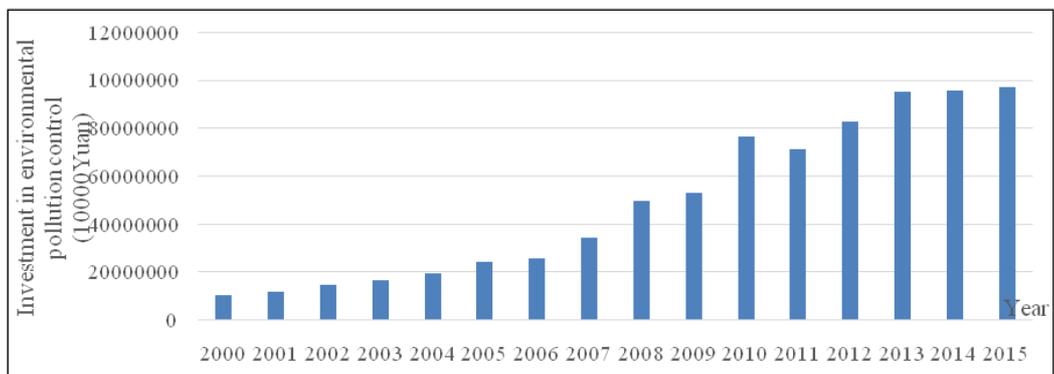


Fig. 2: Investment volume for environmental pollution improvement in China.

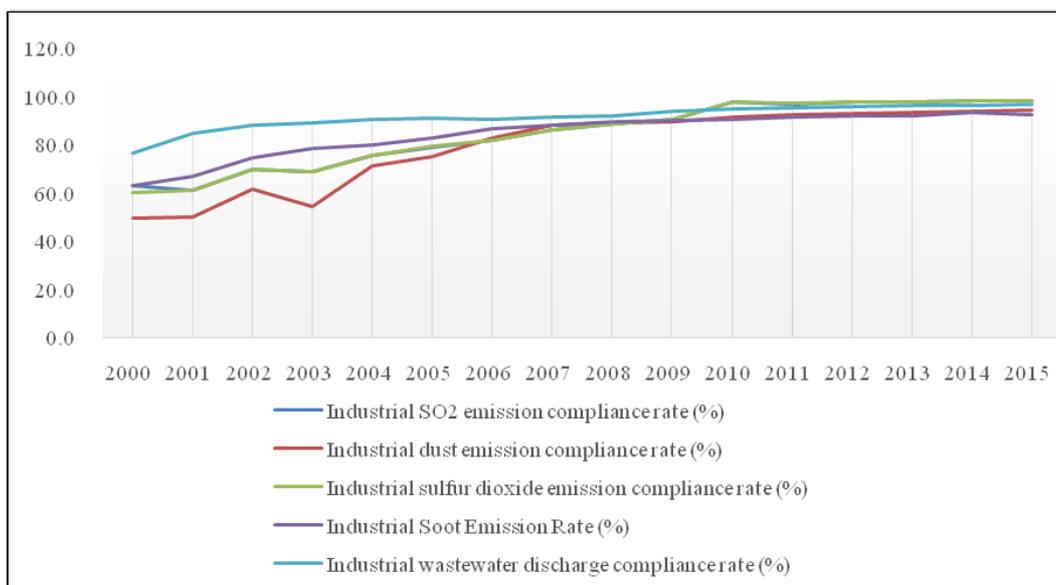


Fig. 3: Control rates of industrial waste emission.

in their strategies, they lack corresponding environmental policies and effective mechanism for internal environmental performance evaluation, and they have poor consciousness and motivation to assume corresponding social and environmental responsibilities. Provision of guidance to enterprises for the implementation of environmental management and improvement of their environmental performance based on laws and regulations, as well as encouragement of heavy pollution enterprises and governmental agencies to participate in environmental management and environmental information disclosure in China and must be further explored. Most enterprises use environmental control as an excuse to cope with external pressure. Environmental management and enterprise management are practically completely separated. Enterprises could not completely comprehend the essence of environmental management. In practical environmental management, a set of perfect environmental management system, environmental policies, environmental indexes, and environmental tools must be established. Chinese enterprises randomly establish environmental protection policies, which are often infeasible; as a result, choosing the appropriate environmental management tools is difficult. Hence, environment-friendly management and clean production of enterprises are basically superficial and have no substantive contents.

Low level of enterprise environmental management and serious violation of environmental laws: Most heavy pollution enterprises in China have poor environmental management system, and only few have established an environmental quality management system according to the requirements of ISO14001. In the absence of a special environmental department, enterprises have not integrated environmental management into their development strategies and have not established effective standard environmental management document and process guidance in their daily management. In most enterprises, environmental management policies are scattered and aim to control and avoid polluting programs. Environmental management policies in enterprises mainly satisfy the demands for standard pollution emission. In recent years, although China has strengthened its environmental protection control for heavy pollution enterprises and formulated the necessary laws and regulations, the implementation effect is barely satisfactory. Related investigations conducted in China showed that pollution enterprises, especially county-level enterprises, violate environmental an increased number of protection laws and regulations and emit excessive amounts of pollutants. These statuses also reflect the poor supervision of environmental protection of concerned agencies in China. Environmental supervision in China is delegated to localized

management. Therefore, many departments display local protectionism and will connive environmental pollution behaviours of enterprises to some extent. Additionally, the shortage of basic law enforcers and equipment are one of the reasons of excessive emission of pollutants by enterprises. Given the limitations in personnel and detection ability, environmental protection agencies cannot easily master pollutant emissions of enterprises timely, which largely influence the continuity and validity of environmental law enforcement.

ENVIRONMENTAL REGULATION MEASURES

Acceleration of industrial restructuring of heavy pollution enterprises and improvement of environmental performance: For a long period, the production mode of heavy pollution industries that depend on high resource input and high resource consumption is a typical extensive development that causes serious environmental damages. With the progress of economic development philosophy and adjustment in China's development strategy, changing their economic development mode has become an important strategy for heavy pollution industries to improve their environmental performance level and achieve sustainable development. Hence, China shall accelerate industrial restructuring of heavy pollution industries to optimize their industrial distribution, change their economic development, mode and increase their core competitiveness. When implementing transition and updating, they shall increase resources utilization, promote energy-saving production technologies, develop circular economy, gradually enhance their capacity for green development and improve their internal environmental management level based on internal and external production and management environments of enterprises. Although promoting industrial restructuring in heavy pollution industries is difficult and challenging, they can achieve sustainable development only by combining their development strategies with China's macroscopic planning.

Enhancement of environmental regulations and formulation of different regulation policies: Environmental regulation policies shall be formulated according to local conditions, industrial situations, and institutional situations. Environmental regulations in east China exert negative impacts on industrial performance. However, with the intensifying environmental pollution and pressure against industrial transition and updating, stricter environmental regulations are needed in east China to promote updating and transition of industrial technologies. Environmental regulations in central and western China exert positive impacts on industrial performance. Therefore, formulating strict

environmental regulation policy is not only conducive to environmental protection but will also facilitate improvement of industrial performance in central and western China, realizing win-win results. Furthermore, strict environmental regulation can prevent middle and western China from becoming a new “paradise of pollution.” The difference in degree of pollution will cause varying influences of environmental regulation on industrial performances. Environmental regulation influences heavy pollution industries more than moderate and light pollution industries. However, heavy pollution industries, such as petrochemical engineering, coal, and steel industries, are mainly strategic resource-intensive industries, which require technological improvement to reduce pollution. Influences of environmental regulation on industrial performance decrease with reduced pollution degree. Therefore, strengthening environmental regulation of heavy pollution industries is not only beneficial to environmental management and technological innovation but is also conducive to upgrading and technological innovation of resource-intensive industries.

Establishment of environmental performance evaluation system for heavy pollution enterprises and support key enterprise projects: Environmental management and environmental performance evaluation of heavy-pollution industries in China is still in its infancy stage. Related policies and funds shall be progressive gradually. Therefore, distribution of policies and funds could not cover all enterprises. Therefore, providing specific financial supports and policy preferences to heavy pollution industries and key enterprises is necessary with the aim to achieve extensive influential results and accumulate experiences for future comprehensive promotions. Combining environmental performance level and environmental management of enterprises with related policy and financial motivation can increase the implementation effect, stimulate enthusiasm of heavy pollution industries to environmental performance evaluation, and improve motivation of environmental management. Heavy pollution industries are key supervision points in current environmental management in China. However, enterprises in different refined industries develop differently. With respect to SMEs, which have limited scale and limited sharing resources, they have many problems to deal with capitals for production and management and lack resources and inputs for environmental protection, limiting their environmental performance and environmental management. For this reason, expanding financing channels for environmental protection of SMEs and exploring new financing mode are keys to overcome poor environmental performance of these enterprises. The government can coordinate for a capital distribution of financial organizations

to SMEs, provide policy preferences (e.g., fiscal appropriation and taxation), and provide special capital funds for environmental protection of SMEs.

Perfection of the legal system for environmental performance evaluation of heavy pollution enterprises: At present, China has few laws and regulations related to environmental performance of heavy-pollution industries. Environmental performance involves environmental protection, corporate governance, and accounting, among others, and no special laws cover all these specific fields; and lack of direct evidences and promotion motivation to environmental performance evaluation. Therefore, the Ministry of Environmental Protection and China Securities Regulatory Commission must strengthen their cooperation to perfect the regulation connection of related departments and the soundness of related departments, integrate constituted regulations and published documents, form a system, expand experimental units and supervision range to offset legislation shortcomings, and lay foundation to establish complete laws and regulations related to environmental performance. Mechanism of environmental information disclosure shall be standardized. Combining with specific conditions in China, it is suggested regulate compulsory disclosure to key enterprises and encourage other enterprises to disclose resources, as well as guide enterprises to increase their enthusiasm in environmental performances while meeting the demands of supervising agencies, weekly enterprise management, and other stakeholders of environmental information. Therefore, the environmental information disclosure system for heavy pollution industries shall be established based on carrier of the environmental reports, environmental accounting data, and environmental management data of enterprises; the environmental information disclosure system serves as a channel to understand and evaluate the environmental performance level of enterprises.

CONCLUSIONS

To put forward specific environmental regulation measures, we analyzed the characteristics and status of environmental pollution caused by enterprises in heavy pollution industries in China; the analysis was based on enterprise data from 2000 2015. Finally, specific control measures are put forward from the perspective of environmental regulation. Results show that the amount of heavy pollution enterprises in China increased continuously from 2000 but decreased slightly after 2005. The environmental pollution caused by heavy pollution enterprises in China display three characteristics: externality, substantivity, and persistence. The enterprise environmental pollution status in heavy pollution industries in China is mainly manifested by increasing

environmental protection inputs and steady rise of environmental performance; gradual increase of industrial waste discharge control rate and large regional difference in environmental performances; lack of internal environmental management mechanism of industrial enterprises and poor implementation of environmental management theory; and low enterprise environmental management level and serious violation of environmental laws. Environmental management measures, such as accelerating industrial restructuring of heavy pollution industries and improving environmental performance level, increasing strength of environmental regulation and formulating different regulation policies, establishing an environmental performance evaluation system of heavy pollution enterprises and supporting key enterprise projects, and perfecting the legal system for environmental performance evaluation of heavy pollution enterprises, can relieve and manage environmental pollution caused by heavy pollution enterprises. Research results can promote and guide environmental regulations to heavy-pollution enterprises in China and provide more scientific references for government and environmental agencies. Given that this paper focuses on analysis of environmental pollution status caused by heavy pollution enterprises and the corresponding environmental regulation measures, future studies can emphasize on evaluation of environmental management practices of heavy pollution enterprises, on related influencing factors of environmental pollution caused by heavy pollution enterprises, and on case studies.

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