Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

p-ISSN: 0972-6268
e-ISSN: 2395-3454

Vol. 17 | No. 4 | pp. 1227-1234 | 2018

Original Research Paper | Open Access

Relationship Between Environmental Pollution and Industrial Restructuring: Hubei Province in China

Deqiang Geng* and Long Wang†**

*School of Economics, Wuhan University of Technology, Wuhan, 430070, China

**School of Management, China Research Center for Emergency Management, Wuhan University of Technology, 430070, China

†Corresponding author: Long Wang

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 11-09-2018
Accepted: 08-11-2018

Key Words:
Environmental pollution
Industrial restructuring
Industrial wastes

ABSTRACT

Patterns of industrial structure have a direct impact on the general allocation of resources and the types and quantity of pollutants, which are closely linked with the quality of production and living environment. The traditional development mode featured by high input, high consumption and high pollution inevitably causes serious environmental pollution. To analyse the quantitative relationship between industrial structure and principal emissions of environmental pollution, the present situation of environmental pollution in Hubei Province of China was analysed, and a comprehensive correlation coefficient was calculated between industrial structure and emissions of environmental pollution using the method of grey comprehensive correlation coefficient. Results show that environmental pollution in Hubei Province is mainly caused by a considerable amount of emissions from industrial wastes, intensification of environmental pollution from unreasonable industrial structure, and the high proportion of nonrenewable energy consumption. The overall relevance is relatively high on the comprehensive correlation degree between the variables of the three major industries (primary, secondary, and tertiary industries) and the three types of industrial wastes (waste gas, waste water, and waste residues) in Hubei Province. The correlation degrees between the variables of the three major industries and wastewater, secondary industry and waste gas, and solid wastes and the three major industries exceed 0.9, 0.8245, and 0.6854, respectively. Related industries, such as mining, manufacturing, electricity, heat, gas and water production and supply, construction, transportation, warehousing, and post office, have strong correlation degrees with the three types of waste, as evidenced by the grey comprehensive correlation degree above 0.8. The conclusion can be used to further understand the dynamic relationship between industrial structure and the environment, and it also helps identify the main environmental polluters, thereby providing a reference for precise industrial restructuring and coordinated development between the economy and the environment.

INTRODUCTION

Natural resources have become depleted because of human activities, such as those caused by fast-paced industrialization, constant exploitation of natural resources, expanding scale of exploitation and utilization, and increasing types of wastes discarded into nature by mankind. For a long time, China's economic growth has been mainly driven by the development of the secondary industry, but such rapid development has been accompanied by a substantial demand for resources. With the considerable consumption of resources, many pollutants have been produced accordingly, and they typically involve industrial wastewater, waste gas, and industrial solid wastes. When the quantity of pollutants exceeds the self-purification capacity of the environment, it will cause serious environmental pollution. To a certain extent, industrial structures can shift the allocation of resources and control environmental pollution because development patterns can help determine the effect of resource allocation. Therefore, the impact of resource allocation will also affect the environment. When the layout of industrial structure is reasonable, the corresponding resources are allocated and utilized reasonably. If the pattern of industrial structure cannot meet the needs of the current economic development, then it will cause wastage of resources and damage to the environment, thus creating a certain adverse impact on the sustainable development of the economy.

As shown in Fig. 1, Hubei's economy has maintained a steady and rapid progress in GDP in recent years along with the increase of economic aggregate. However, the effects of environmental pollution and damage gradually appear, such as serious groundwater pollution of some agricultural development zones, irresponsible discharge of domestic sewage, serious air pollution, frequent haze and acid rain, seri-

ous garbage pollution, and littering and dumping of household garbage in rural areas, due to lacking environmental protection policies in the process of economic development. The contradiction between Hubei's economic growth and environmental quality is increasingly prominent due to the rapid development of the local economy and the grim situation on environmental protection, which has been enhanced by an unreasonable industrial structure and accumulation of long-term pollution damage effect. Accordingly, this study theoretically and practically contributes to the investigation on the effects of industrial restructuring for environmental pollution management and accurately reveals the dynamic relationship between both by considering Hubei Province of China as the case, which is conducive to the long-term and stable development of the economy in Hubei Province.

PREVIOUS STUDIES

Many scholars have mainly studied the relationship between industrial structure and environmental pollution, and focused on the coordinated development of economy and environment. Considerable research has been conducted in many aspects, including input-output model, environmental Kuznets curve, and CGE model. Wang et al. (2000) used a quantitative method of systematic analysis to control water environment pollution and protect water under the premise of ensuring the realization of an economic target. The results showed that optimization model of water environment-economic structure could better coordinate the relationship between economy and environment. Zhou et al. (2002) analysed the present situation of pulp and paper industry in Hubei and proposed comments and suggestions on its pollution control and structural adjustment. Llop (2007) used input-output framework to analyse the change of emission multiplier in Spain from 1995 to 2000. The results revealed that economic structure made a positive contribution to the change of emission multiplier. Oosterhaven et al. (2007) conducted studies to illustrate that an inverse U curve relationship existed between industrial structure and environmental pollution, whereby upgrading the industrial structure effectively with improved environmental quality. However, Brajer et al. (2011) demonstrated that the inverted U-shaped curve relationship did not necessarily exist between environmental pollution and industrial structure. He et al. (2011) analysed the effects of economic structure, development strategy, and environmental regulation on the shape of an environmental Kuznets curve by using panel data in China. The results showed that economic structure, development strategy, and environmental regulation had important influences on the relationship between environmental quality and economic development. Li et al. (2011) employed a new method to construct and reflect China's comprehensive environmental pollution index. On the basis of a decoupling index, Ru et al. (2012) divided the relationship between economic growth and environment into three states, namely, coupling, relative decoupling, and absolute decoupling. Tian et al. (2014) established the correlation and coupling degree models to study the relationship between economic development and the environment. Jiang et al. (2014) conducted a study to show that China's environmental protection and its restoration cost presented a gradient distribution characterized by low-level energy saving and high cost of environment in the western region. At the same time, the industrial structure adjustment exhibited different influences on the pollution produced by different industries. Li et al. (2015) revealed that coal, paper-making, and food processing industries were the backbone industries with high risks of water pollution in Shandong Province and suggested that a new industrial pattern should be formed to protect the watershed environ-

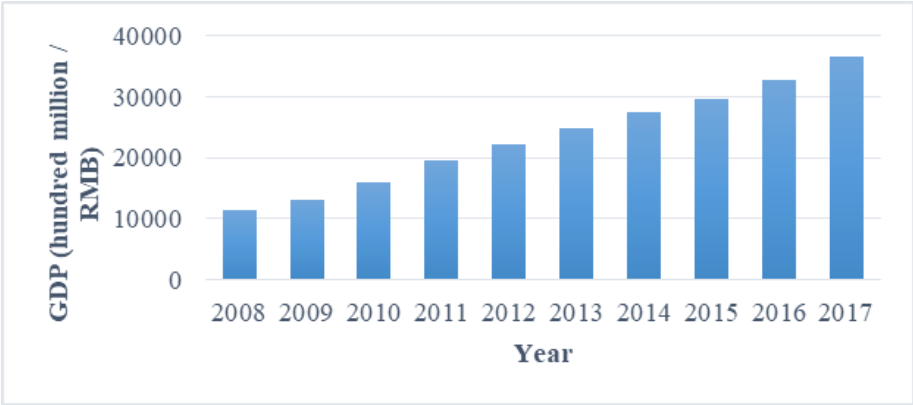

Fig. 1: GDP of Hubei Province from 2008 to 2017.

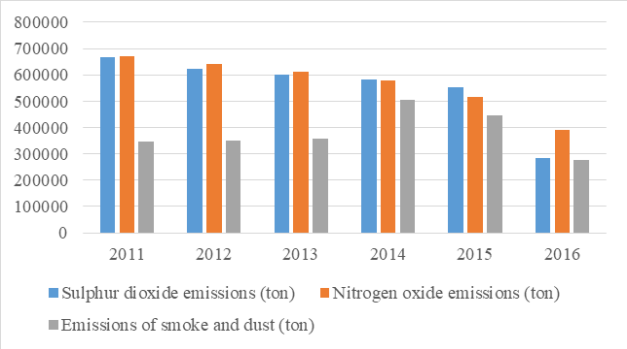

Fig. 2: Main contents of industrial waste gas in Hubei Province from 2011 to 2016.

ment. Wei et al. (2015) studied the impact of pollutants caused by China's cement industry on environmental pollution and believed that optimizing the industrial structure of cement production and increasing the consumption efficiency of energy and raw materials in cement production were effective ways to improve the environmental impact of the cement industry. Han (2016) tested the spatial correlation and agglomeration effects of environmental pollution in 31 provinces in China. The results showed that a significant positive correlation exists between environmental pollution and industrial structure. Accordingly, adjustment and optimization of the industrial structure would cause less pollution to the environment. Wang et al. (2016) illustrated the relationship between the intensity of air pollution and that of atmospheric pollutants, and the control effect of environmental pollution affected by the industrial structure in different regions. Zhang et al. (2016) evaluated the environmental efficiency of 30 provincial-level administrative regions of China and calculated the influencing factors of environmental efficiency using Tobit regression model. The results showed that industrial structure had a remarkable positive impact on environmental efficiency. Therefore, policy recommendations for improving environmental efficiency were proposed. On the basis of the provincial panel data in China from 2010 to 2015, Hou et al. (2018) systematically analysed the regional structure and development trend of green industrial transformation. The results suggested that China's industry had gradually experienced a green transformation, thus greatly reducing pollution emissions. A long-term correlation exists between industrial structure and environmental pollution, and the emission ratio varies between energy input and pollution emissions in different industries. The secondary industry releases the most pollutants among the three major industries. However, the weight of the tertiary industry in GDP and its internal structure has a remarkable influence on the environment. Although many studies show that a long-term correlation exists between industrial structure and environmental pollution, the focus is usually on the impact of the three industries or just one of them on the environment. Minimal attention is given to the related sectors in the secondary and tertiary industries. Therefore, by taking Hubei Province as the case, this study will conduct an empirical study on the impact of industrial structure on environmental pollution to identify which industries are mainly responsible for environmental pollution and propose reasonable suggestions to overcome these problems.

PRESENT SITUATION OF ENVIRONMENTAL POLLUTION IN HUBEI PROVINCE

Good trend of environmental improvement with a considerable amount of industrial wastes: As one of the old industrial bases in China, Hubei promotes iron, steel, and automobile industries, which are important pillars of local industrial development. In the early days of development, extensive modes of production based on resources, high consumption, and heavy pollution have created a remarkable increase in industrial production. However, development has also caused a certain waste of resources and pollution emissions. The discharge of industrial wastewater is on a downward trend. However, substances, such as chemical oxygen demand and petroleum, in the discharge are the major causes of water pollution. Fig. 2 shows that industrial waste gas emissions tend to rise with pollutant emissions as a whole. Waste gas emissions are mainly concentrated in the areas of smelting of ferrous metal, electric power, and solid wastes caused by nonmetallic mineral manufacturing. In recent years, the comprehensive utilization level of industrial solid wastes in Hubei Province has been improved considerably, but the utilization efficiency of resources still needs to be enhanced.

Aggravation of environmental pollution led by the unreasonable industrial structure: The secondary industry mainly produces products by consuming mineral resources and energy with many wastes. Factories are usually focused in a certain area that creates relatively concentrated pollutants, which then causes great pressure on the local environment. As depicted in Fig. 3, although the weight of secondary industry has decreased in Hubei in recent years, it remains high at 45% relative to that of the total environmental pollution in the area. The degree of pollution caused by different internal industrial structures is also different. Within different industries, capital- or technology-intensive enterprises tend to produce less resource consumption and pollution than labour-intensive ones.

Considerable energy consumption and large proportions

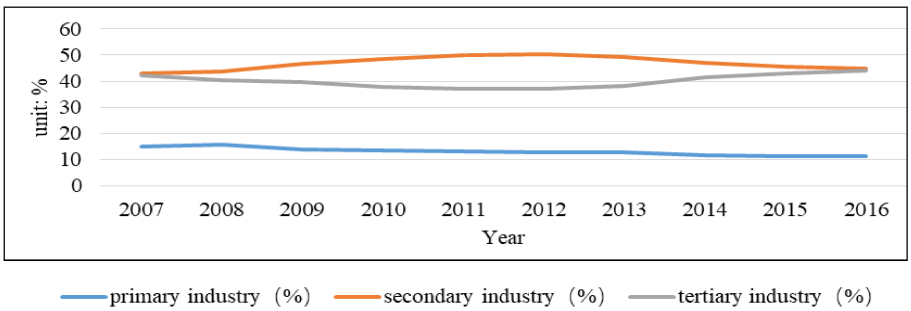

Fig. 3: Proportion of environmental pollution of the three industries in Hubei Province from 2007 to 2016.

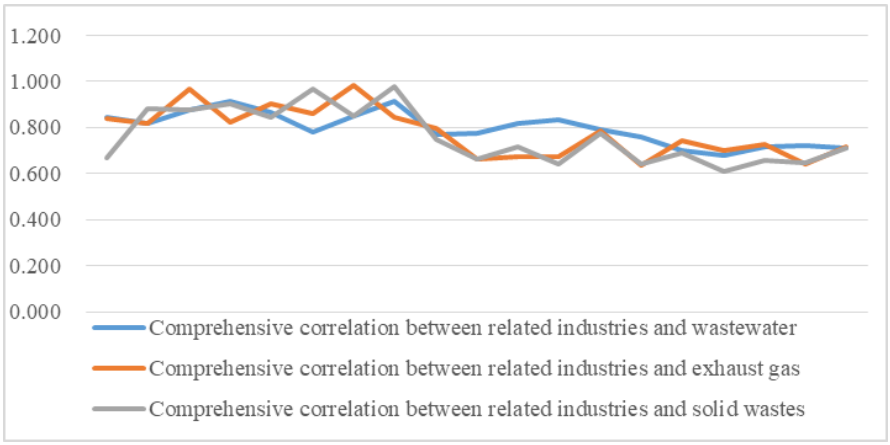

Fig. 4: Comprehensive correlation degrees between the variables of related industries and three types of waste.

of nonrenewable energy consumption: With the single energy consumption structure, Hubei Province has been excessively dependent on the energy resources that usually cause more damaging pollution to the air. Although the consumption of coal and coke has decreased in recent years, the consumption of crude oil, gasoline, kerosene, and diesel oil have increased. Table 1 presents that nonrenewable source of energy has led to serious air pollution. At the same time, sulphur dioxide, chlorine dioxide, and particulate matter in the air can result in serious environmental pollution.

ANALYSIS OF THE RELATIONSHIP BETWEEN ENVIRONMENTAL POLLUTION AND INDUSTRIAL STRUCTURE

Grey relational analysis: Instead of using a considerable amount of sample data, grey relational analysis can reflect the relationship between system and variables by only analyzing the change rate and degree of similarity among the variables. At the same time, we can determine the main and secondary variables that cause the change in the system, thus identifying those industries that have an increased impact on the environment.

First, let the mother and comparison sequences be $X_i = \{X_i(t)\}$ and $Y_j = \{Y_j(t)\}$, where i and j represent the correlation indexes in the mother sequence and comparison sequence, respectively, and t refers to time. These data cannot be compared and analysed because different raw data may have different orders of magnitude. To eliminate this effect, dimensionless processing of index figure is needed. In this study, proportion method of linear dimensionless method is used to preprocess original data, wherein the following equation is obtained:

$$X'_i = \frac{X_i}{\sqrt{\sum_{i=1}^{t} X_i^2}}, Y'_j = \frac{Y_j}{\sqrt{\sum_{j=1}^{t} X_j^2}} \quad ...(1)$$

The new sequences $X'_i = X'_i(t)$ and $Y'_j = Y'_j(t)$ are obtained after dimensionless processing of the original values, and then grey correlation is calculated.

Grey absolute correlation degree: The new mother and comparison sequences are set as X'_i and Y'_j, respectively. Similarly, the sequences will result in an increased grey absolute correlation degree and vice versa. If the starting

point of the mother and comparison sequences is X'^{0}_{i} and Y'^{0}_{j}, then the following definitions are obtained:

$$X'^{0}_{i} = \{0, X'_i(2) - X'_i(1), \cdots, X'_i(t) - X'_i(1)\} = \{X'^{0}_{i}(1), X'^{0}_{i}(2), \cdots, X'^{0}_{i}(t)\},$$

$$Y'^{0}_{j} = \{0, Y'_j(2) - Y'_j(1), \cdots, Y'_j(t) - Y'_j(1)\} = \{Y'^{0}_{j}(1), Y'^{0}_{j}(2), \cdots, Y'^{0}_{j}(t)\},$$

$$|M'_i| = \left|\sum_{k=2}^{t-1} X'^{0}_{i}(k) + \frac{1}{2}X'^{0}_{i}(t)\right|, |N'_j| = \left|\sum_{h=2}^{t-1} Y'^{0}_{j}(h) + \frac{1}{2}Y'^{0}_{j}(t)\right|$$

Grey absolute correlation degree is obtained as follows:

$$\varepsilon_{ij} = \frac{1 + |M'_i| + |N'_j|}{1 + |M'_i| + |N'_j| + |N'_j - M'_i|} \quad ...(2)$$

Grey relative correlation degree: Grey relative correlation degree is a representation of the change rate relative to the starting point between the mother X'_i and comparison Y'_j sequences. A small change rate between X'_i and Y'_j will result in an increased grey relative correlation degree and vice versa. If the following definition is given:

$$X''_i = \left\{\frac{X'_i(1)}{X'_i(1)}, \frac{X'_i(2)}{X'_i(1)}, \cdots, \frac{X'_i(n)}{X'_i(1)}\right\} = \{X''_i(1), X''_i(2), \cdots, X''_i(t)\},$$

$$Y''_j = \left\{\frac{Y'_j(1)}{Y'_j(1)}, \frac{Y'_j(2)}{Y'_j(1)}, \cdots, \frac{Y'_j(n)}{Y'_j(1)}\right\} = \{Y''_j(1), Y''_j(2), \cdots, Y''_j(t)\}$$

And the initial values of sequences exist, including X''_i and Y''_j, and the starting points are set as

$$X''^{0}_{i} = \{0, X''_i(2) - X''_i(1), \cdots, X''_i(n) - X''_i(1)\}$$
$$= \{X''^{0}_{i}(1), X''^{0}_{i}(2), \cdots, X''^{0}_{i}(t)\},$$
$$Y''^{0}_{j} = \{0, Y''_j(2) - Y''_j(1), \cdots, Y''_j(n) - Y''_j(1)\}$$
$$= \{Y''^{0}_{j}(1), Y''^{0}_{j}(2), \cdots, Y''^{0}_{j}(t)\},$$
$$|M''_i| = \left|\sum_{k=2}^{t-1} X''^{0}_{i}(k) + \frac{1}{2}X''^{0}_{i}(t)\right|, |N''_j| =$$
$$\left|\sum_{h=2}^{t-1} Y''^{0}_{j}(h) + \frac{1}{2}Y''^{0}_{j}(t)\right|.$$

Its grey relative correlation degree is obtained in the following equation:

$$\lambda_{ij} = \frac{1 + |M''_i| + |N''_j|}{1 + |M''_i| + |N''_j| + |N''_j - M''_i|} \quad ...(3)$$

Grey comprehensive correlation degree: Grey comprehensive correlation degree combines the characteristics of both absolute and relative correlation degrees, which can be used to determine the degree of closeness of the relationship between mother and comparative sequences. Grey correlation degree is defined as follows:

$$\rho_{ij} = \theta\varepsilon_{ij} + (1 - \theta)\lambda_{ij} \quad ...(4)$$

Where, θ and 1-θ, which are usually set to 0.5, refer to the importance of the absolute quantity and change rate of the comparison sequence in calculating grey comprehensive correlation degree, respectively. However, considering the values, determining the comprehensive correlation order of the three industries and the sectors with environmental pollution is possible to obtain their impact on environmental pollution. Grey comprehensive correlation degrees in the ranges of 0-0.35, 0.35-0.65, 0.65-0.85, and 0.855-1 represent weak, medium, strong, and very strong correlation degrees, respectively.

Data sources and description of indicators: The relationship between industrial structure and environmental pollution is studied using grey correlation degree method. The grey correlation degree between any mother sequence and any comparison sequence is calculated to reflect the overall similarity between the broken lines separately connected by the two sequences, which is based on local similarity. In this study, the percentage of the three major industries and various sectors in GDP is considered the distribution indicator of the industrial structure, whereas the total amount of wastewater, waste gas, and solid waste is considered the indicator of environmental pollution. To ensure the continuity integrity of the data, relevant statistics are selected during the period from 2007 to 2016. Calculating the grey absolute and relative correlation degrees, obtain the grey comprehensive correlation degree. Finally, grey comprehensive correlation degree determines the main industries and relevant sectors that affect the environment. The data are obtained from the statistical yearbook of Hubei Province and the database of the National Bureau of Statistics of the People's Republic of China (http://data.stats.gov.cn/).

Results analysis: On the basis of equation (1), the calculation of comprehensive correlation degree between tertiary industry and wastewater, waste gas, and solid waste is conducted after dimensionless treatment of the original values and treatment of the original mother and comparison sequences, as shown in Table 2.

Table 2 presents that the overall relevance of comprehensive correlation degree between the variables of the three main industries and discharge of the three types of waste is relatively high in Hubei Province, thereby indicating that the current structure of the industries and sectors in Hubei has a relatively remarkable influence on environmental pollution. The results are closely related to high-energy consumption, extensive mode of growth, and backward technical level in the economic development of Hubei. Hence, as a large industrial province, Hubei creates considerable environmental pollution, mainly through its secondary industry, followed by its primary industry and tertiary industry. In addition, the three main industries have a strong correlation with the emissions of the three types of waste. Ta-

Table 1: Energy consumption in Hubei Province from 2011 to 2016 (unit: 10,000 tons).

Indicators	2011	2012	2013	2014	2015	2016
Coal consumption	15805	15799	12166.72	11887.83	11765.91	11685.88
Coke consumption	1172.72	1113.85	1114.39	1124.4	1030.01	1095.31
Crude oil consumption	1026.23	947.74	1176.72	1290.87	1299.01	1239.61
Gasoline consumption	497.81	566.71	616.05	660.05	699.92	743.19
Kerosene consumption	46.75	53.26	63.77	66.04	69.87	94.64
Diesel oil consumption	698.07	732.07	805.41	863.69	859.02	865.85
Fuel oil consumption	97.34	104.29	118.84	135.51	148.75	136.12

Table 2: Comprehensive correlation degrees between the variables of three industries and three waste types.

	Comprehensive correlation degree of wastewater	Comprehensive correlation degree of waste gas	Comprehensive correlation degree of solid wastes	Order
Primary industry	0.9104	0.7564	0.6412	2
Secondary industry	0.9451	0.8245	0.6854	1
Tertiary industry	0.8054	0.7212	0.5941	3

ble 2 shows that the correlation between the variables of the three industries (primary, secondary, and tertiary industries) and wastewater has reached over 0.9, which indicates the most serious impact on the environment. The correlation between tertiary industry and wastewater has also registered 0.8054. In theory, tertiary industries are beneficial to the improvement of the environment, but it can increase environmental pollution. In terms of waste gas, the comprehensive correlation degree between secondary industry and waste gas is 0.8245, which is also the most visible in the comprehensive correlation degree between the variables of the three major industries and waste gas. The statistical data suggest that traditional enterprises in Hubei Province are the main component in the secondary industry, wherein the majority is still in the low end of the industrial chain causing considerable pollution. Moreover, the weight of high-tech companies is relatively small. Compared with wastewater and waste gas, the correlation is less between solid waste and the three major industries. However, the secondary industry has the greatest impact on the environment with a correlation degree of 0.6854.

After analyzing the grey comprehensive correlation coefficient between the variables of the three industries and the main environmental pollutants, the correlation degree between related industries and the three types of waste are calculated. Given that relevant industries are too many, Fig. 4 illustrates the correlation degree between industries and the three types of waste to directly reflect the impact of the industries on the environment.

Related industries, such as mining, manufacturing, electricity, heat, gas and water production and supply, construction and transportation, storage and postal service industries in Hubei Province, are highly correlated with the three types of waste, wherein the grey comprehensive correlation values are above 0.8, thereby indicating that the industries mentioned are the main polluters. As most of them are labour-intensive industries, technical standards of related industries should be improved to minimize the pollution of labour-intensive industries to the environment. In addition, the correlation degree between the variables of the three types of waste and technology-intensive industries, such as information transmission, software and information technology services, scientific research, and technology services, is over 0.7. Thus, we should take environmental influences into consideration when applying advanced production techniques. Industries that have decreased impact on the environment are wholesale and retail trade, water conservancy, environment and utilities management, education, health and social work, culture, public administration of sports and entertainment, and social organization. However, with a low percentage of GDP in the secondary and tertiary industries, these sectors should be promoted vigorously in the future due to their relatively small impact on environmental pollution.

MEASURES TO CONTROL ENVIRONMENTAL POLLUTION

Optimizing the internal structure of the secondary industry and improving the energy efficiency: With an unreasonable industrial structure, the local government of Hubei should focus on the optimization of the internal structure of the secondary industry and lower the weight of heavy industry and demand for energy. At the same time, depending

on the advantage of abundant human capital, the government should focus on the research and development of technology to improve energy efficiency. We should remain committed to exploring industrialization, adjusting the structure of the secondary industry, reducing the proportion of heavy and chemical industries, and strictly limiting the development of energy-intensive industries. Furthermore, industries with high-energy consumption and low output should be phased out because of the considerable challenge of environmental pollution that they create. Doing so will be conducive not only to the economic development of Hubei Province, but also to the improvement of the environment. In the process of developing an advanced manufacturing industry, the first problem to overcome is the cultivation of innovation consciousness and research and development ability for its personnel. Accordingly, a perfect system is needed to guarantee and encouraged to obtain this development.

Innovating agricultural development system by increasing the proportion of tertiary industry: We should be committed to obtaining low or zero carbon emission in the agricultural system by changing the mode of agricultural development and innovating the system of agricultural development by means of promoting circular agriculture model and green low-carbon agricultural technology. In terms of green ecological agriculture, we can use planting pattern by combining multiple and main species to form a reasonable competition among plants. We should also exploit the different types of resources of per unit space and reduce the amount of pesticide spraying. Biogas digesters should be built, and the comprehensive utilization of wastes, such as straw, should be improved. We can reduce the pollution caused by direct combustion in the open air with the above mentioned techniques. The development level of the service industry, which is only a small part in the reduction of environmental pollution, is still lower in Hubei Province than other coastal provinces. Therefore, the local government of Hubei should focus on internal structure optimization of the tertiary industry in the coming years as the weight of the tertiary industry is increased. In the meantime, efforts should be made to raise the technical standards of labour-intensive industries to promote improvement of the industrial structure and reduce the impact of the tertiary industry on environmental pollution in Hubei Province.

Improving the utilization of resources to promote industrialization: We should encourage research and development of processing technology for mineral, coal, and metallic mineral resources to constantly strengthen their comprehensive development and utilization. In the chain of resource consumption, we should ensure the moderate consumption of resources and follow the correct standard and concept to improve the utilization of resources. In the midst of industrialization, enterprises should focus on the production of wastes in production activities, especially heavy industries. When organizing production activities, production technology and productivity should be improved to reduce the excessive discharge of industrial wastewater, and emissions of industrial waste gas and industrial solid wastes. Improving the production of wastes is necessary to upgrade the comprehensive utilization of waste resources, especially of industrial solid wastes. We should also make efforts to strengthen the utilization efficiency of renewable resources that enable companies to enhance the recycling utilization of resources. In terms of resource consumption, the government must enhance the people's expense consciousness and concept by promoting social consumption attitudes and advocating consumption patterns that benefit resource conservation and environmental protection.

Improving the standard system of laws and regulations and environmental tax policy: In the center of industrialization, controlling the emission of environmental pollutants is essential in production activities of enterprises. Pollutant discharge from heavy industries should be supervised, and only by improving the environmental tax policy can behaviours of collection for pollution charge be reduced and restrained. For enterprises that have invested in high and new technology to reduce the discharge of industrial wastes, the government should decrease the environmental pollution tax or develop subsidy policies for them. Accordingly, such enterprises can decrease the cost for research and development of new technology and enhance the enthusiasm of production and enterprise income. New technology will also be developed constantly to reduce the emission of environmental pollutants. The government should formulate standards for levying environmental pollution tax for heavy industries with high pollution and raise the standards of taxation for heavily polluted enterprises to restrain pollution-emission activities. We can stimulate the production behaviours of high-pollution enterprises only by raising the tax standards and increasing the production cost of enterprises to promote the improvement of the level of technological research and development and invest more in high and new technology. Therefore, enterprises will be encouraged to transform from high- to low-pollution production.

CONCLUSION

Industrial structure is the main link of mankind to the ecological environment system. Accordingly, the unreasonable

structuring of industries directly affect the environment improvement measures. This study first analysed the present situation of environmental pollution in Hubei Province and then calculated the comprehensive correlation coefficient between industrial structure and environmental pollutants. The results show that the main characteristics of environmental pollution are the large total amount of industrial wastes, aggravated environmental pollution led by unreasonable industrial structure, and high proportion of nonrenewable energy consumption in Hubei. The overall relevance of comprehensive correlation degree between variables of the three main industries and discharge of the three waste types is relatively high in Hubei. The correlation between the variables of the industries (primary, secondary, and tertiary industries) and wastewater has reached over 0.9. The comprehensive correlation degree between secondary industry and the waste gas is 0.8245, and the correlation degree between solid waste and the three major industries is 0.6854. Mining, manufacturing, electricity, heat, gas and water production and supply, construction, transportation, storage, and postal services and the three types of waste are highly relevant with a gray comprehensive correlation of more than 0.8. Such industries should be studied further as the interaction is crucial among industry transfer and environmental pollution, calculation of environmental effects caused by industrial structure changes in different regions, more complex econometric models for analyzing the relationship between economic growth and environmental pollution, and relationship among technological progress, utilization of resources, and control effect of environmental pollution.

REFERENCES

Brajer, V., Mead, R.W. and Xiao, F. 2011. Searching for an environmental Kuznets curve in China's air pollution. China Economic Review, 22(3): 383-397.

Han, N. 2016. A spatial econometric analysis of economic growth, industrial structure and environmental pollution in China. Environmental Engineering, 34 (7): 155-159.

He, J. and Wang, H. 2011. Economic structure, development policy and environmental quality: An empirical analysis of environmental Kuznets curves with Chinese municipal data. Ecological Economics, 76(1): 49-59.

Hou, J., Teo, T.S.H. and Zhou, F. et al. 2018. Does industrial green transformation successfully facilitate a decrease in carbon intensity in China? An environmental regulation perspective. Journal of Cleaner Production, 184: 1060-1071.

Jiang, Q., Tang, C. and Zhan, J. et al. 2014. Environmental cost and pollution risk caused by the industrial transfer in Qinghai Province. Frontiers of Earth Science, 8(3): 362-374.

Li, N., Yang, H. and Wang, L. et al. 2015. Optimization of industry structure based on water environmental carrying capacity under uncertainty of the Huai River Basin within Shandong Province, China. Journal of Cleaner Production, 112: 4594-4604.

Li, X., Yang, J. and Sheng, P. 2011. Structure and application of a new comprehensive environmental pollution index. Energy Procedia, 5(5): 1049-1054.

Llop, M. 2007. Economic structure and pollution intensity within the environmental input-output framework. Energy Policy, 35(6): 3410-3417.

Oosterhaven, J. and Broersma, L. 2007. Sector structure and cluster economies: A decomposition of regional labour productivity. Regional Studies, 41(5): 639-659.

Ru, X., Chen, S. and Dong, H. et al. 2012. An empirical study on relationship between economic growth and carbon emissions based on decoupling theory. Journal of Sustainable Development, 5(8): 43-51.

Tian, L., Chen, J. and Yu, S.X. et al. 2014. Coupled dynamics of urban landscape pattern and socioeconomic drivers in Shenzhen, China. Landscape Ecology, 29(4): 715-727.

Wang, H.W., Gu, J. and Chen, M.L. 2016. Comprehensive evaluation between regional pollution industry concentration and atmosph-eric pollution emission. Systems Engineering, 34(11): 59-63.

Wang, X.Q., Yang, Z.F. and Liu, C.M. 2000. Regional economic structural adjustment and water environmental protection: A case of Guanzhong region in Shaanxi province. Acta Geographica Sinica, 55(6): 707-718.

Wei, C., Hong, J. and Xu, C. 2015. Pollutants generated by cement production in China, their impacts, and the potential for environmental improvement. Journal of Cleaner Production, 103: 61-69.

Zhang, J., Zeng, W. and Shi, H. 2016. Regional environmental efficiency in China: Analysis based on a regional slack-based measure with environmental undesirable outputs. Ecological Indicators, 71: 218-228.

Zhou, X., Lan, G. and Huang, M. et al. 2002. Investigation of pollution control and industrial structure adjustment of pulp/paper industries in Hubei province. Environmental Science & Technology, 25 (1): 20-22.