Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

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

Vol. 18 | No. 1 | pp. 251-259 | 2019

Original Research Paper

Open Access

Functional Mechanism and Cointegration Relation of Environmental Regulations on Industrial Structure Upgrading in Beijing, China

Lili Zhang*(**)† and Gang Zong*
*School of Economics and Management, Beijing University of Technology, Beijing, 100000, China
**Beijing College of Social Administration, Beijing, 100000, China
†Corresponding author: Lili Zhang

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

Received: 15-01-2019
Accepted: 16-02-2019

Key Words:
Environmental regulation
Industrial structure
Functional mechanism
Cointegration relationship

ABSTRACT

In recent years, China has accelerated its urbanization and industrialization processes. The traditional extensive economic growth mode of high investments, high energy consumption, and high emissions has brought irreversible negative impacts on the ecological environment. Environmental regulation can promote necessary changes in the industrial structure and improve economic structure by eliminating the negative externalities of environmental pollution and enhancing social welfare. With time series data of Beijing from 1998 to 2017, the mechanism and impact of environmental regulations on industrial structure were analysed using cointegration analysis and Granger causality test. Results show that environmental regulations can effectively realize industrial structure upgrading by inhibiting the development of high-pollution enterprises, accelerating the development of the service industry, promoting the environmental protection of enterprise production technology, and promoting the optimization of investment structures. Thus, a long-term and positive equilibrium relationship between industrial structure upgrading and environmental regulation in Beijing can be achieved. The investment in industrial pollution control per unit can drive the growth of the tertiary industry's added value by 0.017 units. The completion of industrial pollution control investment is the one-way Granger reason for the tertiary industry's added value to the proportion of gross domestic product. The conclusions have a certain reference value for finding out the intensity of environmental regulation in promoting Beijing's industrial structure optimization and realizing the transformation of economic structure and coordinated development of ecological civilization construction.

INTRODUCTION

China's economy has rapidly grown in the past 20 years. However, ecological and environmental problems have become increasingly severe, and the contradiction between economic growth and environmental pollution has become increasingly prominent. In recent years, the smog in China has significantly worsened, gradually affecting people's daily lives and physical health. With the previous high-pollution, high-energy-consumption economic development mode, China has experienced a shortage of resources, environmental pollution, and ecological problems. Environmental destruction and other economic and social issues, ecological environmental governance, and resource conservation and utilization have become important issues that China's economic development must face. The extensive economic growth mode of high consumption, high emissions, and high investments has made China the world's largest energy consumer. This growth mode has caused serious environmental pollution and resource destruction, thereby significantly increasing China's resource and environmental constraints. It has seriously affected and restricted the sustainable development of the economy. At present, the main challenge of China is to improve the environmental quality while pursuing sustainable economic development. The main method to overcome this challenge is to transform the economic development mode and optimize the industrial structure upgrading. The externalities of resources and the environment have made government interventions in environmental pollution necessary. Thus far, the Chinese government has implemented a series of environmental regulations, including enacting environmental protection laws, strengthening environmental supervision, increasing investments in environmental protection, and collecting sewage charges.

As a political, economic, and cultural center of China, Beijing also faces environmental problems and unreasonable industrial structure. In particular, during the period of accelerating urbanization and industrialization, Beijing has used traditional economic growth methods, such as high investments, high energy consumption, and high emissions. Such extensive methods have brought irreversible negative impacts on the ecological environment. In recent years, smog has frequently formed over Beijing, environmental pollution problems have reached serious levels in several areas,

and energy consumption has remained high. As shown in Fig. 1, although the proportion of the tertiary industry in Beijing has increased every year, industrial structure optimization remains necessary. A large number of studies and practices have shown that environmental regulation has forced the industrial structure to transform into a service economy, increase the proportion of the service industry in the three industrial structure sectors, and enable the service industry to quickly become the leading industry of the national economy. These measures can effectively reduce resource consumption and improve the environment. Therefore, an in-depth study of whether environmental regulation can promote the optimization and upgrading of the industrial structure while protecting the ecological environment will help understand the relationship between environmental regulation and industrial structure and ecological environmental protection and industrial structure of Beijing. Furthermore, upgrading presents important theoretical and practical implications.

EARLIER STUDIES

With the increasing environmental problems, countries have begun to gradually increase investments in environmental regulation since the 1930s. The impact of environmental regulation on economic development, especially how to affect the upgrading of industrial structures, has gradually attracted the attention of economists. With the continuous development of environmental regulation theory, most scholars believe that the improvement of environmental regulation levels can promote the improvement of enterprise technology innovation levels and will be transmitted to the industrial structure field, thus adjusting the industrial structure. Gray, et al. (1996) mainly studied the relationship between regulators' implementation of air pollution regulations and corporate compliance decisions. The results showed that enterprises implemented better environmental protection policies that were conducive to enterprise development. Lanjouw et al. (1996) considered the situation of the United States and Japan in 1970-1980 as examples. The study found that the industrial structure upgrade is positively correlated with the intensity of environmental regulation. Berman et al. (2001) found that the environmental regulation intensity of the petroleum industry played a significant role in promoting the total factor productivity of enterprises in the field. Lanoie et al. (2008) conducted an empirical research on Canadian manufacturing. The results showed a reverse change between industrial productivity and environmental regulation in the current period. However, a positive correlation is predicted to occur after four years, which indicates environmental regulation with a certain delay in impact. Lee (2008) estimated the cost-limiting function of the Korean steel industry and analysed the impact of environmental regulation on its production efficiency. Christoph et al. (2010) used the German computable general equilibrium model to study the effect of carbon tax unilateral introduction. The results show that industrial structure changes are more obvious under an imperfect competition than under a perfect competition. Zhang (2010) believed that in the development process of industrialization and urbanization, the implementation of a clean production is the best choice for economic development. The industrial structure upgrading is an arduous task for the development of each region and should pay attention to environmental protection.

Relevant studies on regulatory mechanism: Lanoie (2011) used the simultaneous equation method to analyse the microdata of enterprises in seven member countries of Organization for Economic Cooperation and Development. The results also showed that environmental regulation has a significant role in promoting R & D investment. Becker et al. (2013) estimated the relationship between plant size and pollution reduction expenditures through the establishment of level data by US manufacturers. The results showed that the effect of environmental regulation varies depending on the company's size and the industry in which it belongs. Zhu et al. (2014) believed that environmental regulation is an important condition for enterprise structure adjustment. Pollution-intensive industries will accordingly adjust production and promote industrial structure upgrading through technological innovations, technology upgrading, and location layout. Wang et al. (2016) believed that environmental regulation has a significantly positive impact on a clean production industry, but a lagging effect on pollution-intensive industries. Thus, the government should formulate environmental regulation standards and industry characteristics, emphasizing flexibility rather than absolute improvements.

Relevant studies on environmental regulation level: Guo (2017) used 2011-2012 data from 30 Chinese provinces to analyse the relationship among environmental regulation, technological innovation, and regional green performance growth. The results showed that only environmental regulation driven by technological innovation produced a positive impact on regional green performance growth. On the basis of the theory of economics and industrial organization, Zhang (2018) incorporated environmental regulation policies into the traditional SCP paradigm and analysed the transmission mechanism of market structure and market behaviour to the coordinated development of environment and economy. The results of the study showed that the environment was strengthened. Supervision is an

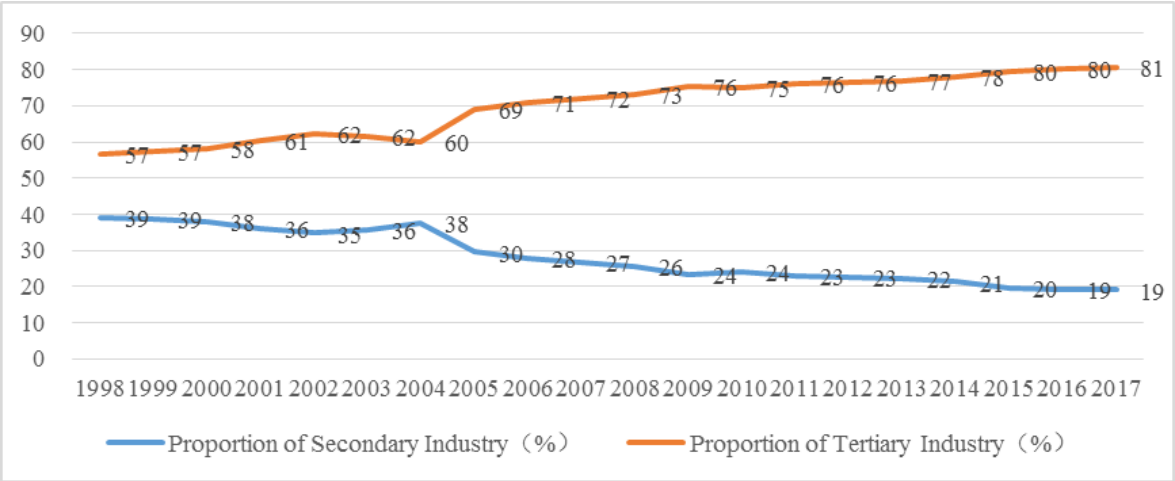

Fig. 1. Proportion of secondary and tertiary industries in Beijing, 1998–2017.

effective means of ensuring economic growth and optimizing environmental quality. Hou et al. (2018) used the 2010-2015 China's Industrial Provincial Panel Data to systematically analyse the regional structure and development trend of industrial green transformation. The study found that China's industry gradually achieved a green transformation and significantly reduced pollution emissions. The existing literature about environmental regulation focused on environmental regulation on economic growth, technological progress, international trade, and industrial restructuring. However, published works on the impact of environmental regulation on industrial structure optimization are scarce. Considering Beijing as an example, this study discusses the impact of environmental regulation on industrial structure from the mechanism of action, expounds the impact of environmental regulation on the optimization of Beijing's industrial structure, and helps the government adopt appropriate environmental regulation policy tools and economic development strategic objectives. By solving resource and environment problems, this study can effectively promote the industrial structure upgrading in various regions of Beijing and achieve sustainable economic development.

INFLUENCE MECHANISM OF ENVIRONMENTAL REGULATION ON INDUSTRIAL STRUCTURE

Environmental Regulation Inhibits the Development of High-pollution Enterprises

The improvement of the environmental regulation intensity can produce the role of survival of the fittest and promote the adjustment and upgrading of industrial structure. Strict environmental regulations will increase production costs by forcing companies to purchase sewage equipment, reduce production to meet environmental regulations, and limit the use of specific factor inputs. Large-scale pollution-intensive industrial enterprises can reduce pollutant emissions by purchasing sewage equipment or limiting production capacity in a short period of time. Then, the combination of factors and inputs can be adjusted and more low-carbon energy-saving production technologies and service intermediate inputs can be used. These efforts will inevitably lead to faster growth of service industries, which will transform the industrial structure into a service economy. For small and medium-sized polluting industrial enterprises, rising environmental costs will affect their optimal and effective scale. Several of these enterprises are unable to obtain the economies of scale, are likewise unable to replace or upgrade production or pollution control equipment, and are eventually forced to withdraw. In the market, the scale of pollution-intensive industries is gradually shrinking, and the clean industry represented by the service industry will occupy a larger proportion. As a result, strict environmental regulations can successfully eliminate the production capacity of pollution-intensive industries, accelerate the development and expansion of the service industry, and effectively drive the adjustment and upgrading of the industrial structure. Strict environmental regulations will also increase the sunk costs and the marginal production or average costs of the polluting industrial sector, resulting in a decrease in the number of companies entering the polluting industry and increasing those entering the clean industry represented by the service industry. The green barriers to environmental regulation can inhibit the expansion of pollution-intensive industries, accelerate the development of service industries, and promote the transformation of industrial structure to higher levels.

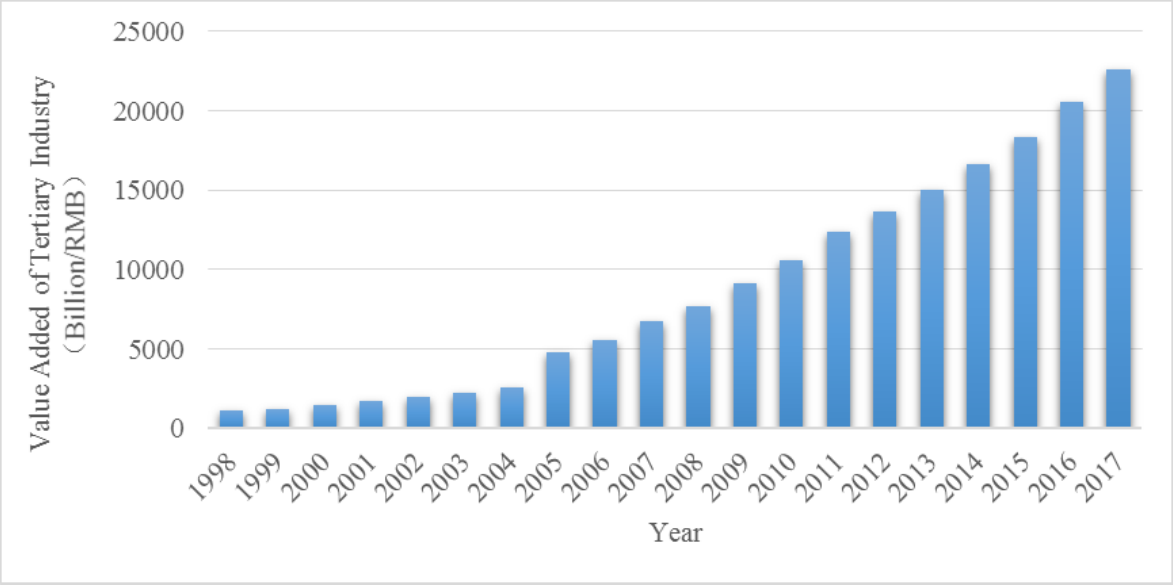

Fig. 2: Value addition of the tertiary industry in Beijing (1998-2017).

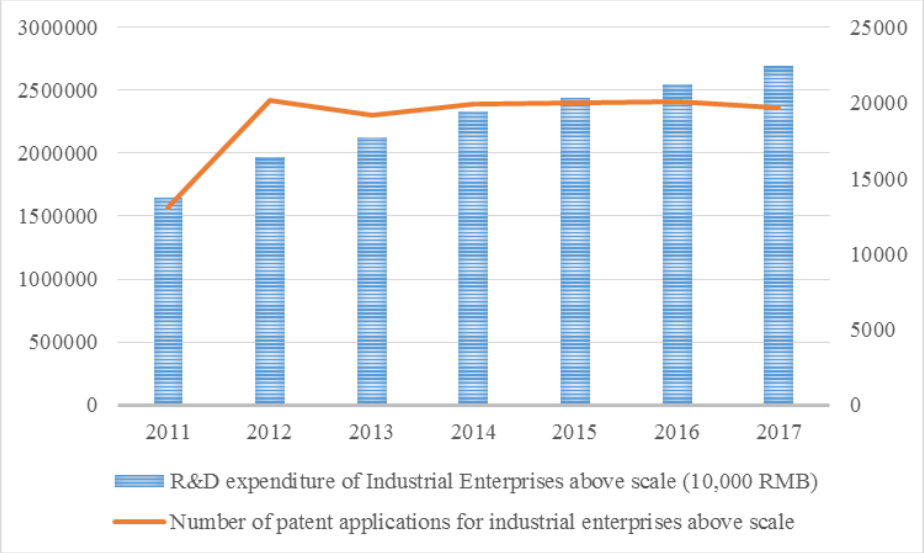

Fig. 3: R&D funds and patent applications of industrial enterprises above scale in Beijing from 2011 to 2017.

Environmental Regulation Accelerates Service Industry Development

Environmental regulation promotes the demand for green consumption. As shown in Fig. 2, the output value of Beijing's service industry has increased every year, which in turn has driven the development of the green service industry. This development is conducive to the transformation of the industrial structure into a service economy. The direction of technology and industrial upgrading ultimately depends on consumer or market recognition. Thus, consumers' response to environmental regulation is the original driving mechanism for industrial restructuring. With the promotion and transmission of the concept of green consumption in the process of environmental regulation, consumer awareness of environmental protection and participation is constantly increasing. Moreover, environmental regulation is conducive to improving consumers' understanding of product energy consumption information, eliminating the asymmetry between producers and consumers

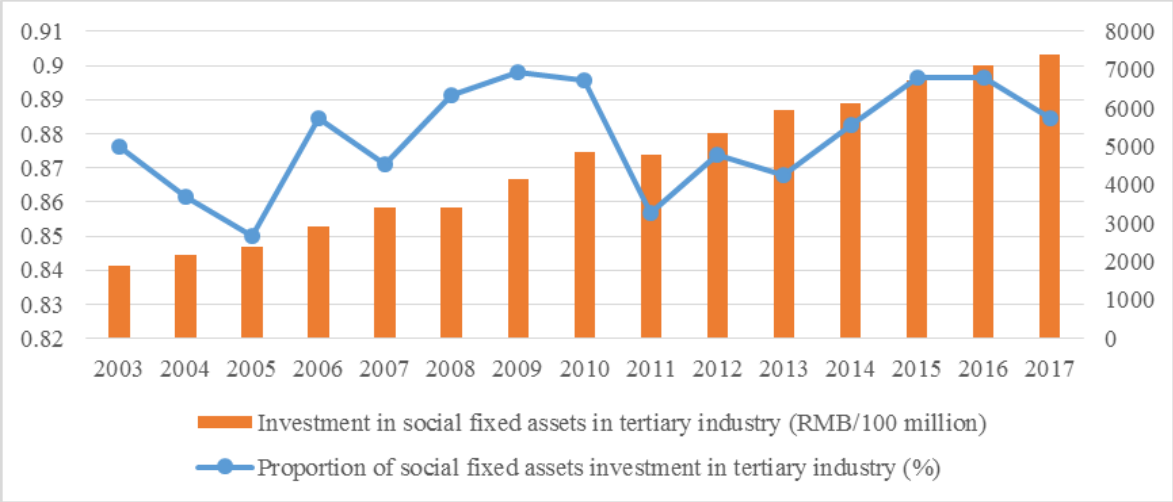

Fig. 4: Amount and proportion of social fixed asset investment in the tertiary industry in Beijing from 2003 to 2017.

about the product environmental protection information, and thus promoting green consumption. In addition, regulation is conducive to encouraging the development and application of green service products and developing and expanding the green service industry. The increase of green consumption will inevitably drive service companies to provide green products and services to consumers, while restricting the circulation of non-green products and entry of non-green services. Such market results in greater power and pressure for the green innovation of service enterprises. Consequently, the scale of green investment for service companies will be inevitably driven and increased, the share of the service industry in the national economy through the investment multiplier effect will be widened, and the industrial structure will be promoted.

Environmental Regulation Promotes More Environment Friendly Production Technology

Environmental regulation can promote the innovation and upgrading of environmental protection technologies, the rapid development of clean and environment-friendly industries represented by the service industry, and the transformation of industrial structure. Enterprises now face strict environmental regulation standards of the government. To control pollution emissions, they will improve their competitiveness by improving production processes, reducing resource input, improving efficiency, reducing production costs, and improving product quality. As shown in Fig. 3, the number of R&D funds and patent applications of industrial enterprises above the designated size in Beijing has increased each year. As a result, industrial enterprises improve their production processes or their pollution control capabilities through technological innovation and ultimately alleviate or offset the environmental regulations implemented by the government. Environmental costs can generate innovative compensation effects, including products and production processes, to achieve a win-win situation. These R&D and innovation activities for clean production or clean products will help develop equipment and technologies that reduce pollution emissions and deal with existing pollution problems. As a result, the production technology advancement and environmental technology upgrades of the entire industry will be driven, in particular the service industry. The clean and environment-friendly industries represented by the rapid development have promoted the transformation and upgrading of the industrial structure to the service economy.

Environmental Regulation Promotes Investment Structure Optimization

The government's development of environmental regulation tools places adverse constraints on the production activities of pollution-intensive industries. As shown in Fig. 4, the amount of fixed asset investment in the tertiary industry in Beijing has increased each year. Similarly, the proportion of fixed asset investment in the tertiary industry to total industrial social fixed assets has remained at a high level of 85%. Due to the existence of environmental regulations, and driven by economic interests, investors will inevitably turn their investments toward industries with relatively low environmental protection and environmental regulations, which will affect the structure of investment demand. In an area with relatively strict environmental regulation intensity, the investment demand of capital will shift

Table 1: Unit root test.

Variable	ADF	Threshold	AIC	SC	D.W	Result
Ln*Inv*	-1.899	-3.029*	1.794	1.894	1.446	Unstable
Ln*Str*	-1.204	-3.832*	-3.897	-3.798	2.327	Unstable
DLn*Inv*	-4.991	-3.858*	1.744	1.845	1.409	Stable
DLn*Str*	-4.696	-3.857*	-3.778	-3.679	2.076	Stable

Note: * is the threshold at the 1% significance level.

to an energy-saving and clean industry. Therefore, environmental regulation will affect the investment preference of capital to a certain extent. Environmental regulation produces a certain degree of influence on the proportion of investment. For example, the low carbon economy and other related initiatives currently advocated by the policy will lead consumers to use environment-friendly products. Generally, such products have high technical content, and the increase in demand and production costs make this a type of environmental protection. Thus, the product has a higher market price than the ordinary product. However, a relatively loose environmental regulation leads to relatively lower cost of production activities of the enterprise and thereby relatively higher investment activities.

EMPIRICAL RESEARCH

Indicator Selection and Data Source

At present, China mainly uses traditional regulatory methods as environmental regulation tools. Thus, we only study the impact of command-controlled and economic-incentive environmental regulation tools on industrial structure upgrading. In view of the availability and representativeness of the data, we use Beijing's industrial pollution control completion investment (*Inv*) as indicator to measure the intensity of command-controlled environmental regulation. The industrial structure upgrade is represented by the ratio of the added value of the tertiary industry in Beijing to the gross domestic product or GDP (*Str*) in 1998-2017. The data are obtained from the China Statistical Yearbook and China Environmental Statistics Bulletin. To eliminate heteroscedasticity, the time series data are first logarithmically transformed and renamed *LnInv* and *LnStr* after the transformation.

Unit Root Test

In practical problems, when obtaining sample data that present a random time series, the first task is to judge its stationarity. Commonly used time series stationarity test methods include graphical analysis, autocorrelation function analysis, unit root test, and the commonly used ADF unit root test. The latter method is used in this study. Conversely, the non-stationary time series is directly regressed, and a "pseudo-regression" problem may occur. The unit root test results of *LnInv* and *LnStr* are shown in Table 1.

As shown in Table 1, the ADF values of *DLnInv* and *DLnStr* are smaller than the critical values, and the DW statistics are close to 2. Thus, time series *LnInv* and *LnStr* are levelled after the first-order difference and classified to the first-order single integer.

Cointegration Test

Cointegration theory holds that although each of the two or more variables is non-stationary, some linear combinations may terminate the influence of the trend term, creating a stable combined variable. The significance of cointegration theory is its avoidance of pseudo-regression and differentiation of the long-term equilibrium relationship and short-term dynamic relationship between variables. The precondition for cointegration is that the variables must all be in the same order; otherwise, the cointegration study cannot be performed. A common method of cointegration testing is the Engle-Granger test of two variables, which is used in this study. The steps are as follows.

The equation between *LnInv* and *LnStr* is estimated using the ordinary least squares method, and the non-uniform error is calculated. The estimated equation is:

$$\underset{}{\mathrm{Ln}Str} = \underset{(0.000)}{4.186} + \underset{(0.068)}{0.017}\,\mathrm{Ln}Inv + \underset{(0.000)}{0.971}\,AR(1) \qquad ...(1)$$

The residuals of the regression equation (1) are named separately, denoted as Resid1, and the residuals are subjected to the ADF unit root test (the threshold are all values at the 1% significance level). The results are shown in Table 2.

As shown in Table 2, the sequence and cointegration relationship reflected by the regression model is established. A long-term equilibrium exists between the investment amount of industrial enterprise pollution control and the industrial structure upgrade, wherein the former produces a positive impact on the latter. A unit of completed industrial pollution control investment in Beijing can drive the growth of 0.017 units of added value from the tertiary industry in proportion to the GDP. This finding shows that Beijing can promote the industrial structure upgrading and rapid development of its tertiary industry by completing industrial

Table 2: ADF test results of regression equation residuals.

Variable	ADF	Threshold	AIC	SC	D.W	Result
Resid1	-4.538	-3.832*	-3.909	-3.809	2.1747	Stable

Note: * is the threshold at the 1% significance level.

Table 3: Granger test of railway freight volume and GDP.

Null hypothesis	Lag order	*P value*	Result
LnStr is not the Granger reason for *LnInv*	2	0.547	Acceptance
LnInv is not the Granger reason for *LnStr*	2	0.024	Rejection
LnStr is not the Granger reason for *LnInv*	3	0.478	Acceptance
LnInv is not the Granger reason for *LnStr*	3	0.038	Rejection

pollution control investments and implementing pollution control. In addition, as the development of real estate, catering, and tourism in the tertiary industry requires relatively high environmental quality as a guarantee, the development of these industries will promote a high degree of investment in environmental pollution control and strengthen the intensity of environmental regulation.

Granger Test

Causality refers to the dependence between variables. The resulting variable is determined by the causal variable, and changes in the causal variable leads to changes in the resulting variable. The basic premise of the Granger test is that the past cannot be predicted in the future; if the change in *Y* is caused by *X*, then the change in *X* should occur before the change in *Y*. Here, the Granger causality test is required for *LnInv* and *LnStr*. The results are shown in Table 3.

As shown in Table 3, at a significance level of 0.05, the lag periods of 2 and 3 all reject *LnInv* as the Granger reason for *LnStr*, that is, Beijing industrial pollution control completed investment is the Granger reason for the added value of the tertiary industry in proportion to GDP. At a significance level of 0.05, the lag periods of 2 and 3 accept that *LnStr* is also not the Granger reason for *LnInv*, that is, the Beijing industrial pollution control completed investment is not the Granger reason for the added value of the tertiary industry in proportion to GDP. Only a one-way Granger causality exists between *LnInv* and *LnStr*, reflecting the obvious adjustment effect of Beijing's environmental regulation on the industrial structure.

POLICY RECOMMENDATIONS

Strengthen the Implementation of Environmental Regulation Policies and Source Governance

An important means to promote the industrial structure upgrading of the manufacturing industry and develop green manufacturing is to formulate differentiated environmental regulation policies. Specifically, thorough and in-depth investigations of different industries in different regions and understanding the actual pollution emissions in the current development of the industry are necessary before specific policy formulations to achieve large-scale production and manufacturing, optimize resource allocation, and eliminate backward production capacity. At the same time, the government can reduce the tax revenue of manufacturing enterprises and subsidize enterprises with better pollution treatments. In addition, the government needs to guide enterprises to change from "end-of-pipe governance" to "source governance" and formulate specific regulations on the use of raw materials and in the manufacturing process. These efforts will help control the emission of pollutants from the source and reduce pollutants in the production process.

Encourage Production Enterprises to Conduct Technological Innovation and Create a Good Talent Atmosphere

Active investments and improved level of technological innovation are necessary to emphasize the shift from "end governance" to "source governance". Under the increasingly strict environmental regulation policy, we should adopt active and sustainable response measures, strengthen technological innovation to promote enterprise transformation and upgrading, and remove the reliance on the "end-of-pipe" approach to passively respond to environmental regulation policies. Instead, our efforts must focus on "source governance". Technical innovation should be applied in the production, and the utilization efficiency of raw materials should be improved. The manufacturing process requires improvements and the equipment need upgrades. In addition, enterprises should actively absorb high-quality talents, create good working conditions, and hardware and software environment for technological innovation. Then,

a corporate ideology and cultural atmosphere that emphasizes and pursues technological innovation should be established.

Strengthening Environmental Regulation and Eliminating Backward Production Capacity

The monitoring and testing of pollutant emissions in the process of environmental regulation and the statistical indicators of pollutants should be improved to better detect pollutant emissions and enhance the effectiveness of environmental regulation. An increase in manpower input of the environmental protection department and further improvements of environmental regulation laws and regulations are necessary to ensure the orderly conduct of environmental regulation. As such, the technical level of some industries is lower than the industry average, partly because its production capacity is low, and the energy consumption and pollution emissions of production processes are higher than the industry average. Thus, outdated production capacity should be eliminated. The government should hasten the elimination of backward production capacity by improving market access, improving relevant laws and regulations, and increasing penalties for such industries.

Increase Investment in Technology and Develop High-tech Industries

Despite its rapid development, China's manufacturing industry has long remained in the middle and low-end manufacturing position. On the one hand, many sectors in China's manufacturing industry encounter problems of insufficient technology investment. With their low profit margins, increasing technology investments will inevitably increase their R&D investment and management costs, thereby putting pressure on their survival. On the other hand, in the current international market, the competition among high-tech industries has entered a feverish degree. However, China's high-tech industry is still in its slow development. Therefore, if China wishes to remove its low-end status in the international competition, then the government must strongly support the development of science and technology. The mandatory tasks include increasing investment in technology, prioritizing the development of high-tech industries, optimizing the investment structure, guiding the upgrading of industrial structure, and promoting the integration of "production, study, and research". We should actively seek and strengthen the training mechanism for high-tech talents, increase large-scale production in industries with high pollution control, and provide a certain level of financial support for clean enterprises. The transformation and upgrading of the traditional manufacturing industry should be sped up, and the reshaping of the industrial structure and transfer to the high-tech industry should be completed.

CONCLUSION

With the continuous growth of China's economy and the continuous advancement of modernization, the contradiction between the environment and the extensive economic development growth mode of high emissions, high energy consumption, and high investment has become increasingly prominent. The emerging environmental problems have not only seriously affected people's daily lives and physical health, but also caused huge economic losses. Environmental regulation can promote the optimization and upgrading of the industrial structure while protecting the ecological environment. Considering Beijing as an example, this study first analyses the mechanism of environmental regulation that impact industrial restructuring and then uses the cointegration analysis and Granger causality test to measure the impact of environmental regulation on the industrial structure in Beijing from 1998 to 2017. The research results show that a long-term and positive equilibrium relationship exists between the industrial structure upgrading and environmental regulation in Beijing. A unit of Beijing industrial pollution control completed investment can pull the growth of 0.017 units in the tertiary industry in proportion to the GDP. This factor is determined as the one-way Granger reason for the added value. Finally, this study puts forward relevant measures in strengthening the implementation of environmental regulation policies, encouraging production enterprises to conduct technological innovation, strengthening environmental regulation, and increasing investment in high-tech industry. For future studies, relevant personnel can continue to conduct in-depth research in the following aspects. First, the path from the environmental regulation to the upgrading of the industrial structure should be determined. Second, the measurement system of environmental regulation and industrial structure upgrading should be enhanced. Third, the development model of industrial structure upgrading should be re-examined from the perspective of sustainable development. Finally, an in-depth study should be conducted on the relationship between the level of environmental regulation and the level of technological innovation of enterprises.

ACKNOWLEDGEMENT

This study was supported by the Chinese Social Science Fund (15BJY048).

REFERENCES

Becker, R.A., Pasurka, C.A. and Shadbegian, R.J. 2012. Do environ-

mental regulations disproportionately affect small businesses? Evidence from the pollution abatement costs and expenditures survey. Journal of Environmental Economics and Management, 66(3): 523-538.

Berman, E. and Bui, L.T.M. 2001. Environmental regulation and productivity: Evidence from oil refineries. Review of Economics and Statistics, 83(3): 498-510.

Christoph, B., Andreas, L. and Welsch, H. 2010. Environmental taxation and induced structural change in an open economy: The role of market structure. German Economic Review, 9(1): 17-40.

Gray, W.B. and Deily, M.E. 1996. Compliance and enforcement: Air pollution regulation in the U.S. steel industry. Journal of Environmental Economics & Management, 31(1): 96-111.

Guo, L.L., Qu, Y. and Tseng, M.L. 2017. The interaction effects of environmental regulation and technological innovation on regional green growth performance. Journal of Cleaner Production, 162: 894-902.

Hou, J., Teo, T. S. H., Zhou, F., Lim, M. K. and Chen, H. 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.

Lanjouw, J.O. and Mody, A. 1996. Innovation and the international diffusion of environmentally responsive technology. Research Policy, 25(4): 549-571.

Lanoie, P., Laurentlucchetti, J., Johnstone, N. and Ambec, S. 2011. Environmental policy, innovation and performance: new insights on the porter hypothesis. Journal of Economics & Management Strategy, 20(3): 803-842.

Lanoie, P., Patry, M. and Lajeunesse, R. 2008. Environmental regulation and productivity: testing the porter hypothesis. Journal of Productivity Analysis, 30(2): 121-128.

Lee, M. 2008. Environmental regulation and production structure for the Korean iron and steel industry. Resource and Energy Economics, 30(1): 1-11.

Wang, Y. and Shen, N. 2016. Environmental regulation and environmental productivity: The case of China. Renewable and Sustainable Energy Reviews, 62: 758-766.

Zhang, H., Zhu, Z. and Fan, Y. 2018. The impact of environmental regulation on the coordinated development of environment and economy in China. Natural Hazards, 91(2): 473-489.

Zhang, J. F. and Deng, W. 2010. Industrial structure change and its eco-environmental influence since the establishment of municipality in Chongqing, China. Procedia Environmental Sciences, 2(1): 517-526.

Zhu, S., He, C. and Liu, Y. 2014. Going green or going away: Environmental regulation, economic geography and firms' strategies in China's pollution-intensive industries. Geoforum, 55(55): 53-65.