Transactions on Economics, Business and Management Research
ISSN: 2960-1789, eISSN: 2960-2254 | Volume 15
MEEA 2025

The Influence of Environmental Regulation on Industrial Structure Upgrading in Beibu Gulf Urban Agglomeration

Xiang Cui*

School of Economics and Management, Nanjing University of Science and Technology, Nanjing, China

*Corresponding author: 1902484915@qq.com

Abstract. This study examines the impact of environmental regulations on industrial structure upgrading in urban clusters through an economic theory framework. Using panel data from 10 prefecture-level cities in the Beibu Gulf Urban Cluster (2010-2021), we measure industrial upgrading through three dimensions: comprehensive structural transformation, industrial sophistication, and rationalization. Through a fixed-effects model, empirical analysis demonstrates that environmental regulations drive comprehensive industrial upgrading while partially hindering rationalization. The findings suggest establishing a multi-tiered regulatory system to strengthen coordinated pollution control across the cluster, ensuring holistic industrial rationalization. Policy recommendations include improving environmental infrastructure to reduce corporate pollution costs, and removing barriers to comprehensive industrial upgrading.

Keywords: industrial structure upgrading; environmental regulation; Beibu Gulf city cluster.

1. Background and Significance of the Topic

Since the release of the "Beibu Gulf Urban Agglomeration Development Plan" in 2017, the region has consolidated its development foundation. However, it has also encountered notable challenges, including relatively lower economic development levels compared to other urban clusters, a single industrial structure, and inadequate environmental infrastructure. To accelerate transformation and better achieve the dual carbon goals of "carbon peaking and carbon neutrality," these issues must be effectively addressed. This paper examines the role of environmental regulations in promoting industrial upgrading within the Beibu Gulf Urban Agglomeration from an economic theory perspective, conducts empirical analysis, and proposes policy recommendations based on the region's actual economic development conditions.

2. Literature Review

Current research primarily analyzes how environmental regulations can influence industrial structure upgrading from perspectives such as the interaction of local government environmental regulation enforcement and the transformation and upgrading of industries in special regions. On one hand, at the inter-provincial level of China, scholars have constructed spatial Durbin models, using panel data from 30 provinces in China to empirically test the interaction of environmental regulation strategies and their effects on industrial structure upgrading [1]. It is argued that environmental regulation exhibits a U-shaped relationship with regional industrial transfer and structural upgrading, and only by crossing the threshold of environmental regulation can industrial structure adjustment be promoted [2]. On the other hand, at the specific regional level, some scholars have conducted quasi-natural experiments using panel data from the Beijing-Tianjin-Hebei region and surrounding cities [3], demonstrating that environmental regulation can significantly enhance industrial structure sophistication. The role of environmental regulation in industrial structure upgrading is heterogeneous in terms of natural resources, with non-resource-based cities being more adaptable to stricter environmental regulations during industrial upgrading [4]. A threshold effect model constructed based on 14 years of municipal panel data from the Yangtze River Delta can verify that increased environmental regulation intensity mitigates the negative effects of foreign direct

investment on industrial structure upgrading and enhances the positive regulatory effects of environmental regulation [5].

Most studies on how environmental regulations influence industrial structure upgrading primarily adopt two perspectives: positive promotion and nonlinear effects. On one hand, some research suggests that environmental regulations can stimulate and accelerate industrial structure upgrading: when environmental regulation intensity reaches an optimal level, the efficiency of enterprises' industrial resource allocation processes will also peak at this optimal level [6]. Some scholars propose using ecological compensation mechanisms to "positively cleanse" industrial clusters, eliminating high-energy-consuming traditional industries while retaining high-quality service sectors and developing emerging green industries, thereby enhancing corporate innovation incentives and promoting industrial restructuring [7]. On the other hand, some studies indicate that environmental regulations are influenced by multiple factors, exerting nonlinear effects on industrial structure upgrading, which exhibit different characteristics of acceleration or hindrance in decision-making processes regarding industrial transformation and innovation for enterprises across multiple countries [8].

3. The Mechanism of Urban Agglomeration Environmental Regulation on Industrial Structure Upgrading

From the theoretical level, environmental regulation may have inhibitory effect or promoting effect on industrial structure upgrading in urban agglomeration.

First, heightened environmental regulations may impede industrial upgrading in urban agglomerations. According to neoclassical theory, as environmental regulations intensify, enterprises within these regions face increasing ecological pressures, compelling them to allocate resources toward pollution reduction. This inefficient resource allocation may hinder the optimization of product structures within urban agglomerations [9]. Moreover, environmental regulations impose constraints on production costs, diverting funds originally intended for industrial upgrading to environmental governance. As fundamental units of urban economies, enterprises operate within complex, multi-core urban systems [10]. When resources for corporate transformation are diverted to environmental management, it may slow down the industrial upgrading process within urban agglomerations.

Second, environmental regulations may accelerate industrial structure upgrading in urban agglomerations. According to the "Pollution Paradise Hypothesis," as environmental regulations intensify, enterprises unable to bear pollution control costs in urban agglomerations may relocate to surrounding areas with less stringent regulations. This creates new industrial market gaps, providing more opportunities for modern emerging industries [11]. Meanwhile, other enterprises avoid excessive capital, labor, and equipment investments required to comply with emission-restricted policies. By improving energy-efficient production processes, enhancing productivity, and promoting resource recycling, they achieve industrial upgrading while meeting environmental standards. Environmental regulations guide enterprises in urban agglomerations to reduce energy consumption, increase social value, and realize sustainable development. This drives the transformation of traditional resource-wasting production models into more environmentally friendly, service-oriented, and high-quality industrial models.

4. Design of the Empirical Study on the Influence of Environmental Regulation on Industrial Structure Upgrading in the Urban Agglomeration of the Beibu Gulf

4.1. Description of Indicator Variables and Data Sources

Based on the previous review and analysis of the influencing mechanisms, this paper will further utilize Stata software to conduct an empirical study design on the impact of environmental regulation on industrial structure upgrading in the Beibu Gulf city cluster. The study covers the municipal panel

data of the 10 major prefecture-level cities in the Beibu Gulf city cluster from 2010 to 2021, specifically Nanning, Beihai, Qinzhou, Fangchenggang, Yulin, and Chongzuo in Guangxi Zhuang Autonomous Region, Zhanjiang, Maoming, and Yangjiang in Guangdong Province, and Haikou in Hainan Province. Among them, Danzhou in Hainan Province was excluded from the study due to excessive data gaps in consecutive years. The study uses environmental regulation as the core explanatory variable, with the dependent variable of industrial structure upgrading measured from three aspects: overall industrial structure upgrading, industrial structure sophistication, and industrial structure rationalization. Based on a summary of previous literature, six factors—economic development level, openness level, infrastructure construction level, government regulation degree, social demand level, and urbanization level—are introduced as control variables in the model. Table 1 illustrates the symbols and meanings of the variables involved in the empirical analysis. The data used in the study mainly comes from the "China Urban Statistical Yearbook," the "China Environmental Statistical Yearbook," and local statistical yearbooks and local government statistical bureaus of various provinces and cities, with a small portion of missing data supplemented using interpolation methods.

Table 1. Explanation of variable symbols and meanings

type of variable	variable symbol	Variable meaning
explained variable	UIS	Integrated industrial structure upgrading
	UISA	Advanced industrial structure
	UISR	Rationalization of industrial structure
core explanatory variable	ER	environmental regulation
controlled variable	PGDP	level of economic development
	OPEN	Openness to the outside world
	INFRA	The level of infrastructure development
	GOV	degree of government regulation
	SN	level of social demand
	URB	Urbanization level

(1) Dependent Variables: Holistic Industrial Structure Upgrade (UIS), Industrial Structure Advancement (UISA), and Industrial Structure Rationalization (UISR). The study focuses on industrial structure upgrade, which refers to the process where industries continuously eliminate outdated production capacities, transform traditional production techniques, and develop high-tech, high-value-added, and high-capacity technology-intensive industries driven by technological and human resource factors. This paper constructs the concept into three dimensions: holistic industrial structure upgrade (UIS), industrial structure advancement (UISA), and industrial structure rationalization (UISR). To comprehensively measure holistic industrial structure upgrade (UIS), the study adopts the methodology of Xie Zhouliang and Li Zhiying (2020), using the sum of products of labor productivity ratios of various industries relative to GDP. Industrial structure advancement (UISA) indicates effective utilization of multiple resource factors, emphasizing productivity improvements, and is measured by the ratio of combined output values of secondary and tertiary industries to regional GDP. Industrial structure rationalization (UISR) refers to structural transformation capabilities between industries and coordination among production factors, employing the structural deviation index proposed by Li Qiang and Wang Yacang (2022) to measure the industrial structure rationalization index.

(2) Core Explanatory Variable: Environmental Regulation (ER). To address the limitations of single-indicator approaches and comprehensively assess environmental regulation intensity, the study adopts a methodology similar to Yuan Yijun and Xie Ronghui's (2014) framework, utilizing available data to evaluate environmental regulation intensity across 10 major prefecture-level cities in the Beibu Gulf Urban Agglomeration. Three key indicators are selected: industrial wastewater discharge, industrial nitrogen oxide emissions, and industrial smoke/powder dust emissions. These metrics form the basis of a comprehensive environmental regulation measurement system. A lower ER value indicates reduced emissions of these pollutants, reflecting stronger environmental regulation.

(3) Control Variables: In addition to environmental regulations influencing industrial structure upgrading, multiple other factors should be included as control variables. The selected control variables in this study are: (1) Economic Development Level (PGDP): Represented by per capita regional GDP; (2) Openness Level (OPEN): Measured as the ratio of regional import-export volume to regional GDP; (3) Infrastructure Development Level (INFRA): Defined as the ratio of annual road mileage in prefecture-level cities to their total population; (4) Government Regulation Degree (GOV): Represented by the ratio of regional government fiscal expenditure to regional GDP; (5) Social Demand Level (SN): Calculated as the ratio of total fixed asset investment to regional GDP; (6) Urbanization Level (URB): Represented as the percentage of urban population in prefecture-level cities relative to their total population.

4.2. Descriptive statistics of sample data

Table 2 presents the descriptive statistics of the sample data for each variable.

Table 2. Descriptive statistics of variables in

variable	sample capacity	mean	standard deviation	least value	crest value
UIS	120	945.16	413.87	416.59	3103.65
UISA	120	0.8281	0.0538	0.7053	0.9581
UISR	120	2.4504	7.8421	0.0210	73.8237
ER	120	0.6036	0.4736	0.0000	2.0437
PGDP	120	4.3617	1.6714	1.5011	8.2657
OPEN	120	0.5298	0.7712	0.0178	3.9369
INFRA	120	21.8195	7.5815	6.9114	41.4128
GOV	120	0.1659	0.0460	0.0812	0.3806
SN	120	0.8960	0.4264	0.1245	2.5074
URB	120	37.0646	16.4390	9.9187	95.2620

5. Empirical Analysis on the Influence of Environmental Regulation on Industrial Structure Upgrading in Beibu Gulf Urban Agglomeration

5.1. Stationarity Test and Cointegration Test of Data

To address heteroscedasticity and multicollinearity, the study applied logarithmic transformations to all variables and conducted tail-trimming on selected variables. Prior to empirical analysis, stability tests under identical and different root conditions were performed to prevent spurious regression. The first-order difference series values passed significance tests using the likelihood-ratio test (LLC), integrated-predictive-squared (IPS), and price-predictive-fisher (PP-Fisher) methods, confirming all variables as first-order integrated. The dataset selected for this study is therefore stable and reliable.

To verify the long-term equilibrium relationship between the dependent variables lnUIS, lnUISA, and lnUISR and the independent variables lnER, along with the control variables lnPGDP, lnOPEN, lnINFRA, lnGOV, lnSN, and lnURB, this study conducted Pedroni and Westerlund tests. The results rejected the null hypothesis of no cointegration among the variables, confirming their cointegration relationship, which justifies subsequent regression analysis. Due to space constraints, the test tables are omitted in this section.

5.2. Benchmark Regression Analysis of the Impact of Environmental Regulation on Industrial Structure Upgrading in Beibu Gulf Urban Agglomeration

5.2.1. Setting up the empirical model

To test the hypothesis, we construct an econometric model to examine the direct impact of environmental regulation on industrial structure upgrading. First, we establish three benchmark models, with the dependent variables being overall industrial structure upgrading, industrial structure sophistication, and industrial structure rationalization, respectively. Each model incorporates the six control variables mentioned earlier. The details are as follows:

$$\ln UIS_{it} = \alpha_0 + \alpha_1 \ln ER_{it} + \alpha_2 \ln PGDP_{it} + \alpha_3 \ln OPEN_{it} + \alpha_4 \ln INFRA_{it} + \alpha_5 \ln GOV_{it} + \alpha_6 \ln SN_{it} + \alpha_7 \ln URB_{it} + \varepsilon_{it}$$

$$\ln UISA_{it} = \alpha_0 + \alpha_1 \ln ER_{it} + \alpha_2 \ln PGDP_{it} + \alpha_3 \ln OPEN_{it} + \alpha_4 \ln INFRA_{it} + \alpha_5 \ln GOV_{it} + \alpha_6 \ln SN_{it} + \alpha_7 \ln URB_{it} + \varepsilon_{it}$$

$$\ln UISR_{it} = \alpha_0 + \alpha_1 \ln ER_{it} + \alpha_2 \ln PGDP_{it} + \alpha_3 \ln OPEN_{it} + \alpha_4 \ln INFRA_{it} + \alpha_5 \ln GOV_{it} + \alpha_6 \ln SN_{it} + \alpha_7 \ln URB_{it} + \varepsilon_{it}$$

In this model, the subscript i denotes prefecture-level cities, t represents the year, while lnUIS, lnUISA, and lnUISR are the dependent variables. lnER serves as the core explanatory variable, with lnPGDP, lnOPEN, lnINFRA, lnGOV, lnSN, $\varepsilon_{it}$and lnURB as control variables. The coefficients α1 to α7 quantify the impact of each control variable on the dependent variable, and the residual term is denoted by ε.

5.2.2. Benchmark Regression Results and Analysis

To examine how environmental regulations in cities within the Beibu Gulf Urban Agglomeration influence industrial structure upgrading, this study employs panel data from 2010 to 2021 for benchmark regression analysis. Table 3 presents regression results from three models using comprehensive industrial structure upgrading as the dependent variable: the fixed-effects model (fe), random-effects model (re), and pooled regression model (OLS). The optimal panel model was selected through F-tests and Hausman tests. The F-test strongly rejected the null hypothesis, indicating the fixed-effects model outperformed the pooled regression model. Subsequent Hausman tests further confirmed the fixed-effects model's superiority. The fixed-effects model's regression results show an estimated parameter value of-0.2279 for environmental regulation intensity, which is statistically significant at the 5% level. As calculated from the lnER variable, lower lnER values correspond to stricter environmental regulations. The findings demonstrate that environmental regulations positively impact comprehensive industrial structure upgrading in the Beibu Gulf Urban Agglomeration, with stricter regulations facilitating greater industrial upgrading. Specifically, a 1% increase in environmental regulation intensity results in an average 0.2279% improvement in comprehensive industrial structure upgrading.

Regarding control variables, the parameter estimate of lnPGDP (logarithm of GDP) was 0.9470, passing the 1% significance test, indicating that improved economic development levels positively influence the structural upgrading of the Beibu Gulf Urban Agglomeration's industrial composition. The parameter estimate of lnOPEN (logarithm of openness) was 0.4960, showing statistical significance at the 1% level, demonstrating that enhanced openness significantly promotes the urban

agglomeration's industrial structure transformation. Although lnINFRA (logarithm of infrastructure) yielded a positive estimate, it failed to pass the significance test, suggesting that infrastructure development's impact on industrial upgrading remains inconclusive. The parameter estimate of lnGOV (logarithm of government) was 0.3445, passing the 5% significance test, indicating that government regulation facilitates the urban agglomeration's industrial upgrading. While lnSN (logarithm of social demand) showed a positive estimate, its significance test result was inconclusive, implying that social demand levels have no significant positive effect on industrial upgrading. Finally, lnURB (logarithm of urbanization) produced a negative estimate, but its significance test failed to confirm the inhibitory effect of urbanization levels on industrial upgrading.

Table 3. Regression Results of Three Models of Comprehensive Industrial Structure Upgrading

variable	fe	re	ols
lnER	-0.2279**	-0.1724*	-0.1867**
	(-2.47)	(-1.74)	(-2.24)
lnPGDP	0.9470***	0.3637***	0.4705***
	(6.02)	(4.42)	(6.42)
lnOPEN	0.4960***	-0.1371***	-0.1688***
	(3.53)	(-4.53)	(-6.23)
lnINFRA	0.0829	0.4382***	0.6308***
	(0.78)	(4.70)	(6.89)
lnGOV	0.3445**	0.2518*	0.0717
	(2.47)	(1.72)	(0.61)
lnSN	0.1032	0.1159	0.0735
	(1.51)	(1.57)	(1.47)
lnURB	-0.1027	-0.1893***	-0.3688***
	(-1.48)	(-2.75)	(-10.30)
constant term	7.0388***	5.9813***	5.5012***
	(15.08)	(14.22)	(21.61)
sample capacity	120	120	120
adj. R2	0.5640	-	0.5585
F checkout		12.44(0.0000)	
Hausman test		38.93(0.0000)	

Note: (1) Values in parentheses are t-statistics; (2) *, **, and *** indicate significance at the 10%,5%, and 1% levels, respectively (the table below will not repeat these points).

Table 4 presents the regression results of three models when industrial structure upgrading was used as the dependent variable. Following the model selection process outlined earlier, the fixed-effects model was identified as the optimal choice. The first column of regression results shows that the parameter estimate for environmental regulation intensity is 0.0184, but it fails to pass the 10% significance test. This indicates that the increase in environmental regulation intensity in the Beibu Gulf Urban Agglomeration does not significantly inhibit industrial structure upgrading.

Regarding control variables, the parameter estimate of lnPGDP (logarithm of GDP) was 0.1399, passing the 1% significance test, indicating that the economic development level of prefecture-level

cities significantly drives the industrial structure of the Beibu Gulf Urban Agglomeration toward higher-level evolution. The parameter estimate of lnOPEN (-0.0124) was significant at the 5% level, suggesting that enhanced openness curbs the industrial structure upgrading in the urban agglomeration. The parameter estimate of lnINFRA (-0.0836) was significant at the 1% level, indicating that infrastructure development in the urban agglomeration suppresses the effect of industrial structure upgrading. The parameter estimate of lnGOV (0.1206) passed the 1% significance test, demonstrating that government regulation can promote industrial structure upgrading in urban agglomerations. The parameter estimate of lnSN (-0.0364) was significant at the 1% level, showing that increased social demand in urban agglomerations negatively impacts industrial structure upgrading. The parameter estimate of lnURB (0.0599) was significant at the 1% level, confirming that improved urbanization levels have a significant positive effect on industrial structure upgrading in urban agglomerations.

Table 4. Regression Results of Three Models of Industrial Structure Upgrading

variable	fe	re	ols
lnER	0.0184	0.0112	0.0242
	(1.21)	(0.81)	(1.37)
lnPGDP	0.1399***	0.0350**	0.0547***
	(6.03)	(2.56)	(3.27)
lnOPEN	-0.0124**	-0.0067	0.0057
	(-2.32)	(-0.80)	(1.68)
lnINFRA	-0.0836***	0.0008	-0.0895***
	(-6.53)	(0.05)	(-6.93)
lnGOV	0.1206***	-0.0032	0.0152
	(3.49)	(-0.15)	(0.97)
lnSN	-0.0364***	-0.0003	-0.0211**
	(-2.84)	(-0.03)	(-2.68)
lnURB	0.0599***	0.0172*	0.0697***
	(6.18)	(1.69)	(6.31)
constant term	-0.1565**	-0.3227***	-0.2202***
	(-2.57)	(-4.78)	(-5.61)
sample capacity	120	120	120
adj. R2	0.6720	-	0.6278
F checkout	3.31(0.0006)		
Hausman test	670.12(0.0000)		

Table 5 presents the regression results when industrial structure rationalization is treated as the dependent variable. Following the same methodology as in previous sections, the fixed-effects model proves to be the optimal choice. The first column of regression results indicates that the parameter estimate for environmental regulation intensity is 0.7646, which is statistically significant at the 5% level. Based on the calculation process of the environmental regulation variable lnER mentioned earlier, it can be observed that a higher lnER value corresponds to lower environmental regulation

intensity. This suggests that environmental regulations have a negative impact on the rationalization of industrial structure in the Beibu Gulf Urban Agglomeration. Conversely, more lenient environmental regulation policies tend to facilitate industrial structure rationalization. Specifically, a 1% reduction in environmental regulation intensity results in an average 0.7646% increase in the overall level of industrial structure upgrading.

Regarding control variables, the parameter estimate of lnPGDP (-1.8405) passed the 1% significance test, indicating that economic development has a negative impact on the rationalization of industrial structure in the Beibu Gulf Urban Agglomeration. The parameter estimate of lnOPEN (-1.9753) was significant at the 1% level, suggesting that enhanced openness hinders industrial structure rationalization. Although lnINFRA showed a negative value, it failed to reach statistical significance, implying that infrastructure development has no significant adverse effect on industrial rationalization. The parameter estimate of lnGOV (-1.6159) passed the 1% significance test, demonstrating that government regulation suppresses industrial structure rationalization. Similarly, lnSN (-) showed no significant negative impact on industrial rationalization, while lnURB (+) failed to reach statistical significance, indicating that urbanization levels do not significantly promote industrial structure rationalization.

Table 5. Regression Results of Three Models of Industrial Structure Rationalization

variable	fe	re	ols
lnER	0.7646**	0.0806	0.0806
	(2.08)	(0.21)	(0.30)
lnPGDP	-1.8405***	-0.3544	-0.3544
	(-2.93)	(-1.16)	(-1.14)
lnOPEN	-1.9753***	0.5433***	0.5433***
	(-3.52)	(7.03)	(5.45)
lnINFRA	-0.4065	-1.9212***	-1.9212***
	(-0.96)	(-6.36)	(-6.58)
lnGOV	-1.6159***	0.2624	0.2624
	(-2.90)	(0.48)	(0.55)
lnSN	-0.1536	-0.2561	-0.2561
	(-0.56)	(-0.90)	(-0.83)
lnURB	0.0541	1.0574***	1.0574***
	(0.20)	(4.47)	(4.63)
constant term	-2.6732	3.6462***	3.6462***
	(-1.43)	(2.63)	(4.10)
sample capacity	120	120	120
adj. R2	0.1793	-	0.4105
F checkout	11.82(0.0000)		
Hausman test	288.56(0.0000)		

5.2.3. Robustness Testing

To validate the credibility of the regression results presented earlier, this study conducted additional regression analyses by removing selected samples and trimming control variables. The sign and

significance of the core explanatory variable (lnER coefficient) remained unchanged, consistent with the previous conclusions. This demonstrates the robustness of the constructed model, confirming the reliability of the regression outcomes.

6. Research Conclusions and Policy Recommendations

6.1. Research Conclusions

Environmental regulations can facilitate the comprehensive industrial upgrading of the Beibu Gulf urban agglomeration, though their impact on industrial sophistication remains limited, which to some extent hinders the rationalization of industrial structures. This may be because environmental regulations such as eco-taxes and pollution discharge fees can incentivize enterprises in cities to adopt more environmentally friendly production methods, thereby driving the transformation toward high-end, eco-conscious industries and promoting the overall industrial upgrading of the urban cluster. However, industrial sophistication requires deeper capital investment and broader resource coverage, making environmental regulations less effective in this regard. Moreover, overly stringent regulatory policies may impose burdens on certain industries, increasing structural deviations and preventing the transition to a rational industrial structure in the short term.

In other aspects, the improvement of economic development levels and government regulatory measures can significantly promote the overall industrial structure upgrading and advanced development of urban agglomerations. However, these factors may suppress industrial rationalization in the short term. The reason might be that economic growth and government regulation provide greater financial, tax, and capital support for urban agglomerations, facilitating smoother industrial upgrading. Yet some policies may not yet cover industries requiring adjustment and rationalization. Achieving balanced development between industries and employment still requires more time. With enhanced openness, the overall industrial structure upgrading of urban agglomerations has been significantly accelerated. However, this progress has created negative impacts on industrial rationalization. The increased market access for traditional industries has brought broader opportunities, driving overall structural upgrades. Yet it has also led to cutthroat competition within certain sectors, where core elements like capital and talent remain inadequately allocated. This imbalance ultimately hinders the advanced and rational development of industrial structures.

6.2. Policy Recommendations

(1) Construct a multi-level environmental regulation policy system, strengthen the joint prevention and treatment of urban agglomeration, and achieve the overall coverage of industrial structure rationalization

First, given the varying development conditions of cities and counties in the Beibu Gulf Urban Agglomeration, we should adopt location-specific environmental regulations to avoid rigid, one-size-fits-all approaches, thereby establishing a multi-tiered and multidimensional policy framework. For less developed cities and counties, more flexible environmental policies should be implemented to prioritize the growth of eco-friendly modern services, which will gradually drive the transformation of traditional industries with high pollution emissions. Conversely, in more developed cities and counties, stricter environmental regulations may be enforced to accelerate the exit of energy-intensive industries that rely on environmental pollution, thereby boosting the market share of environmentally sustainable industries.

Second, leverage the unique spatial configuration of the Beibu Gulf Urban Agglomeration to enhance industrial relocation and corporate collaboration within the cluster. Strengthen integrated pollution prevention and control mechanisms, improve coordinated pollution prevention and governance systems, and intensify performance evaluations of local governments in ecological conservation to achieve high-quality development across the urban agglomeration. For industries requiring targeted adjustments, implement tailored environmental regulations and increase funding depth and resource

allocation to ensure relative balance between industrial growth and employment. Consolidate the ecological protection barrier of the Beibu Gulf Urban Agglomeration, achieve comprehensive environmental improvements across all sectors, and promote full-scale industrial restructuring.

(2) Improve the infrastructure construction of environmental regulation, reduce the cost burden of pollution control for enterprises, and remove the constraints of overall industrial upgrading.

First, establish a more comprehensive and systematic environmental regulation framework to drive ecological civilization development from quantitative to qualitative progress. For wastewater management, intensify pollution source control, upgrade urban pipeline networks, properly treat and recycle domestic and industrial wastewater, and actively promote sponge city construction. Regarding emission reduction, develop intelligent environmental quality monitoring systems, implement stringent industrial emission standards, address severe pollution at its root, create carbon emission monitoring tools, and boost new energy vehicle R&D. In solid waste management, ensure widespread coverage of waste treatment plants, recycling stations, and supporting facilities to achieve classified and phased reduction of municipal solid waste.

Second, implement tiered pollution discharge fees for enterprises, establish specialized research programs for green and environmental protection, and promote the development and application of circular economy technologies. Provide financial support to enterprises in urban clusters through measures such as loans, tax incentives, and fund credits. Facilitate the sharing of intellectual property rights for green technologies, and reduce pollution control costs for enterprises through funding and collaboration. Encourage reciprocal exchanges among enterprises in urban clusters to optimize the allocation of core resources like capital and talent, thereby avoiding cutthroat competition and resource waste within the same industry. This approach will overcome constraints on comprehensive industrial structure upgrading.

References

[1] Zhang Xiao. The Impact of Environmental Regulation Strategy Interaction on Industrial Structure Upgrading. Xuzhou: China University of Mining and Technology, 2022.

[2] Zhong Maochu, Li Mengjie, Du Weijian. Can environmental regulation force industrial restructuring? An empirical test based on China's inter-provincial panel data [J]. China Population·Resources and Environment, 2015, 25(08): 107-115.

[3] Li Guozhu, Li Xiaozhuang. Environmental Regulation, Industrial Structure Upgrading and High-Quality Economic Development: A Case Study of Beijing-Tianjin-Hebei Region [J]. Statistics and Decision-Making, 2022,38(18):26-31.

[4] Zheng Zuxuan, Li Bing, Yu Ping. The Impact of Environmental Regulation on Industrial Structure Upgrading: Evidence from the "2+26" Cities [J]. Science Decision, 2023, No.306(01):1-17.

[5] Hu Yan, Zhang Li. FDI, Environmental Regulation and Industrial Structure Upgrading: Empirical Evidence from the Yangtze River Delta [J]. East China Economic Management, 2021,35(09):31-38.

[6] Porter M E,Linde C V D.Towards a New Conception of the Environment-Competitiveness Relationship[J].Journal of Economic Perspectives,1995,4(4):97-118.

[7] Paul Lanoie, Jérémy Laurent-Lucchetti, Nick Johnstone, et al. Environmental Policy, Innovation and Performance: New Insights on the Porter Hypothesis[J]. Journal of Economics & Management Strategy,2011,20(3):803-842.

[8] Ramanathan R., He Q., Black A., [8] Ramanathan R., He Q., Black A., et al. Environmental regulations, innovation and firm performance:A revisit of the Porter hypothesis[J].Journal of Cleaner Production,2016,155:79-92.

[9] Chen Lu. Environmental Regulation, Technological Innovation and Economic Growth. Wuhan: Wuhan University, 2017.

[10] Ma Haitao, Xu Xuanfang, Jiang Kailuo. Evolution characteristics and innovation effects of technical knowledge multi-centrality in China urban agglomerations [J]. Journal of Geography, 2023,78(02):273-292.

[11] Tian Guanghui. Environmental Regulation, Local Protectionism and the Geographical Distribution of Pollution-Intensive Industries. Zhengzhou: Henan University, 2019.