Pol. J. Environ. Stud. Polit. Econ. Ind. Vol. XX, No. X (XXXX), 1-13
DOI: *10.15244/peai/208009* ONLINE PUBLICATION DATE: 2025-08-13

Original Research

The Impact of Environmental Regulation on Employment Structure: Evidence from China

Daojun Bi[1]°*, Qiuyue Yang[2], Wenfang Fu[3]

[1]School of Business, Xinyang Normal University, No. 237 Nanhu Road, Xinyang 464000, China
[2]School of Marxism, Anhui University, No. 111 Jiulong Road, Hefei 230601, China
[3]School of Economics, Wuhan Business University, No. 816 Dongfeng Road, Wuhan 430073, China

Received: 5 June 2025
Accepeted: 7 July 2025

Abstract

Based on China's provincial-level panel data from 2007 to 2023, this study examines the optimizing effect of environmental regulation on employment structure using a GMM model, and clarifies its mechanism of action using a mediated effect model. The conclusion shows that the impact of environmental regulation on employment structure presents multidimensional characteristics. On the one hand, environmental regulation directly promotes the adjustment of employment structure; on the other hand, it guides the labor force to gather in environmentally friendly service industry by forcing the green transformation of industrial structure; at the same time, it promotes the transfer of labor force to high technology field by stimulating technological innovation of enterprises, and promotes the evolution of employment structure to knowledge-intensive direction by improving human capital level. Heterogeneity analysis shows that the marginal effect of environmental regulations on the industrial structure of employment is limited in China's eastern coastal economic zone and regions with high urbanization rates. Moreover, the contribution of enhanced environmental regulatory intensity to the efficiency of cross-sectoral allocation of labor factors is constrained by the regional urbanization rate.

Keywords: environmental regulation, employment structure, upgrading of industrial structure, technological innovation

Introduction

Environmental regulation, as an important means of reducing environmental pollution, has not only made an important contribution to the improvement of environmental quality, but has also had a significant impact on China's employment situation, especially in driving the adjustment of the employment structure. According to the China Employment Development Report (2024), many factors make the job market face opportunities and challenges, and the change of employment structure adjustment intensifies. The report, in particular, emphasized the importance of promoting ecological civilization and employment in green development. The Future Employment Report 2025, released by the World Economic Forum, points out that green transformation promotes industry change, creates a large number of green jobs, and accelerates

*e-mail: bdj0522@163.com
°ORCID iD: 0009-0005-0328-0903

the adjustment of employment structure. Among them, low-carbon industries such as renewable energy, green buildings, and electric vehicles have created a large number of jobs. The popularity of digital technology has also accelerated the shift in skills demand in the job market, resulting in a significant increase in the demand for high-skilled jobs.

In recent years, the Chinese government has continued to promote the construction of environmental governance capacity, and the changing industrial structure, technological innovation level, and human capital level under the effect of environmental regulation have had a profound impact on the employment structure. It is worth noting that the process of environmental pollution control has accelerated the decline of employment in traditional industries such as coal, iron, and steel, and green technological innovation and application have increased the employment ratio of skilled personnel, alleviating structural employment conflicts to a certain extent. The study of China's experience in promoting the transformation of employment structure through environmental regulation in the process of green and low-carbon transformation can provide a reference for countries around the world to seize the opportunities of labor market development while coping with climate change. Therefore, it is of practical significance for this paper to study the relationship between environmental regulation and employment structure.

Existing research on the relationship between environmental regulation and labor employment predominantly focuses on the impact of environmental regulation on employment scale [1-3]. The central debate in this literature revolves around whether environmental protection and employment growth can achieve a win-win scenario, specifically whether environmental protection necessitates employment sacrifices and whether the "double dividend" of employment effects in pollution control activities exists [4-6]. However, no consensus has been reached. Berman and Bui [7] and Yu and Li [8] posit that environmental regulation can simultaneously promote emission reduction, technological improvement, and production factor reallocation, thereby generating additional employment opportunities. Their findings suggest that environmental regulation can positively influence employment scale while reducing environmental pollution [9]. Conversely, opposing views argue that environmental regulation imposes substantial costs on enterprises, leading to increased unemployment [10, 11]. An alternative perspective suggests that the impact of environmental regulation on employment scale is complex and non-linear, with outcomes contingent upon factors such as environmental regulation intensity [12, 13].

As the resource and environmental constraints on economic development tighten and the green transition leads to deep changes in the job market, some studies have begun to try to explore the impact of environmental regulation on the structure of employment [14, 15]. These studies fall into two categories. The first category examines the heterogeneity of environmental regulations. It investigates how different types, intensities, and implementation stages of environmental regulations affect employment structure [16, 17]. This research aims to improve the environmental protection system design for better employment structure optimization. For instance, Jiang and Shen [18] based on China's provincial panel data, showed that the effects of command and voluntary environmental regulations on the employment skill structure exhibit a "U" curve, while the improvement of market-based environmental regulations can promote the gradual optimization of employment structure. The second category focuses on specific dimensions of employment structure. Most studies concentrate on skill structure transformation under environmental regulation [19, 20]. A few studies have explored changes in industrial structure. These studies generally agree that strengthening environmental regulation can improve the employment absorption capacity of the service industry [21, 22]. It is also argued that environmental regulation accelerates the coordination between the employment structure and industrial structure, and optimizes the employment and industrial structures [23-25].

Previous literature provides valuable insights for this study. However, research on the relationship between environmental regulation and employment structure requires further development. Specifically, the theoretical mechanisms through which environmental regulation affects employment structure need deeper exploration. Additionally, more comprehensive measurement methods for employment structure are necessary. This study makes three main contributions. First, it theoretically expands the understanding of environmental regulation's impact on employment structure by examining both direct and indirect mechanisms. Second, this study focuses on the impact of environmental regulation on employment structure and comprehensively examines the employment structure from three levels: industry, sector, and skill, to more thoroughly measure the changes in China's employment structure under environmental regulation. Third, in terms of research data and methodology, we measure the levels of environmental regulation and employment structure with the help of China's 2007-2023 provincial data, and use a two-stage GMM model to measure the employment structure optimization effect of environmental regulation, which mitigates the endogeneity problem to a certain extent.

This study is structured as follows: firstly, from a theoretical level, we initially analyze whether environmental regulation can lead to the optimization of employment structure. Secondly, in terms of empirical design and testing, in order to analyze the employment structure more comprehensively, this paper adopts China's provincial panel data and analyzes the employment structure effect of environmental regulation at the industry level, sectoral level, and skill

level with the help of a dynamic panel GMM model. It also discusses the heterogeneity of the employment structure effect of environmental regulations based on the differences in regions, economic development levels, and urbanization levels. Finally, the specific mechanism by which environmental regulation affects employment structure is examined, and corresponding countermeasures are proposed.

Theoretical Analysis

The solution to the problem of employment structure has become the key to improving the quality of employment, and therefore, the implementation of environmental policy also needs to pay attention to changes in the structure of employment. On the one hand, environmental regulation can directly affect the allocation of labor factors, and the distribution of labor in different industries and trades directly reflects the changes in the employment structure. On the other hand, the upgrading of industrial structure, technological innovation, and the improvement of human capital under environmental regulation are important factors affecting the transformation of employment structure. Therefore, the mechanism of environmental regulation on the employment structure of the labor force can be divided into two categories: direct and indirect effects; the specific mechanism is shown in Fig. 1.

Direct Mechanisms

Environmental regulations directly affect the structure of employment through labor allocation effects in two main ways. The first is the cost effect, as stricter environmental regulations increase firms' production costs. This puts pressure on energy-intensive polluting industries in particular, forcing some firms to shut down and leading to a reduction in the labor force in traditional industries [26, 27]. As a result, there was an immediate restructuring of employment at the industrial level. In addition, the closure of these industrial firms disproportionately affects middle/low-skilled workers, driving short-term labor migration to the service sector. For example, when firms face long-term environmental shutdowns, displaced workers tend to shift to the catering and food distribution services sector [28]. While environmental regulations spur green job creation, these emerging jobs require higher skill levels. Together, these dynamics reshape the skill structure and sectoral distribution patterns of employment.

Second, the pollution abatement effect suggests that firms that endeavor to maintain their operations increase their pollution control investments, leading to higher capital intensity. This cleaner production process elevates the demand for skilled labor [29]. In addition, environmental compliance requirements and the operation and maintenance of state-of-the-art equipment create additional labor demand in the service sector. These combined effects directly reshape the employment structure.

Indirect Mechanisms

First, environmental regulation influences industrial-level employment structure through industrial upgrading. Increased environmental regulation imposes higher pollution control costs on pollution-intensive industries [30, 31]. This cost pressure drives these industries to adopt cleaner production methods and transition toward less polluting sectors. Compared with industry, the service sector has lower energy inputs, lower pollution emissions, and a stronger absorption capacity for employment. With the upgrading of industrial structure, the labor force will also be transferred from industry to the service industry, so the employment structure of the labor force at the industrial level will change as well. Moreover, stringent environmental regulation accelerates the market exit of pollution-intensive enterprises while stimulating environmental protection industries [32]. This dual process promotes advanced industrial restructuring, ultimately optimizing employment structure through industrial transformation.

Second, environmental regulations reshape the structure of employment at the sectoral level through technological innovation. It has been shown that stringent environmental standards can incentivize firms to increase R&D investment and enhance

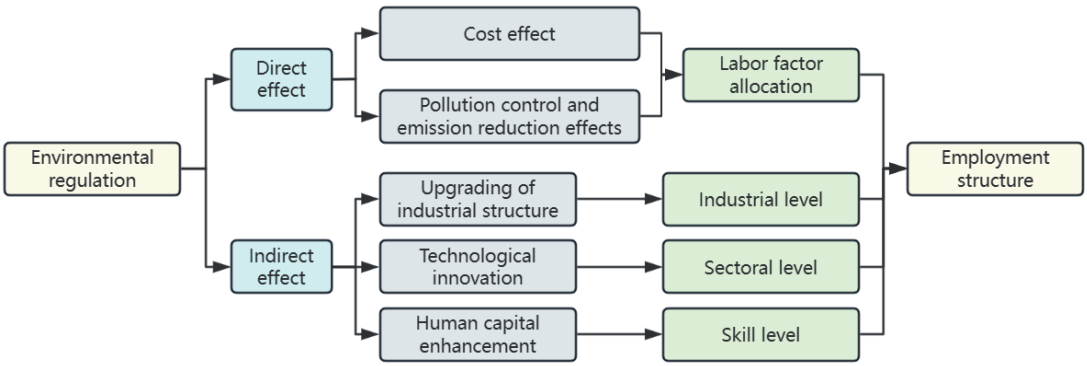

Fig. 1. Mechanisms of environmental regulation affecting the employment structure.

technological capabilities [33, 34]. Technological innovation can create new jobs and optimize the employment structure. For example, the application of artificial intelligence technology breaks the traditional employment pattern and increases the labor demand in high-end manufacturing and service industries. Governments actively promote green technology innovation and encourage clean production in the process of environmental governance. At the same time, digital technologies (cloud computing, big data, and Internet applications) have reduced emissions, improved employment matching efficiency, and changed the employment structure at the industry level. China has implemented a series of policies to encourage technological innovation, such as the establishment of high-tech industrial parks and e-commerce demonstration cities, where high-tech enterprises are clustered in the region [35]. This agglomeration has generated knowledge spillover effects, and the spread of technological innovation and advanced equipment has eliminated some jobs in high-pollution industries and led to more employment in high-technology sectors.

Third, environmental regulations reshape the structure of employment at the skill level by increasing human capital. Strict environmental standards promote the accumulation of human capital by improving public health, raising public awareness of environmental protection, and attracting highly skilled labor to move in. Human capital is an important factor in optimizing the employment structure of the labor force, which improves the skills of the labor force, sends a large number of workers with new knowledge and new technologies to the emerging industries, guarantees the effective supply of the labor force, and promotes the development of the employment structure of the labor force in the direction of high skills [36]. Accompanied by the continuous improvement of environmental standards, the creation of new production processes and procedures increases the demand for high-skilled labor [37]. The enhancement of human capital under environmental regulation helps low-skilled workers transition into high-skilled labor through education and training to adapt to the new needs of the market, so that the employment structure gradually develops in the direction of high skills.

Materials and Methods

Research Methods

Guided by the theoretical analysis, this section explores two key research questions: the relationship between environmental regulation and the structure of employment, and whether environmental regulation contributes to the optimization of the structure of employment through specific transmission channels. In order to examine these questions systematically, the modeling consists of the following key components.

First, we empirically examine the specific relationship between environmental regulation and employment structure. Theoretical analysis suggests that environmental regulation exerts both direct effects on employment structure. Accounting for employment structure rigidity, we incorporate the one-period lagged term of employment structure as an explanatory variable, constructing the following dynamic panel model:

$$Ems_{it} = \alpha_0 + \alpha_2 Ems_{it-1} + \alpha_3 ER_{it} + \gamma \sum CV_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (1)$$

Ems_{it} is the explanatory variable of employment structure, which represents the employment structure of province i in year t, including three dimensions of industry, sector, and skill employment structure. ER_{it} denotes the intensity of environmental regulation of province i in year t. CV_{it} denotes a series of control variables affecting employment structure. λ_i is the fixed effect of year, μ_t is the fixed effect of provinces, and ε_{it} is a random error term.

The mechanism of environmental regulation on employment structure adopts the mediation effect model. The specific model setup is as follows.

$$Med_{it} = \alpha_0 + \alpha_1 Med_{it-1} + \alpha_2 ER_{it} + \alpha_3 \sum CV_{it} + \lambda_{2i} + \mu_{2t} + \varepsilon_{2it} \quad (2)$$

$$Ems_{it} = \alpha_0 + \alpha_1 Ems_{it-1} + \alpha_2 ER_{it} + \alpha_3 Med_{it} + \alpha_4 \sum CV_{it} + \lambda_{3i} + \mu_{3t} + \varepsilon_{3it} \quad (3)$$

Equation (1) measures the direct effect of environmental regulation on employment structure. Equation (2) takes the mediator variable Med_{it} as the explanatory variable and includes three variables: industrial structure upgrading, technological innovation, and human capital. Equation (3) takes the employment structure as the dependent variables and incorporates the mediating variables into the explanatory variables to illustrate the impact of environmental regulation on the employment structure at different levels through different mediating variables and to verify the indirect effect of environmental regulation on the employment structure.

Variable Description and Data

Measurement of Variables

Dependent Variable: Employment Structure (Ems). To comprehensively capture employment structure dynamics, we measure it across three dimensions. At the industrial level, we use the ratio of tertiary to secondary sector employment. For sectoral composition, we employ the share of high-tech

industry employment, encompassing both advanced manufacturing and high-end services. Advanced manufacturing data are derived from the annual average employment in high-tech industries, as reported in the China High-Tech Industry Statistical Yearbook. High-end services employment is calculated as the sum of four sectors: scientific research and technical services; information transmission, computer services, and software; finance; and leasing and business services. Skill-level employment structure is measured by the ratio of high-skilled to medium/low-skilled workers, with high-skilled employment represented by the proportion of workers holding college diplomas, bachelor's degrees, or postgraduate qualifications.

Explanatory Variable: Environmental Regulation (ER). Environmental regulation represents the strength of environmental protection and environmental policy objectives. The existing literature uses a variety of means to measure the level of environmental regulation. This paper firstly adopts the proportion of investment in pollution control in each province to GDP to represent environmental regulation. Secondly, in order to maintain the reliability of the conclusion, in the robustness test part, this paper adopts the environmental regulation intensity, measured based on the textual analysis of government work reports, as a replacement variable for the analysis. The government work report of each region reflects the strength of environmental regulation as well as the full picture of governance policies in that year. Therefore, to construct the environmental regulation intensity variable, we count the frequency of terms related to 'environmental regulation' in the government work reports of each province in the past years. Specific terms include: "environmental protection, low carbon, air, green, $PM_{2.5}$, pollution" and 15 other terms.

Mediating Variables. Guided by theoretical mechanisms, we employ three mediators: industrial structure upgrading (Ins), technological innovation (Tec), and human capital (Hum). Industrial upgrading is measured by the ratio of tertiary to secondary sector output value. Technological innovation is represented by the high-tech industry's new product sales revenue as a percentage of GDP. Human capital is quantified using the education-year approach, calculated as the average years of schooling for populations aged six and above at the provincial level [38]. Following China's educational system, we assign 6 years for primary school, 9 for junior secondary, 12 for senior secondary, and 16 for college education and above. The specific calculation method is as follows:

$$Hum = s1 \times 6 + s2 \times 9 + s3 \times 12 + s4 \times 16 \quad (4)$$

In Equation (4), s1, s2, s3, and s4 represent the proportions of the population aged six and above with primary school, junior secondary, senior secondary, and college or higher education levels, respectively.

Control Variables. We account for additional factors influencing employment structure. Urbanization rate (Urban) is measured by the proportion of urban permanent residents, reflecting labor supply expansion. Trade openness (Open), represented by the ratio of import-export volume to GDP (converted using annual average exchange rates), captures regional economic dynamics and labor mobility. Employment training (Train) is proxied by the proportion of trainees in employment training centers, indicating workforce skill development. Investment level (Invest) is measured by fixed asset investment as a percentage of GDP, reflecting capital-driven structural changes. Transportation accessibility (Traffic) is represented by passenger volume per capita, indicating regional connectivity.

Data

In accordance with data availability and consistency, this study uses panel data from 2007-2023 for 30 provinces, municipalities, and autonomous regions in China, excluding Hong Kong, Macao, Taiwan, and Tibet. The data on labor and employment in each province, city and autonomous region are mainly from China Population and Employment Statistical Yearbook, China Labor Statistical Yearbook, and China Urban Statistical Yearbook, while the data on environmental regulation and industrial structure upgrading are mainly from China Regional Economic Statistical Yearbook, China Environmental Statistical Yearbook, and Express Professional Superior (EPS) Data. The value variables are deflated using 2007 as the base period to eliminate the effect of inflation. Descriptive statistics of the variables are shown in Table 1.

Results and Discussion

Baseline Regression Results

Accounting for employment structure rigidity and following the empirical model specification in Equation (1), we employ a two-step difference GMM approach for dynamic panel analysis at the provincial level, with results presented in Table 2. Columns (1) and (2) report regression results for industrial-level employment structure, with column (1) excluding control variables. Columns (3) and (4) present results for sectoral-level employment structure, while Columns (5) to (6) display findings for skill-level employment structure.

The regression results in Table 2 yield three key findings. First, diagnostic tests confirm the model's validity: the p-values for AR (1) statistics are consistently below 0.1, while those for AR (2) exceed 0.1, indicating no second-order autocorrelation. Hansen test results further validate the appropriateness of instrumental variables. Second, the positive and statistically significant coefficients of environmental regulation (ER) across all specifications suggest that environmental regulation generally promotes employment structure optimization.

Table 1. Definitions, indicators, and descriptive statistics of the variables.

Variables	Description	Samples	Mean	Std.Dev	Min	Max
Esin	Industry employment structure	510	0.701	0.271	0.164	1.481
Essh	Sectoral employment structure	510	0.078	0.242	0.013	0.247
Essk	Skill employment structure	510	0.190	0.197	0.024	1.649
ER	Environmental regulation	510	1.361	0.721	0.300	4.240
Ins	Industrial structure upgrade	510	0.830	0.539	0.401	5.061
Tec	Technological innovation	510	9.176	1.688	4.248	13.176
Hum	Human capital	510	0.770	0.063	0.523	0.875
Urban	Urbanization rate	510	0.536	0.144	0.269	0.896
Open	Trade openness	510	0.321	0.412	0.043	1.814
Train	Employment training	510	14.210	9.730	2.100	62.200
Invest	Investment level	510	0.494	0.229	0.190	1.309
Traffic	Transport accessibility	510	12.050	0.855	9.129	14.126

Table 2. Baseline regression results.

Variables	Esin		Essh		Essk	
	(1)	(2)	(3)	(4)	(5)	(6)
L. Ems	0.922*** (0.058)	0.626*** (0.112)	0.628*** (0.056)	0.535*** (0.068)	0.833*** (0.050)	0.250*** (0.002)
ER	0.038*** (0.010)	0.043** (0.018)	0.005** (0.002)	0.002* (0.001)	0.038** (0.017)	0.012*** (0.003)
Urban		0.018*** (0.006)		0.036 (0.021)		0.004 (0.002)
Open		0.049 (0.055)		0.061*** (0.021)		0.007 (0.006)
Train		0.007* (0.004)		0.007*** (0.002)		0.019*** (0.003)
Invest		0.031 (0.067)		0.001 (0.041)		-0.036*** (0.003)
Traffic		0.038 (0.040)		0.002* (0.001)		0.032* (0.018)
AR (1)	0.012	0.030	0.040	0.060	0.067	0.051
AR (2)	0.584	0.704	0.567	0.783	0.751	0.431
Hansen	0.523	0.700	0.421	0.921	0.471	0.553
N	450	450	450	450	450	450

Note: ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively, with standard error statistics in parentheses; the values corresponding to AR and Hansen tests are reported as prob>z and prob>chi2, respectively.

The empirical results reveal three distinct patterns of employment structure transformation driven by environmental regulation. At the industrial level, stricter environmental standards accelerate the transition from industrialization to service-oriented economies, evidenced by increasing tertiary sector employment. Sectoral-level analysis demonstrates that environmental regulation enhances employment shares in high-tech industries through technological innovation, as firms offset pollution control costs with innovation-driven efficiency gains. Skill-level dynamics show a rising ratio of high-skilled to low-skilled employment, indicating a structural shift toward skill-intensive labor markets.

Robustness Test

Alternative Estimation Methods

In the baseline regression part of the paper, a two-stage dynamic panel GMM approach is used

to analyze the relationship between environmental regulation and labor force employment structure at three levels. To ensure the robustness of the findings, a systematic GMM approach is used for robustness testing. The results are shown in Table 3.

From the empirical results in Table 3, after changing the estimation method, the coefficients of environmental regulation on different levels of employment structure are still significantly positive, which is consistent with the results of the benchmark regression. This indicates that environmental regulation can promote the optimization of employment structure, and the research conclusion is robust.

Alternative Core Explanatory Variables

To further validate the robustness of our findings and reduce possible measurement bias in the environmental regulatory indicators, we reconstructed the core explanatory variables and re-estimated the baseline model. As shown in Table 4, the new ERS variables are derived from textual analyses of provincial government work reports, and we quantify environmental regulatory intensity by calculating the frequency of occurrence of ecological protection-related sentences in annual policy documents.

The results show that after substituting the core explanatory variables, environmental regulation maintains a statistically significant positive effect on the multidimensional employment structure (industry, sector, and skill level), consistent with the baseline regression results. This result confirms the reliability of our conclusions on the optimal effect of environmental regulation on labour market structure.

Endogeneity Treatment

To address potential endogeneity from reverse causality, we employ an instrumental variable (IV) approach. Reverse causality may arise because employment structure optimization could incentivize provinces to increase pollution control investments, thereby altering environmental regulation levels. Reverse causality biases the estimation results. Following Xu et al. [39], we select the green coverage rate in built-up areas as the IV for environmental regulation. The greening coverage rate of built-up areas is related to environmental regulation and does not directly affect the employment structure, so, according to the principle of selecting instrumental variables, it can be considered that the greening coverage rate of built-up areas is suitable to be used as an instrumental variable for environmental regulation.

The results in Table 5 show that the coefficients of the core explanatory variables are still significantly positive. This further confirms the positive impact of environmental regulation on the optimization of employment structure, thus enhancing the reliability of the findings of this study.

Table 3. Estimation results of changing estimation methods.

Variables	(1)	(2)	(3)
	Esin	Essh	Essk
L. Ems	1.089*** (0.017)	1.021*** (0.005)	1.078*** (0.001)
ER	0.029*** (0.010)	0.086*** (0.031)	0.037*** (0.001)
Control variables	YES	YES	YES
AR (1)	0.010	0.030	0.083
AR (2)	0.599	0.610	0.589
Hansen	0.773	0.654	0.698
N	480	480	480

Table 4. Estimation results of changing the explanatory variable measurement.

Variables	(1)	(2)	(3)
	Esin	Essh	Essk
L. Ems	1.089*** (0.017)	1.021*** (0.005)	1.078*** (0.001)
ER	0.029*** (0.010)	0.086*** (0.031)	0.037*** (0.001)
Control variables	YES	YES	YES
AR (1)	0.010	0.030	0.083
AR (2)	0.599	0.610	0.589
Hansen	0.773	0.654	0.698
N	480	480	480

Table 5. Estimation results of endogeneity treatment.

Variables	(1)	(2)	(3)
	Esin	Essh	Essk
L. Ems	0.986*** (0.003)	0.807***	1.017***
		(0.001)	(0.001)
IV	0.086***	0.011*	0.014***
	(0.005)	(0.006)	(0.003)
Control variables	YES	YES	YES
AR (1)	0.012	0.034	0.086
AR (2)	0.382	0.538	0.575
Hansen	0.799	0.685	0.671
N	450	450	450

Mechanism Examination

In order to verify the indirect mechanism of environmental regulation on employment structure proposed in the analysis part of the theoretical mechanism, this paper adopts the mediation effect model according to the setup form of Equations (1) to (3) for verification. The regression results are shown in Tables 6 to 8, which are used to verify the mediating role of industrial structure upgrading before environmental regulation and the employment structure at the industry level of the labor force, the role of technological innovation between environmental regulation and the employment structure at the industry level, and the role of human capital upgrading between environmental regulation and the employment structure at the skill level, respectively.

Industrial Structural Upgrading Effects

Based on the regression results in Table 6, it can be concluded that environmental regulation can affect the structure of employment by acting on industrial structure upgrading. Specifically, the regression results in Column (1) of Table 6 are based on Equation (1), which estimates the direct effect of environmental regulation on the industrial structure of employment, consistent with the results of the benchmark regression. Column (2), when industrial structure upgrading is used as the explanatory variable, the environmental regulation variable is significantly positive, indicating that environmental regulation plays a facilitating role in industrial structure upgrading. Column (3) takes industry-level employment structure as the explanatory variable, and after adding the mediating variable, the coefficient of environmental regulation is still significant, and the coefficient of the industrial structure upgrading variable is significantly positive. To sum up, the mediating effect exists, and environmental regulation can not only directly affect the employment structure at the industry level, but also have an impact on the employment structure through industrial structure upgrading. According to the definition of employment industry structure, with the increase of environmental regulation intensity, the employment structure will develop in the direction of the service industry.

Technological Innovation Effects

In order to verify whether environmental regulation can have an impact on the structure of labor employment at the industry level through technological innovation, this section includes technological innovation (Tec) as a mediating variable. Column (1) in Table 7 shows the results of the regression without the mediating variable, which are consistent with the baseline regression. Column (2) uses technological innovation as the explanatory variable, and the regression results show that the coefficient of the environmental regulation variable is significantly positive, which implies that there is a significant promotion effect of environmental regulation on technological innovation, verifying Porter's hypothesis. According to the regression results in Column (3), with industry-level employment structure as the explanatory variable, the estimated coefficient of the mediating variable, technological innovation, is positive at 1% significance level. Based on the above analysis, environmental regulation not only directly affects the employment structure of the labor force at the industry level, but also indirectly makes the employment

Table 6. Results of the mediating effect of industrial structure upgrading.

Variables	(1)	(2)	(3)
	Esin	Ins	Esin
L. Esin	0.626*** (0.112)		0.416*** (0.013)
L. Ins		0.887*** (0.036)	
ER	0.043** (0.018)	0.190*** (0.025)	0.025*** (0.006)
Ins			0.024*** (0.002)
Control variables	YES	YES	YES
AR (1)	0.030	0.001	0.044
AR (2)	0.704	0.703	0.371
Hansen	0.700	0.422	0.711
N	450	450	450

Table 7. Results of the mediating effect of technological innovation.

Variables	(1)	(2)	(3)
	Essh	Tec	Essh
L. Essh	0.535*** (0.068)		0.514*** (0.003)
L. Tec		0.392*** (0.098)	
ER	0.002* (0.001)	0.277*** (0.051)	0.002* (0.001)
Tec			0.003*** (0.001)
Control variables	YES	YES	YES
AR (1)	0.060	0.002	0.054
AR (2)	0.783	0.538	0.740
Hansen	0.921	0.476	0.915
N	450	450	450

structure at the industry level develop in the direction of high technology by promoting the level of technological innovation.

Human Capital Enhancement Effects

In order to illustrate whether environmental regulation can drive the employment structure in the direction of high-skilling through the enhancement of human capital, human capital is used as a mediating variable in this section. In Table 8, Column (1), with employment skill structure as the explanatory variable, does not include the mediating variable for examining the direct effect of environmental regulation on employment skill structure, consistent with the benchmark regression. Column (2), with human capital as the explanatory variable, shows estimation results indicating that environmental regulation has a significant effect on the level of human capital. The reason for this is that higher environmental standards can contribute to the improvement of the ecological environment, which is conducive to the increase in the level of human capital. According to the regression results in Column (3), the overall effect of environmental regulations on the employment structure of the labor force at the skill level remains significant when the employment skill structure is used as the explanatory variable, and human capital, as the mediating variable, is added to the model for regression. From the above analysis, it can be seen that environmental regulation not only has a direct impact on the employment structure of labor at the skill level, but also has an indirect effect on the employment structure through the human capital effect.

Table 8. Results of the mediating effect of human capital enhancement.

Variables	(1)	(2)	(3)
	Essk	Hum	Essk
L. Essk	0.250*** (0.002)		0.730*** (0.010)
L. Hum		0.251*** (0.002)	
ER	0.012*** (0.003)	0.217** (0.080)	0.006** (0.002)
Hum			0.013*** (0.004)
Control variables	YES	YES	YES
AR (1)	0.051	0.001	0.054
AR (2)	0.431	0.880	0.704
Hansen	0.553	0.418	0.599
N	450	450	450

Heterogeneity Analysis

Heterogeneity of Regions

Due to the differences in geographic location, the development of various aspects such as industrial structure and education level varies among regions in China, which in turn may lead to variability in the findings of this paper. Therefore, from the perspective of regional heterogeneity, based on the geographical distribution of each province, the whole sample is divided into two sub-samples, the eastern region and the central and western region, for estimation, and the estimation results are shown in Table 9.

As shown in Table 9, Columns (1)-(3) present the relationship between environmental regulation and employment structures in eastern China. Environmental regulation significantly enhances sectoral and skill-level employment structures, consistent with baseline results. However, its impact on industrial-level employment structure remains statistically insignificant, potentially due to eastern regions' advanced environmental regulation and industrial structure, coupled with already high service sector employment shares. Columns (4)-(6) reveal significantly positive coefficients for environmental regulation in central-western China, demonstrating its effectiveness in promoting employment structure optimization across all three dimensions.

Heterogeneity of Urbanization

With population growth and economic development, China's urbanization level has been increasing, and is also an important factor influencing labor mobility between urban and rural areas [40]. For this reason, this paper uses the proportion of urban population in the total population to indicate the level of urbanization, and divides the whole sample into two sub-samples of high and low urbanization levels according to its median level, in order to analyze the changes in the structural effects of environmental regulation on employment under different levels of urbanization.

In Table 10, Columns (1) to (3) indicate the relationship between environmental regulation and employment structure at high urbanization levels. Based on the results, it can be seen that there is a significant positive relationship between environmental regulation and the employment structure of the labor force at the industry level and skill level, while the effect of environmental regulation on the employment structure of the labor force at the industry level is not significant. According to the regression results in Columns (4) to (6), environmental regulation can effectively promote the optimization of the employment structure of the labor force at the industry level and the skill level under the low level of urbanization, while its effect on the employment structure at the industry level is not obvious. This implies that the impact of environmental

Table 9. Regional heterogeneity analysis results.

Variables	Eastern region			Central and western region		
	(1) Esin	(2) Essh	(3) Essk	(4) Esin	(5) Essh	(6) Essk
L. Ems	0.995*** (0.051)	0.773*** (0.052)	0.966*** (0.125)	0.833*** (0.067)	0.654*** (0.042)	0.849*** (0.045)
ER	0.004 (0.014)	0.002* (0.001)	0.045** (0.020)	0.029** (0.012)	0.003*** (0.001)	0.021*** (0.004)
Control variables	YES	YES	YES	YES	YES	YES
AR (1)	0.074	0.012	0.087	0.037	0.031	0.003
AR (2)	0.423	0.416	0.124	0.559	0.704	0.243
Hansen	0.882	0.915	0.799	0.970	0.848	0.916
N	165	165	165	285	285	285

Table 10. Urbanization heterogeneity analysis results.

Variables	High urbanization			Low urbanization		
	(1)	(2)	(3)	(4)	(5)	(6)
	Esin	Essh	Essk	Esin	Essh	Essk
L.Ems	0.738*** (0.073)	0.568*** (0.059)	0.199*** (0.049)	0.267*** (0.091)	0.627*** (0.109)	0.020*** (0.007)
ER	0.032 (0.026)	0.003** (0.001)	0.053* (0.027)	0.142** (0.064)	0.003 (0.031)	0.021*** (0.004)
Control variables	YES	YES	YES	YES	YES	YES
AR (1)	0.027	0.078	0.037	0.017	0.076	0.004
AR (2)	0.939	0.690	0.424	0.311	0.534	0.494
Hansen	0.883	0.887	0.844	0.861	0.659	0.912
N	209	209	209	241	241	241

regulations on employment structure is influenced by the level of regional urbanization. The reason for this may be that in regions with a low level of urbanization, where there is still a large number of laborers in the countryside as a reserve army, an increase in the intensity of environmental regulation can have a significant effect on the industrial structure of employment. However, in regions with lower levels of urbanization, high-end industries are not sufficiently developed, and the effect of increased environmental regulation on the industrial structure of employment is not obvious.

Conclusions

Promoting the integration of environmental protection and the high-quality development of employment, and giving full play to the role of environmental regulation in optimizing the employment structure are crucial to solving the employment problem in the new situation. Based on the provincial panel data from 2007 to 2023, this paper systematically examines the changes in employment structure under environmental regulation at the industry, sector, and skill levels. It also discusses the heterogeneity of the findings based on the differences in regions, levels of economic development, and urbanization.

The main conclusions are as follows. (1) Environmental regulation has a multi-dimensional role in promoting the optimization of employment structure. Specifically, raising the amount of investment in environmental pollution control is conducive to accelerating the transformation of industrial structure in the direction of cleanliness and enhancing the absorptive capacity of the tertiary industry for labor. Higher environmental standards stimulate the transfer of labor to high-end manufacturing and service industries and increase the number of employees in high-skill industries. The share of high-skilled labor under environmental regulation grows steadily. (2) The mechanism of environmental regulation affecting employment structure can be divided into

direct and indirect mechanisms. Industrial structure upgrading, technological innovation, and human capital enhancement constitute the three core conduction paths of environmental regulation on employment structure. (3) There is obvious heterogeneity in the impact of environmental regulation on employment structure. Specifically, the service industry is already relatively developed in the developed eastern coastal regions, and the enhancement of environmental regulation has a limited effect on the optimization of the employment structure at the industrial level, but it can significantly promote the shift of the employment structure towards high technology, and effectively increase the demand for high-skilled personnel. In addition, under environmental regulation, the shift of employment structure towards high technology is more obvious in regions with high urbanization rates, while regions with low urbanization rates are more likely to achieve the adjustment of employment structure at the industry level. This difference stems from the different dynamic interactions between regional labor factor reserves and industrial base under different levels of urbanization.

Implications

Based on the findings of the study, this paper puts forward policy recommendations for promoting the optimization of employment structure through environmental regulation. (1) Optimize employment structure through multiple channels. Environmental regulation can promote the optimization of employment structure through industrial structure innovation, technological innovation, and human capital enhancement. Therefore, localities should pay attention to industrial structure adjustment while implementing environmental regulations, and actively play the role of the tertiary industry in driving employment. Relying on the digital economy and technological innovation to promote the development of new and high-tech industries, it will open up a broader space for employment. At the same time, strengthen the talent policy to absorb the inflow of high-skilled talents. (2) Differentiated environmental regulation strategies should be adopted in different regions. The central and western regions need to moderately increase the amount of investment in environmental pollution control and, concurrently, should pay attention to the development of high-tech industries and high-end industries and strengthen the role of environmental regulation in the optimization of the structure of the employment industry and skill structure. The eastern region should further enhance the level of human capital while strengthening environmental pollution control to meet the demand for highly skilled personnel in the green low-carbon transition. (3) The government should focus on safeguarding workers' rights while addressing the green and low-carbon transformation of the economic development mode, so as to provide a sustainable and favorable environment for the optimization of the employment structure. Regions should actively address the unemployment problem caused by environmental regulations, strengthen unemployment protection, and guide the unemployed to actively participate in green skills training and return to employment.

Limitations

This study has limitations that warrant further investigation. First, constrained by provincial-level macro statistics, we were unable to construct firm-level employment indicators due to data scarcity on enterprise environmental investments and disaggregated industry employment. Future research should develop multi-scale panel datasets and composite environmental regulation indices, integrating enforcement intensity and public responsiveness to elucidate micro-level transmission mechanisms. Second, while emphasizing regional heterogeneity, our spatial analysis did not address inter-jurisdictional policy coordination. Subsequent studies should employ spatial econometric models to explore regional synergies in environmental regulation and conduct cross-national comparative analyses to refine theoretical frameworks for green employment transitions.

Acknowledgments

This work was supported by the Philosophy and Social Science Planning Project Fund of Henan Province (2024CJJ157) and the Research Project Fund of the Federation of Social Science Circles of Henan Province (SKL-2024-2147).

Conflicts of Interest

The authors declare no conflict of interest.

References

1. REN S., LIU D., LI B., WANG Y., CHEN X. Does emissions trading affect labor demand? Evidence from the mining and manufacturing industries in China. Journal of Environmental Management. **254**, 109789, **2020**.
2. WANG C., LIU X., LI H., YANG C. Analyzing the impact of low-carbon city pilot policy on enterprises' labor demand: Evidence from China. Energy Economics. **124**, 106676, **2023**.
3. SHI D., LUO C., ZHANG K., BU C. Does stringent environmental regulation improve labor force employment? Evidence from China. Environment, Development and Sustainability. **6**, 1, **2024**.
4. YAMAZAKI A. Jobs and climate policy: Evidence from British Columbia's revenue-neutral carbon tax. Journal of Environmental Economics & Management. **83** (5), 197, **2017**.
5. HILLE E., MÖBIUS P. Do energy prices affect employment? Decomposed international evidence. Journal

of Environmental Economics and Management. **96**, 1, **2019**.
6. GRAY W.D., SHADBEGIAN R.J., WOLVERTON A. Environmental Regulation and Labor Demand: What Does the Evidence Tell Us? Annual Review of Resource Economics. **15**, 177, **2023**.
7. BERMAN E., BUI L T.M. Environmental Regulation and Productivity: Evidence from Oil Refineries. Review of Economics & Statistics. **83** (3), 498, **2001**.
8. YU D.J., LI J. Evaluating the Employment Effect of China's Carbon Emission Trading Policy: Based on the Perspective of Spatial Spillover. Journal of Cleaner Production. **292** (490), 126052, **2021**.
9. WANG H., LIU C., SHI P., WANG Y. The social effects of energy regulation: Energy-consuming rights trading system and corporate labor demand. Journal of Environmental Management. **366**, 15, **2024**.
10. LI Z., LI Y. Environmental regulation and employment: Evidence from China's new Environmental Protection Law. Economic Analysis and Policy. **82**, 400, **2024**.
11. JIAO Z. The Impact of Accountability for Energy Efficiency Targets on Labor Demand of Enterprises: Evidence from China's Top-1000 Energy-Saving Program. Sustainability. **16**, 9447, **2024**.
12. GUO W., DAI H., LIU X. Impact of different types of environmental regulation on employment scale: an analysis based on perspective of provincial heterogeneity. Environmental Science and Pollution Research. **27**, 45699, **2020**.
13. HUANG J., XU X., ZHAO T. The moderating effect of clean technology innovation in the process of environmental regulation affecting employment: Panel data analysis based on 22 industrial sectors in China. Journal of Cleaner Production. **414**, 137672, **2023**.
14. LI Y., HU M., ZHAO L. Study on the impact of industrial green development and technological innovation on employment structure. Frontiers in Earth Science. **11**, 1115476, **2023**.
15. LV K.J., ZHU S.W., PAN M.J., HUANG M. Does the Emissions Trading System Affect the Structure of Firms' Labor Hiring? --Evidence from listed SO_2 emitting firms in China. Management Review. **35**, 239, **2023** [In Chinese].
16. LI Z., LIN B. Analyzing the impact of environmental regulation on labor demand: A quasi-experiment from Clean Air Action in China. Environmental Impact Assessment Review. **93**, 106721, **2022**.
17. ELLIOTT R.J.R., KUAI W., MADDISON D., OZGEN C. Eco-innovation and (green) employment: A task-based approach to measuring the composition of work in firms. Journal of Environmental Economics and Management. **127**, 103015, **2024**.
18. JIANG Y.H., SHEN H.L. Environmental regulation patterns and the upgrading of employment skill structure: theoretical mechanisms and empirical tests. Journal of Jianghai. **5**, 248, **2020** [In Chinese].
19. ZHONG S., XIONG Y., XIANG G. Environmental regulation benefits for whom? Heterogeneous effects of the intensity of the environmental regulation on employment in China. Journal of Environmental Management. **281** (69), 111877, **2021**.
20. LI M., DU W. The impact of environmental regulation on the employment of enterprises: an empirical analysis based on scale and structure effects. Environmental Science and Pollution Research International. **21**, 11356, **2021**.
21. HE Z., CHEN Z., FENG X. The role of green technology innovation on employment: does industrial structure optimization and air quality matter? Environmental Sciences Europe. **35** (1), 1, **2023**.
22. ZHAO K., GAO Y., LIU X. The impact of environmental regulation on industrial structure upgrading: A case study of low carbon city pilot policy. Energy Policy. **197**, 114432, **2025**.
23. LIAO H., YANG L., DAI S., VAN ASSCHE A. Outward FDI, industrial structure upgrading and domestic employment: empirical evidence from the chinese economy and the belt and road initiative. Journal of Asian Economics. **74**, 101303, **2021**.
24. QIN B., LIU L., YANG L., GE L. Environmental Regulation and Employment in Resource-Based Cities in China: The Threshold Effect of Industrial Structure Transformation. Frontiers in Environmental Science. **10**, 3389, **2022**.
25. SUN W., ZHANG J. Heterogeneous environmental policies and employment: evidence from China. Environmental Science and Pollution Research. **31**, 820, **2024**.
26. LI Z., LYU P., SUN J. Environmental regulation and equilibrium unemployment in China: Evidence from a multiple-sector search and matching model. China Economic Review. **89**, 102336, **2025**.
27. LIU M., SHADBEGIAN R., ZHANG B. Does environmental regulation affect labor demand in China? Evidence from the textile printing and dyeing industry. Journal of Environmental Economics & Management. **86** (11), 277, **2017**.
28. ZENG X.Q., WEI X.L., ZENG X.J. Impact of environmental protection tax on employment - a quasi-natural experiment based on A-share listed companies. Academic Research. **12** (6), 81, **2023** [In Chinese].
29. MARIN G., VONA F. Climate policies and skill-biased employment dynamics: Evidence from EU countries. Journal of Environmental Economics and Management. **98**, 102253, **2019**.
30. BAXAMUSA M., JALAL A. Environmental regulations, agency costs, and firm performance. Research in International Business and Finance. **70**, 102307, **2024**.
31. MACZULSKIJ T. How are green jobs created? A decomposition analysis. Economics Letters. **244**, 111950, **2024**.
32. HAFSTEAD M.A.C., WILLIAMS R.C.I. Unemployment and Environmental Regulation in General Equilibrium. Journal of Public Economics. **160** (4), 50, **2018**.
33. DU K., CHENG Y., YAO X. Environmental regulation, green technology innovation, and industrial structure upgrading: The road to the green transformation of Chinese cities. Energy Economics. **98**, 105247, **2021**.
34. HU J., HU M., ZHANG H. Has the construction of ecological civilization promoted green technology innovation? Environmental Technology & Innovation. **29**, 102960, **2023**.
35. WEI P., CHEN B., ZHAO Y. Green governance, technological progress and employment. Contemporary Economic Science. **46** (3), 18, **2024** [In Chinese].
36. CHEN Y. Environmental regulation, local labor market, and skill heterogeneity. Regional Science and Urban Economics. **101**, 103898, **2023**.
37. WANG A., HU S., LIN B. Can environmental regulation solve pollution problems? Theoretical model and empirical research based on the skill premium. Energy Economics. **94**, 105068, **2021**.

38. ZHANG J., XU H., WANG H. Study on Knowledge Spillover and Convergence of China's Regional Economic Growth. Macroeconomic Research. **12** (4), 71, **2020** [In Chinese].
39. XU B., PAN C., LI S. Are environmental regulations inhibiting the expansion of Chinese firms? Journal of China University of Geosciences (Social Science Edition). **20**, 74, **2020** [In Chinese].
40. TONG Y., ZHOU M., ZHOU W. The impact of high-end industrial structure upgrading on Beijing's population size. Journal of Labor Economics Review. **14** (2), 1, **2021**.