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Environmental Regulation and Employment in Resource-Based Cities in China: The Threshold Effect of Industrial Structure Transformation

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Resource-based cities in China face the dual pressure of environmental pollution and unemployment. Therefore, it is necessary to measure the effect of environmental regulation on employment. In this study, we first analyzed the theoretical mechanism of employment effects of environmental regulation. Second, we constructed a nonlinear panel threshold regression model with industrial structure rationalization and optimization as the threshold variables and used data from 115 resource-based prefecture-level cities to empirically examine the impact of environmental regulation on employment. The results demonstrate that 1) There is a significant threshold effect between environmental regulation and employment in resource-based cities, with the rationalization and optimization of the industrial structure gradually crossing the threshold from a low threshold to a high threshold, and the impact of environmental regulation on employment has gradually changed from an inhibitory effect to a promotion effect; 2) This conclusion still holds after the robustness test and the division of life cycles of different types of resource-based cities; 3) The coal resource cities as a representative of this kind of resource-based cities with serious environmental pollution, strengthening environmental regulation, have an obvious role in promoting employment. This study enriches the research content of environmental regulation on employment and provides useful references for rational improvement of unemployment in China.

Keywords: resource-based cities, environmental regulation, employment, industrial structure transformation, threshold

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1 INTRODUCTION

Resource-based cities in China are widely considered to be found for the sustainable development of resources and the national economy. The leading industry in resource-based cities is the exploitation and processing of resources. Earlier, a series of strategies were formulated in China to develop heavy industries. However, with the rapid economic development, the ecological environment was severely damaged, leading to the deterioration of environmental quality within natural and built environments. This is particularly evident in China's resource-based cities; with the continuous consumption of natural resources, these cities have declined rapidly, and the labor force engaged in mining activities have lost their jobs. This resulted in a series of social dilemmas. Thus, the

coordination of relationships among resource consumption, environmental pollution, and employment has become an urgent problem that must be addressed for the sustainable development of resource-based cities.

The "14th Five-Year Plan for Ecological Environmental Protection" proposes that local governments should improve the quality of the regional ecological environment by implementing strict environmental protection systems. In the report of the 19th National Congress of the Communist Party of China, it is pointed out that all regions should actively use environmental regulation to transform the backward production capacity of resource-based cities and achieve cleaner production. Local governments should improve the quality of the regional ecological environment by implementing strict environmental protection systems. At the same time, all regions should actively transform the backward production capacity of resource-based cities and achieve cleaner production through environmental regulation. Can the implementation of environmental regulations bring double dividends of environmental improvement and employment promotion? We plotted the trend of total employment in 115 resource-based cities from 2003 to 2016 (as shown in **Figure 1**) and also plotted the trend of the total industrial dust emissions and industrial SO_2 emissions in 115 resource-based cities from 2003 to 2016 (as shown in **Figure 2**). From this, we can clearly find that with the continuous improvement of the environmental regulation level in resource-based cities, the total employment showed a slow-growth trend, and this phenomenon is particularly obvious after 2011. At the same time, industrial dust emissions and industrial SO_2 emissions in resource-based cities showed a gradual downward trend, and this phenomenon is particularly obvious after 2013.

The implementation of environmental regulation not only brings about environmental effects but also produces many social effects. The most apparent one is the impact on employment. In other words, the enhancement of environmental regulation has forced enterprises that fail to meet environmental protection standards to rapidly shut down, which weakens the ability of high-polluting industries to reallocate labor, thus exacerbating unemployment (Walker, 2013). Additionally, environmental regulations reduce the scale of production and thus lead enterprises to reallocate resources owing to the increase in production costs, which, in turn, induces a decrease in employment within the industry in question (Henderson, 1997; Greenstone, 2002). Reed (2013) used linked worker-firm data in the United States to estimate the transitional costs associated with reallocating workers from newly regulated industries to other sectors of the economy and found that the re-allocative costs of the environmental policy were significant. In addition, the introduction of advanced equipment can directly improve the efficiency of enterprises, replace the labor force, and reduce employment (Orlitzky et al., 2003). Ambec et al. (2013) found that environmental regulation requires cleaner production, which increases entry barriers for enterprises and hence reduces market vitality. Thus, it is evident that environmental regulation has a negative effect on employment in many industries from this point of view.

However, the enhancement of environmental regulations can promote the development of new industrial sectors, such as environmental protection and cleaning departments, leading to an increase in the employment capacity (Bezdek et al., 2008; Mishra and Smyth, 2012). This will partly alleviate the unemployment brought about by the enhancement of environmental regulations. Wagner, (2005) revealed that tax on emissions stimulates the emergence of an abatement sector that provides pollution control and vacancies for job seekers. Anindita and Rajat (2011) claimed that with an improvement in the environmental quality, the productivity effect generated among skilled and unskilled workers improves their health, leading to an increase in productivity. In addition, based on Porter's hypothesis (Porter, 1991), environmental regulation can force enterprises to spend more on technology innovations to improve the resource allocation efficiency, which is conducive to promoting employment (Ferreira et al., 2017; Munir and Ameer, 2018). Vivarelli and Pianta, (2000) conducted a statistical analysis of 21 departments in five countries, including Italy, Finland, Norway, Germany, and Denmark, and found that the innovation activities of enterprises have a positive effect on overall employment. However, Yang et al. (2021) indicated that the effects of the technological change induced by environmental regulation have not been fully manifested, which may not have a significant promotion to employment. Xu et al. (2020) investigated the long-term economic consequences of the corporate environmental responsibility (CER) by companies from the perspective of earnings persistence and investors' response and found that the CER of China's heavily polluting listed companies has significantly improved their earnings persistence. From the aforementioned two aspects, environmental regulation does not aggravate unemployment and has a significant positive effect on regional employment. Thus, a mutually advantageous situation for both environmental protection and employment, which is referred to as the double dividend of environmental regulation, can be realized.

To date, there have been no clear-cut conclusions in existing studies about whether strengthening environmental regulations can promote employment. Therefore, in this study, we examined the impact of environmental regulations on employment in resource-based cities. Simultaneously, the adjustment of regional industrial structures will also have an impact on the employment effect of environmental regulation. The enhancement of environmental regulations will promote the adjustment of industrial structures. Environmental regulation policies can guide the reconfiguration of resource elements among different industries by setting up barriers to market entry, leading to the reallocation of resources among different industries to promote the advanced development of regional industrial structures (Ramanathan et al., 2010; Ahmed et al., 2016; Gurtoo and Antony, 2007). At the same time, China's Sustainable Development Plan of National Resource-Based Cities also promotes the development of the tertiary industry and facilitates the upgrading of the industrial structure in resource-based cities (Li et al., 2020). Some studies have analyzed the age distribution of labor productivity and found that the adjustment of labor age causes temporary fluctuations in productivity and

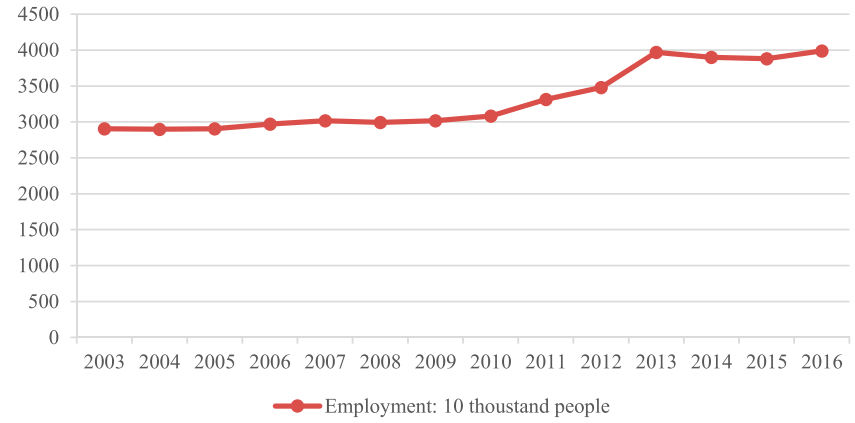

FIGURE 1 | Employment in resource-based cities.

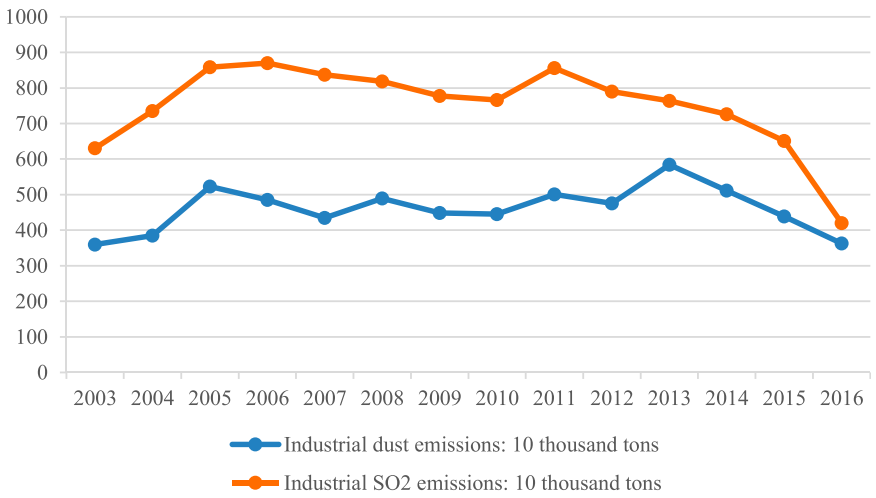

FIGURE 2 | Industrial dust emissions and industrial SO_2 emissions in resource-based cities.

further affects industrial upgrading (Delia, 2011). Different industries have different roles in absorbing labor forces. Amadeo and Pero, (2000) analyzed the changes in the employment structure between the manufacturing and service industries in Brazil from 1985 to 1995 and claimed that the service industry played a role as a buffer for labor employment in the recession. Under different industrial structures, the impact of environmental regulation on employment is different. Therefore, this study considers industrial structure transformation and links environmental regulation, labor employment, and industrial structure transformation.

In this study, we first analyzed the theoretical mechanism of employment effects of environmental regulation. Second, we constructed a nonlinear panel threshold regression model with industrial structure rationalization and optimization as the threshold variables and used data from 115 resource-based prefecture-level cities to empirically examine the impact of environmental regulation on employment. The results show that there is a significant threshold effect between environmental regulation and employment in resource-based cities; with the rationalization and optimization of the industrial structure gradually crossing the threshold from a low threshold to a high threshold, the impact of environmental regulation on employment has gradually changed from an inhibitory effect to a promotion effect. The coal resource cities as a representative of this kind of resource-based cities with serious environmental pollution, strengthening environmental regulation, have an obvious role in promoting employment.

This study contributes to the existing literature in the following three ways. First, from the perspective of the research subject, it focuses on 115 resource-based cities facing the dual issues of environmental degradation and unemployment, and then, we analyzed the effect of environmental regulation on employment. Second, from the perspective of research methods and models, based on the nonlinear relationship, with the

rationalization and upgrading of industrial structures as threshold variables, a panel threshold model was established to analyze the effect of environmental regulation on employment. Third, from the perspective of the research category, this study puts forward differentiated policy suggestions that cross the threshold value to realize the steady and rapid development of resource-based cities.

The remainder of this study is organized as follows. In **Section 2**, we conducted a theoretical analysis and proposed the hypothesis. **Section 3** introduces the research models and explains the data sources. **Section 4** analyzes the empirical results. In **Section 5**, we analyzed a case study about a coal-mining resource city. In **Section 6**, we concluded the study and provided the corresponding policy implications.

2 THEORETICAL ANALYSIS AND HYPOTHESIS ARE PROPOSED

The impact of environmental regulation on employment depends on the characteristics of the surrounding environment. Due to the different levels of industrial structures in different regions, the extent to which environmental regulation can promote or inhibit employment will also vary.

2.1 Threshold Effect of the Rationalization of the Industrial Structure

The rationalization of the industrial structure means the coordinated development among the primary industry, the secondary industry, and the tertiary industry. This study uses the distribution of labor factors in various industrial sectors to measure. The change of the industrial structure is usually accompanied by the change of the employment structure. No matter which industry reduces the scale, it will inevitably bring employment pressure, and the improvement of employment pressure also depends on the adjustment of the industrial structure. When analyzing the impact of structural factors on economic growth, Kuznets investigated the sector output value structure and labor force structure and found that the changing trend of labor force distribution in the three industries is consistent with that of GDP distribution, but the rise of the service sector is more significant.

If the change of the industrial structure is inconsistent with the change of the labor structure, it may lead to the unreasonable detention or separation of the labor force from the production process in the original industry, increasing unemployment. From the perspective of the three industrial structures, in China, the primary industry is mainly agriculture. Compared with other countries, the level of agricultural mechanization in China is low. Agricultural production will occupy most of the labor force, while the output value of agriculture is not high, which leads to the low labor productivity of the primary industry.

The secondary industry is the mining industry, specifically resource-based cities, that is, the mining industry focusing on the development and utilization of resources. This industry drives economic development to a large extent. However, with the continuous development and utilization of resources and the increasing reduction of resources, industrial enterprises have to reduce the production scale to maximize profits. Accordingly, the labor force engaged in the extractive industry is also decreasing.

The tertiary industry is mainly a service industry, with a high output value and labor productivity at a high level. When the rationalization level of the industrial structure is low, there is a large gap in labor productivity between the primary industry, the secondary industry, and the tertiary industry, indicating that a large number of the surplus labor force are concentrated in the primary industry, while the secondary industry dominated by mining in resource-based cities cannot absorb a large number of the labor force.

At the same time, the development of the tertiary industry is relatively slow, which hinders the expansion of the scope of employment on the whole. Then, environmental regulations are strengthened, and enterprises that cannot meet environmental protection standards in a short period choose to shut down or reduce the scale of production, exacerbating the unemployment of the secondary industry labor force. However, due to the low level of rationalization of the industrial structure, they cannot absorb these unemployed labor forces.

Therefore, when the rationalization level of the industrial structure is low, the enhancement of environmental regulation has an inhibitory effect on labor employment. When the rationalization level of the industrial structure is improved and close to the equilibrium state, the employment structure is more reasonable, which can effectively absorb the unemployed labor force due to the enhancement of environmental regulation. The inhibitory effect of environmental regulation on labor employment is weakened and becomes a positive promotion.

Based on the above discussion, the following hypotheses are put forward.

Hypothesis 1: when the rationalization of the industrial structure is improved, the impact of environmental regulation on employment has gradually changed from a negative inhibitory effect to a positive promotion effect.

2.2 Threshold Effect of the Optimization of the Industrial Structure

According to the Petty-Clark law, with the economic development and the improvement of per capita income, the labor force shifts from the agricultural sector to the non-agricultural sector. The remarkable feature of the advanced industrial structure is the rising proportion of the tertiary industry. Most of China's resource-based cities are mining cities. These cities mainly rely on the exploitation and processing of natural resources to develop their economy, especially the secondary industry such as the mining industry, which causes serious damage to the environment. Strengthening environmental regulation has a great impact on such industries.

We use the proportion of the output value of the tertiary industry in GDP to measure the upgrading of the industrial structure. The economic development experience of various countries shows that when the economic and social

development reaches a certain degree, the dependence of national economic development on the primary industry will gradually decrease, followed by the gradual increase of dependence on the secondary industry and the tertiary industry.

The most urgent problem faced by resource-based cities is to realize the transformation and upgrading of industrial structures. However, due to the long-term development and utilization of resources, the local economy has formed serious resource dependence. If the resources tend to dry up, it is difficult to imagine the future development of such cities. Resource-based cities are facing the dilemma of industrial structure transformation. Due to the accelerated consumption of resources, secondary industries such as the mining industry have been reduced. Then, the tertiary industry has not been fully developed.

When the optimization of the industrial structure is low, that is, the proportion of the tertiary industry in GDP is low, strengthening environmental regulation will make the employees of the extractive industry with serious environmental pollution unemployed. At this time, the secondary industry cannot absorb the surplus labor force of the primary industry, and there is also a reduced labor force due to the adjustment of the scale of the extractive industry. The task of absorbing the surplus labor force in the primary industry and the secondary industry is all concentrated in the tertiary industry. However, the proportion of the tertiary industry has not reached a certain level to absorb these unemployed labor forces, so the enhancement of environmental regulation will aggravate unemployment. When the optimization of the industrial structure is further improved, the proportion of the tertiary industry increases, and the ability of the service industry to absorb employment continues to increase. At this time, the tertiary industry can absorb more labor force, and it can also absorb the labor force reduced from the primary industry and the secondary industry. Then, strengthening environmental regulation will promote labor employment.

Based on the above discussion, the following two hypotheses are put forward.

Hypothesis 2: when the optimization of the industrial structure is improved, the impact of environmental regulation on employment has gradually changed from a negative inhibitory effect to a positive promotion effect.

3 DATA AND EMPIRICAL MODEL

In this study, one main variable of interest is employment, which is measured by the number of employees at the end of a year. The other variable of interest is environmental regulation. First, environmental regulation can be measured by both the number of environmental regulation laws and regulations and administrative penalty cases related to environmental protection (Cole et al., 2008; Lanoie et al., 2008). Second, environmental regulation is measured by the proportion of pollution control investment or pollution control expenditure in the total cost or total production of enterprises (Wayne, 1987). Third, environmental regulation is measured by the emission density or pollution control level of different pollutants (Arik, 1996). Fourth, environmental regulation is represented by the level of per capita income (Antweiler et al., 2001). Hence, in this study, we chose different pollutant removal rates and comprehensive utilization with the entropy value method of the objective weight method to obtain the combined weight of the evaluation indexes to measure the environmental regulation intensity, which can prevent the one-sidedness of a single indicator from happening.

In addition, since the standard discharge rate of industrial wastewater has not been disclosed after 2010, we selected the standard discharge rate of industrial wastewater, the removal rate of industrial SO_2, the comprehensive utilization rate of industrial solid waste, and the removal rate of industrial smoke (powder) from 2003 to 2010 and the other three indicators besides the standard discharge rate of industrial wastewater from 2011 to 2016. The entropy method is used to determine the weight and comprehensively measure the intensity of environmental regulation.

Based on this fact, we chose two threshold variables in this study. The first is the rationalization of the industrial structure (RIS). Here, we used the Thiel index, which is also well known as the Thiel entropy, to measure it[1]. The relevant calculation formula is presented as

$$ris = \sum_{i=1}^{n}\left(\frac{Y_i}{Y}\right)\ln\left(\frac{Y_i}{L_i}\Big/\frac{Y}{L}\right) = \sum_{i=1}^{n}\left(\frac{Y_i}{Y}\right)\ln\left(\frac{Y_i}{Y}\Big/\frac{L_i}{L}\right), \quad (1)$$

where i represents the ith industry, n denotes the number of industrial sectors, and (query) represent the output value and the number of employees, respectively. Therefore, (query) indicates the productivity level. Based on the classical economic theory, we should note that when the economy is in the final equilibrium state and the productivity levels among different sectors are the same, that is, then it follows. Meanwhile by contrast, if the industrial structure deviates from the equilibrium state, then the Thiel index is not 0, which indicates that the industrial structure is unreasonable. In addition, the RIS can also be used to reflect the coupling between the output structure and employment structure. In this study, the index is calculated from the data of primary, secondary, and tertiary industries in each city. The second threshold variable is the optimization of the industrial structure (OIS). It is noted that the optimization of the industrial structure usually implies the evolution process from the primary industry to the secondary industry and then to the third industry, which is always characterized by the decline of the first industry. Thus, in this study, we used the tertiary industry output value proportion of GDP to measure the optimization of the industrial structure.

Furthermore, in order to examine other factors that might have an influence on employment, we followed the existing literature and incorporated a series of control variables. Among these, the economic development scale of a region should be given special concerns. This is mainly because that

[1]Note that the Thiel index is first proposed by Theil and Henri (1967) and later used by some scholars in studies of regional income gap. In this study, the Thiel index takes all three industries into consideration, which can better reflect the rationalization level of the industrial structure.

TABLE 1 | Variable definitions and summary statistics.

Variables	Definitions	Observations	Mean	Standard deviation	Min	Max
emp	Employment	1,610	28.64	17.11	5.23	109.80
reg	Environmental regulation	1,610	53.12	20.08	9.56	97.11
ris	Rationalization of the industrial structure	1,610	−2.83	0.88	−5.80	0.06
ois	Optimization of the industrial structure	1,610	33.71	7.01	8.58	57.65
ln*gdp*	The level of economic development	1,610	15.57	0.92	12.93	17.97
hc	The level of human capital	1,610	17.22	9.84	3.13	102.68
ln*fd*	The level of financial development	1,610	15.10	0.91	12.86	18.31
ln*wage*	The wage level	1,610	9.22	0.38	2.24	10.87

employment growth is inseparable from economic development. Generally, the areas with high levels of human capital are rarely confronted with high unemployment. Furthermore, the level of financial development affects the industrial structure of a region and then indirectly has an impact on the level of employment. In addition, a higher wage level usually means higher labor costs for an enterprise. From the point of view of profit maximization, it has a negative effect on employment as well. Thus, the definitions and summary statistics for all the aforementioned variables are given in **Table 1**.

In this study, we selected 115 resource-based prefecture-level cities in China from 2003 to 2016 as the research samples and thus obtained a total of 1,610 sample data points[2]. Here, the original data come from the Economy Prediction System database, and the missing data are supplemented by using the method of trend extrapolation[3]. First, the stationarity tests of each variable are carried out, and it is concluded that the explained variables, explanatory variables, and control variables are stationary series. Second, the sample of this study is 115 resource-based prefecture-level cities in China from 2003 to 2016, which belongs to short panel data, and the autocorrelation problems will not be considered. At last, the results of the multiple collinearity test with the variance inflation factor (VIF) also show that the VIF value of each variable is less than 10, so there is no multicollinearity problem.

It should be noted that environmental regulation has various effects on employment, which may vary with the RIS and OIS. Thus, there may be a nonlinear relationship between employment and environmental regulation. To examine the impact of environmental regulation on employment, we followed the Hansen (1999) panel threshold regression model and estimated the following panel threshold model.

$$\begin{cases} employ_{it} = \alpha_0 + \alpha_1 reg_{it} \cdot I\left(ris_{it} \le \gamma\right) + \alpha_2 reg_{it} \cdot I\left(ris_{it} > \gamma\right) \\ \qquad\qquad +\lambda \ln X_{it} + \mu_{it} \\ employ_{it} = \beta_0 + \beta_1 reg_{it} \cdot I\left(ois_{it} \le \delta\right) + \beta_2 reg_{it} \cdot I\left(ois_{it} > \delta\right) \\ \qquad\qquad + \phi \ln X_{it} + \upsilon_{it}, \end{cases} \tag{2}$$

where $I(\cdot)$ denotes the indicative function, and the value is 0 if the expression in parentheses is false and 1 if it is not. According to the threshold variable, it is observed whether the rationalization of the industrial structure and the optimization of the industrial structure are greater than the threshold value γ and δ; now, the sample interval can be divided into two intervals and the two intervals are distinguished (α_1, α_2 and β_1, β_2) by slope values. X represents the control variable. μ_{it} and υ_{it} denote the random disturbance term.

4 EMPIRICAL RESULTS AND ROBUSTNESS TEST

4.1 Full Sample Regression Results and Analysis

To examine the effect of environmental regulation on resource-based urban labor employment, we take the RIS and OIS as threshold variables, and the existence of a single threshold, double threshold, and triple threshold is tested, respectively. Considering the "self-help method" (the bootstrap) from Hansen (1999), we repeat sampling 300 times to obtain the p-value corresponding to the test statistics to determine whether there is a threshold effect. The related results are shown in **Table 2**.

When the rationalization of the industrial structure is taken as the threshold variable, there are two thresholds, both of which are highly statistically significant. When the optimization of the industrial structure is taken as the threshold variable, there is a single threshold, which is statistically significant at the 10% level. The specific threshold value estimation results are shown in **Table 3**.

By calculating the threshold value and testing the statistical significance of the threshold value, we find that the double threshold effect exists when the rationalization of the industrial structure is taken as the threshold variable, and the single threshold effect exists when the optimization of the industrial structure is taken as the threshold variable. In addition, double threshold and single threshold models are also used for regression, respectively, and the regression results are reported in **Table 4**.

First, we can see that the impact of environmental regulation on employment varies with different levels of the RIS from **Table 4**. Specifically, when the level of the RIS is low (i.e., $ris \le -4.5443$), the coefficient on employment is negative and statistically significant at the 1% level. In contrast, when the

[2]See the **Supplementary Appendix** for a list of these cities.

[3]Trend extrapolation assumed that the factors influencing the historical series in the past are likely to remain constant rather than to change in the future. For more details, please see Lecz, R. C., and Lanford, H. W. (1973). Trend extrapolation: workhorse of technological forecasting. Industrial Marketing Management, 3(1), 57-65.

TABLE 2 | Existence test of a threshold effect.

		Threshold variable	Threshold variable
		Rationalization of the industrial structure	Optimization of the industrial structure
Single threshold test	F1	309.32	56.88
	p-value	0.0000	0.0200
	10%, 5%, 1% the critical value	29.0944, 35.6448, 55.1590	26.8470, 35.7027, 64.2586
Double threshold test	F2	115.70	9.05
	p-value	0.0000	0.6000
	10%, 5%, 1% the critical value	28.1927, 33.5749, 45.6275	27.2427, 36.5838, 55.8652
Triple threshold test	F3	62.41	13.96
	p-value	0.4833	0.2733
	10%, 5%, 1% the critical value	131.9136, 197.3242, 284.209	22.1413, 30.8514, 50.2454

TABLE 3 | Estimated results of threshold values.

Threshold variable	The threshold value	95% confidence interval	Threshold variable	The threshold value	95% confidence interval
Rationalization of the industrial structure	–4.5443	(–4.656, –4.5088)	Optimization of the industrial structure	39.0800	(39.0000, 39.1600)
	–3.0390	(–3.0519, –3.0323)			

TABLE 4 | Parameter estimation results of the panel threshold model.

	Threshold variable		Threshold variable
	Rationalization of the industrial structure		Optimization of the industrial structure
$reg \cdot I(ris \leq -4.5443)$	–0.0546*** (0.0113)	$reg \cdot I(ois \leq 39.0800)$	–0.0390*** (0.0126)
$reg \cdot I(-4.5443 < ris \leq -3.0390)$	0.0174 (0.0120)	$reg \cdot I(ois > 39.0800)$	0.0152 (0.0133)
$reg \cdot I(ris > -3.0390)$	0.3300*** (0.0213)		
ln*wage*	–2.1079*** (0.5797)	ln*wage*	–2.5002*** (0.6449)
ln*gdp*	2.3309*** (0.5747)	ln*gdp*	1.2842** (0.6356)
hc	–0.1645*** (0.0300)	*hc*	–0.1489*** (0.0332)
ln*fd*	3.8103*** (0.5323)	ln*fd*	4.8344*** (0.5909)
Constant	–41.9211*** (6.8241)	Constant	–37.2958*** (7.5970)
Observations	1,610	Observations	1,610
R-squared	0.4296	R-squared	0.2949
Number of cities	115	Number of cities	115

*Notes: Robust standard errors are in parentheses. Asterisks denote significance at the following levels: ***p < 0.01, **p < 0.05, *p < 0.1.*

level of the RIS is high ($ris \geq -3.0390$), the coefficient on employment is positive and statistically significant at the 1% level. When the level of the RIS is moderate ($-4.5443 \leq ris \leq -3.0390$), the coefficient on employment, although positive, is statistically insignificant. According to the adjusted R-squared test, environmental regulation explains 43% of the variation in employment. Moreover, the regression results also show that with the increase in the level of the RIS, the coefficient is first negative and then positive, which implies that the inhibiting effect of environmental regulation on employment in China's resource-based cities will gradually weaken along with the ER effect which is strengthened. Once the level of the RIS passes the threshold value of −3.0390, environmental regulation will boost jobs, which also proves the correctness of hypothesis 1 in this study.

The reason behind this result is as follows. Generally, the RIS indicates the coordinated development of various sectors of the national economy. In this study, we used the distribution of labor factors in various industrial sectors to measure the RIS. The change of the industrial structure is an increasingly reasonable process. More specifically, the closer the RIS is to 0, the higher is the rationalization level of the industrial structure. However, the RIS is not close to 0, and it will induce a distortion of the employment structure, thus indicating that a large number of the surplus labor force is gathered in the primary industry, and the labor productivity is low. This is because the growth rate of the labor force absorbed by the secondary industry is limited. The tertiary industry develops slowly, which limits the expansion of the employment scope. It is unable to absorb a large number of idle labor resources in the primary and secondary industries. At this time, environmental regulations will be strengthened, and enterprises that fail to meet the environmental protection standards in a short time will choose to shut down, thus

exacerbating the unemployment of the labor force in the secondary industry. However, due to the low rationalization level of the industrial structure, these unemployed labor forces cannot be absorbed. Therefore, when the rationalization level of the industrial structure is low, the enhancement of environmental regulations will aggravate unemployment. When the rationalization level of the industrial structure is improved to be close to the equilibrium state, the employment structure is more reasonable, which can effectively absorb the unemployed labor force due to the enhancement of environmental regulations, and the inhibiting effect of environmental regulations on employment is weakened, turning into a positive promoting effect.

Second, when the OIS is treated as the threshold variable, environmental regulation that has different impacts on employment varies, which changes with the level of the OIS. When the level of the industrial structure optimization is low ($ois \leq 39.0800$), the coefficient on employment is negative and statistically significant at the 1% level. When the industrial structure optimization is further improved ($ois > 39.0800$), the coefficient on employment, although positive, is statistically insignificant across all models. According to the adjusted R-squared, environmental regulation explains 29% of the variation in employment. From the regression results, we can see that the inhibiting effect of environmental regulation on employment in resource-based cities in China will gradually decrease with the continuous improvement of the industrial structure optimization. When the level of industrial structure optimization passes the threshold value of 39.0800, the inhibiting effect of environmental regulation on employment will disappear and turn into an insignificant positive effect, which proves the correctness of Hypothesis 2 to a certain extent.

The reason behind this result is that the prominent feature of the optimization of the industrial structure is characterized by the rise of the proportion of the tertiary industry in the total industry. In this study, we used the proportion of the output value of the tertiary industry in GDP to measure the OIS. In fact, China's resource-based cities are dominated by mining cities. In these cities, the leading industry is usually the exploitation and processing of natural resources, such as the mining industry, which is dominated by the secondary industry. The secondary industry destroys the environment seriously. Thus, enhancing environmental regulation brings about a great impact on this kind of industry. When the level of the OIS is low, strengthening environmental regulation will enhance the unemployment rate in the mining industry, and meanwhile, the tertiary industry has not reached a certain level, which allows it to absorb this unemployed labor. Therefore, we can see that the enhancement of environmental regulation exacerbates unemployment. When the OIS is further improved, the proportion of the tertiary industry in the total industry increases. Thus, the ability of the tertiary industry to absorb employment also increases. Compared with the other two industries, the ability of the tertiary industry absorbs more employment. In this sense, enhancing environmental regulation can boost employment.

Now, turn to the control variables, the regression coefficient and significance levels of wage, economic development, human capital, and financial development are aligned fairly well in respect of whether the OIS or RIS is taken as the threshold variable.

First, a higher wage reduces the employment rate, which shows that the higher the wage level, the higher it will increase the burden on enterprises and the less conducive to employment. From the point of view of an enterprise and following the principle of profit maximization, the higher the wage level, the more is the labor cost. Hence, enterprises will cut the labor force and then input other factors of production with lower costs to replace the labor force. Second, the regression coefficient of the economic development level is significantly positive. It suggests that there are more employment opportunities in the cities where the economic development level is high, which promotes economic development. The two aspects are complementary and mutually reinforcing. Third, the human capital level of the regression coefficient is significantly negative, but it is not consistent with the expected results. One possible reason for this is that the education cost of government spending accounts for the proportion of GDP is selected to measure the level of human capital. Although the government supports education to a large extent and also cultivates a group of high-quality talents, part of the high-quality talented people outflow other cities due to the serious environmental pollution. At last, the regression coefficient of the financial development level is significantly positive. The higher the level of financial development, the more complete are the functions of the financial system and the higher is the efficiency. The financial development level can better promote economic development and thus promote employment.

In addition, we will examine whether the 115 resource-based cities cross the threshold or not. This study measures the resource city industrial structure rationalization level in 2016; according to the aforementioned threshold of the measured values, 115 resource-based cities are taken in a coordinate system (as shown in **Figure 3**). The horizontal axis represents the rationalization of the industrial structure, and the vertical axis represents the optimization of the industrial structure. The name with the color black represents the mature city, the name with the color yellow represents the growth city, the name with the color red represents the decline city, and the name with the color green represents the regeneration city. From the horizontal axis, we divide all of the resource-based cities into three parts, according to the first and second thresholds. It shows that all RISs of 105 resource-based cities cross over the first threshold (−4.5443), indicating that the inhibiting effect on employment caused by strengthening environmental regulation disappears.

However, the fact that the RIS of the second part lies between the first and second thresholds means the effect of ER on employment is positive but not significant. If the double bonus of environmental regulation is to be realized, the RIS of the second group of cities needs to be improved. The RIS of the third part crossed the second threshold, and the bonus dividend of environmental regulation, which refers to improving the environment and promoting employment, was realized. It suggests the government should reduce the gap in labor productivity between the three industries, thus improving the

FIGURE 3 | Distribution of whether resource-based cities have crossed the threshold value in 2016.

rationalization of the industrial structure, to release the dual dividend of environmental regulation, which refers to improving the environment and promoting employment, especially the first group. On the whole, the cities in the first group need to improve the rationalization of the industrial structure, to realize the coordinated development among various industries.

From the perspective of the life cycle of cities (see **Supplementary Appendix 2** for a list of cities), all declining cities have already passed the first threshold, so we can continue to enhance the environmental regulation intensity of these cities and pay attention to improve the rationalization level of the industrial structure in cities between the first and second thresholds. Most mature cities and regenerative cities are still between the first and second thresholds, and the double dividend of environmental regulation is not obvious. The distribution of growing cities is relatively scattered, so the environmental regulation intensity should be differentiated according to the region where the cities are located.

From the vertical axis, we divided the resource-based cities into two parts according to the thresholds. There are 50 resource-based cities under the vertical threshold, while the rest are over the vertical threshold. Similarly, from the perspective of the life cycle of cities, almost all regenerative cities have passed the threshold value, and the inhibiting effect of environmental regulation on employment disappearance has gone. In 2016, the added value of the tertiary industry in these regenerative cities accounted for more than 39.08% of GDP, which indicates they have gotten rid of the dependence on resources and realized the steady transformation of the industrial structure.

For the cities of the other three types, their corresponding added values are evenly distributed around the threshold value. For the cities located on the left of the threshold, whose number accounts for 43.49% of the total resource-based cities, the overall level of the industrial structure of resource-based cities is not high. Therefore, the local government should increase the proportion of the tertiary industry, and meanwhile, vigorous efforts should be made to develop the service sector to give full play to the role of the service industry in absorbing the labor force, by which the cities eventually realize the upgrading of the industrial structure.

4.2 Robustness Test

In this study, we adopted one method for the robustness test to ensure the reliability and robustness of the aforementioned results, which investigates the environmental regulation with a single index. We used a single index of the general comprehensive utilization of industrial solid waste to represent the environmental regulatory and conducted a regression analysis on the above threshold model. Compared with the intensity of environmental regulation measured by comprehensive indicators, the regression coefficient and significance degree of core explanatory variables and control variables are consistent. Hence, the regression results of the whole sample are robust.

5 A SPECIAL CASE: THE ANALYSIS OF A COAL RESOURCE CITY

Since 2013, there have been a total of 262 resource-based cities pronounced by the government. In this study, we selected 115 resource-based prefecture-level cities due to data limitations (see **Supplementary Appendix 3** for a list of cities). Here, we should note that there are 61 prefecture-level cities whose economies heavily rely on coal or coal-related

TABLE 5 | Robustness test.

	Threshold variable		Threshold variable
	Rationalization of the industrial structure		Optimization of the industrial structure
$reg \cdot I(ris \leq -4.5443)$	−0.0539*** (0.0094)	$reg \cdot I(ois \leq 39.0500)$	−0.0355*** (0.0104)
$reg \cdot I(-4.5443 < ris \leq -3.3504)$	0.0151* (0.0099)	$reg \cdot I(ois > 39.0500)$	0.0137 (0.0112)
$reg \cdot I(ris > -3.3504)$	0.2743*** (0.094)		
ln*wage*	−2.0363*** (0.5708)	ln*wage*	−2.4370*** (0.6415)
ln*gdp*	2.5166*** (0.5720)	ln*gdp*	1.4204** (0.6385)
hc	−0.1370*** (0.0294)	*hc*	−0.1419*** (0.0331)
ln*fd*	3.4639*** (0.5174)	ln*fd*	4.4494*** (0.5798)
Constant	−39.8371*** (6.3775)	Constant	−33.9335*** (7.1810)
Observations	1,610	Observations	1,610
R-squared	0.4468	R-squared	0.3011
Number of cities	115	Number of cities	115

*Notes: Robust standard errors are in parentheses. Asterisks denote significance at the following levels: ***p < 0.01, **p < 0.05, *p < 0.1.*

industries (hereafter referred to as "coal resource cities"), accounting for 53% of the number of resource-based cities.

Coal cities, dominated by coal mining and coal chemical industries, have undergone significant changes from prosperity to decline from 1978 to present (Lin et al., 2020; Zhao et al., 2021). Specifically, from 1978 to 2012, coal cities have experienced economic prosperity because of the strong demand for coal. However, since 2013, with China's economic development entering a new normal stage, the traditional energy consumption structure dominated by coal consumption has been gradually transformed into environment-friendly clean energy, resulting in the decline of coal cities. Under such circumstances, the Chinese government implements a series of strict environmental regulation measures to promote coal cities' employment. However, because coal cities heavily rely on coal-related industries (path dependence or lock-in effect) (Wang et al., 2021) and the weak connection with knowledge and innovative networks, the effect of government policies is suspected. In some coal cities, resource depletion, economic recession, and environmental deterioration have become more severe, which pose a huge threat to high-quality development proposed by the Chinese government. Therefore, verifying whether environmental regulation has played its effect and how to improve employment for coal cities are very important for coal cities' sustainable development.

As coal mining has been the pillar industry in these cities for a long time, ecological degradation and environmental pollution are inevitable. Furthermore, from a long-term perspective, the dependence on coal mining may lead to the imbalance of the industrial structure. Thus, environmental regulations are required urgently by residents and firms. However, whether environmental regulations in such cities can benefit both the environment and the economy at the same time is ambiguous, and meanwhile, the impact of environmental regulations on employment remains to be further explored when the RIS and OIS have different levels. Therefore, we tested the existence threshold effect, and the results are shown in **Table 5**.

From **Table 5**, when the RIS is taken as the threshold variable, there is a double threshold effect between environmental regulation and employment; the two corresponding threshold values are −4.5961 and −3.8131, respectively; the first and second thresholds of coal resource cities are both smaller than that of overall resource-based cities. This means that the coal resource cities as a representative of this kind of resource-based cities with serious environmental pollution, strengthening environmental regulation, have an obvious role in promoting labor employment.

When the OIS is taken as the threshold variable, there is a single threshold effect between environmental regulation and employment, respectively. Thus, we can see that the threshold effect existence tests of coal resource-based cities are the same as that of overall resource-based cities. Compared with **Table 3**, it can be seen from **Table 6** that the threshold values of coal resource cities are different from that of overall resource-based cities. Specifically, the first and second thresholds for the rationalization of the industrial structure in coal resource cities are all smaller than the overall thresholds, indicating that the thresholds for the rationalization of the industrial structure in coal resource cities are easier to cross. The threshold value of industrial structure upgrading is higher than the whole, which is 3.34 percentage points higher than the whole, which is related to the resource dependence caused by long-term coal resource exploitation.

Table 6 also shows the regression results of the coal resource cities, compared with the overall resource-based cities' regression results. First, consider the case where the RIS is taken as the threshold variable; when the level of the RIS belongs to the interval, the regression coefficient is positive and statistically significant at the 5% level. It implies that environmental regulation has a significantly positive impact on employment. When the level of the RIS passed over the second threshold value −3.8131, the promotion effect was enhanced, with a 1% increase in environmental regulation and a 39% increase in employment.

Table 7 when industrial structure upgrading is taken as the threshold variable, the threshold value is greater than that of the overall resource-based cities, that is, when the added value of the tertiary industry in coal resource cities accounts for 42.42% of GDP, the inhibiting effect of environmental regulation on employment will disappear. The regression results of the

TABLE 6 | Threshold variables test and threshold value estimation.

Threshold variables	Number of thresholds	F1	Threshold	95% confidence interval
RIS	Single threshold	439.36***	−4.5961	(−4.6660, −4.5038)
	Double threshold	49.88**	−3.8131	(−3.8433, −3.8104)
OIS	Single threshold	29.05*	42.4200	(41.7850, 42.5650)

TABLE 7 | Parameter estimation results of the coal resource city panel threshold model.

	Threshold variable		Threshold variable
	Rationalization of the industrial structure		Optimization of the industrial structure
$reg \cdot I(ris \leq -4.5961)$	−0.0402*** (0.0132)	$reg \cdot I(ois \leq 42.4200)$	−0.0425** (0.0166)
$reg \cdot I(-4.5961 < ris \leq -3.8131)$	0.0379** (0.0168)	$reg \cdot I(ois > 42.4200)$	0.0224 (0.0193)
$reg \cdot I(ris > -3.8131)$	0.3936*** (0.0235)		
ln*wage*	−1.6932*** (0.5782)	ln*wage*	−2.8759*** (0.7233)
ln*gdp*	2.7130*** (0.7032)	ln*gdp*	1.9466** (0.8870)
hc	−0.1894*** (0.0405)	*hc*	−0.1805*** (0.0507)
ln*fd*	3.6887*** (0.6716)	ln*fd*	4.9704*** (0.8432)
Constant	−49.3528*** (7.6348)	Constant	−45.3767*** (9.5455)
Observations	1,610	Observations	1,610
R-squared	0.5631	R-squared	0.3139
Number of cities	61	Number of cities	61

*Notes: Robust standard errors are in parentheses. Asterisks denote significance at the following levels: ***p < 0.01, **p < 0.05, *p < 0.1.*

control variables are similar to the population regression and will not be repeated here.

6 CONCLUSION AND POLICY IMPLICATIONS

The coordination of resource consumption, environmental pollution, and economic development has become the biggest restriction of China's sustainable economic development, which is particularly obvious in resource-based cities. In this study, by taking the transformation of the industrial structure as the threshold variable based on dividing industrial transformation into the rationalization and optimization of the industrial structure, we constructed a nonlinear panel threshold regression model and used the data of 115 resource-based prefecture-level cities to empirically examine the impact of environmental regulation on employment in resource-based cities. The results show that if the RIS is used as the threshold variable, for all resource-based cities, the impact of environmental regulation on employment varies with different levels of RIS. When the level of the RIS is low (i.e., $ris \leq -4.553$), the coefficient of employment is negative and statistically significant at the 1% level; in contrast, when the level of the RIS is high ($ris > -3.0390$), the coefficient of employment is positive and statistically significant at the 1% level. When the level of the RIS is in the middle ($-4.553 < ris \leq -3.0390$), the coefficient on employment, although positive, is statistically insignificant. As for coal resource cities, environmental regulation has a double threshold effect on labor employment, while the two corresponding thresholds are lower than those of other resource-based cities. Moreover, when the level of the RIS exceeds the first threshold of −4.5961, environmental regulation has a significant positive impact on labor employment, although the regression coefficient is small.

Second, when the OIS is treated as the threshold variable, for all resource-based cities, environmental regulation has different impacts on employment, which changes with the level of the OIS. When the level of the industrial structure optimization is low ($ois \leq 39.0800$), the coefficient on employment is negative and statistically significant at the 1% level; when the industrial structure optimization is further improved ($ois > 39.0800$), the coefficient on employment, although positive, is statistically insignificant across all models. Similarly, for coal resource cities, environmental regulation has a single threshold effect on labor employment, while the corresponding threshold is higher than that of all resource-based cities. In other words, when the level of the OIS exceeds 42.42%, the effect of environmental regulation on labor employment turns from negative to positive, but it should be noted that this effect is insignificant.

Based on the above results, the possible policy implications are as follows: with the improvement in the rationalization level of the industrial structure, the impact of environmental regulation on employment changes from negative to positive; environmental regulation has a significant positive impact on labor employment at a higher level of the RIS. This shows that environmental regulation is not in contradiction with labor employment, and the key is how to promote the coordinated development of the three industries. Therefore, the local government should improve the level of agricultural mechanization and guide surplus labor to migrate from rural districts to towns to improve the labor productivity of the

primary industry. Meanwhile, the government should strive to develop tertiary industries. Specifically, first, local governments should give certain policy support to the tertiary industry, especially the small and medium-sized catering industry, and increase their capital investment to reduce their financing difficulty, encourage mass entrepreneurship, and inject vitality into economic development. Second, based on the rapid development of the low-end service industry, local governments should develop the high-tech industry, that is, to promote the real upgrading of the industrial structure and improve the technical content of the tertiary industry.

With the improvement in the optimization level of the industrial structure, the impact of environmental regulation on employment changes from negative to positive, but environmental regulation does not have a significant positive impact on labor employment at a higher level of the OIS. Therefore, local governments should strive to improve the level of the OIS, to cross the threshold as soon as possible to avoid the negative effects of environmental regulations on employment. For resource-based cities that cross the threshold, local governments should increase environmental supervision and public participation and improve the level of green technology innovation, to maximize the positive role of environmental regulation in promoting employment. In this way, enterprises can be given a good incentive, while in the environmental protection, which reduces the burden of enterprises, and releases the potential ability of enterprises to absorb the labor force. It can alleviate the inhibitory effect of environmental regulation on labor employment to a certain extent.

The threshold over which the negative impact of environmental regulation on employment disappears is higher in the case of examining the coal resource cities than in examining all resource-based cities. Therefore, the government should pay special attention to the tertiary industry's proportion of coal resource cities with serious environmental pollution and resource dependence when making the corresponding policies concerning environmental regulation. With the increase in the intensity of environmental regulation, the governments of coal resource cities should increase the proportion of tertiary industries. Only in this way can the double dividend of environmental regulation be realized.

At the same time, regional governments should improve system construction and accelerate industrial transformation and upgrading. The level of environmental regulation in China is currently uneven and has not yet reached a quantitative level of effective regulation. The regional government should strengthen environmental regulations and impose environmental constraints on enterprises of different types. Enterprises are bound to move toward technological innovation and strict control of pollution emissions, and employment levels will also increase. Furthermore, the transformation and upgrading of industrial structures and the optimization of industrial layouts in various regions are very important for upgrading the entire industrial system, increasing welfare performance and improving employment levels. Therefore, the regional government should improve the market entry threshold of the "three high" industries and give full rein to its scale advantages to improve the efficiency of resource allocation.

As the largest developing country in the world, China has a large number of non–resource-based cities. Although these do not face the dual threat of environmental degradation and employment, they are still worthy of study. As this study only focuses on resource-based cities, future research could investigate the impact of environmental regulations on employment in non–resource-based cities and then compare results with this study. Furthermore, the impact of environmental regulation on employment in resource-based cities may have a spatial effect. Future research can use spatial econometric models to study the impact of environmental regulation on employment in local and surrounding areas and explore the spatial spillover effect of environmental regulation in resource-based cities.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**; further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Major projects of the National Social Science Foundation. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

BQ contributed to conceptualization, investigation, and funding acquisition. LL contributed to software, formal analysis, and data curation. LY contributed to supervision and validation. LG contributed to writing-original draft, methodology, and writing-review and editing.

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SUPPLEMENTARY MATERIAL

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