

Can environmental regulation solve China's employment dilemma: Empirical analysis based on scale and structure effects

Mengjie Li

Shandong Technology and Business University

Weijian Du (✉ duweijian_ok@sdtbu.edu.cn)

Shandong Technology and Business University

Research Article

Keywords: environmental regulation, employment scale, employment structure, regional differences, industrial structure, institutional environment

Posted Date: May 13th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-417665/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

1 Can environmental regulation solve China's employment dilemma:
2 Empirical analysis based on scale and structure effects

3

4 Mengjie Li^a Weijian Du^{b,c*}

5 ^a*School of Economics, Shandong Technology and Business University, Yantai,*
6 *Shandong, 264005, PR China.*

7 ^b*School of Management and Economics, Beijing Institute of Technology, 100081,*
8 *Beijing, China.*

9 ^c*Synergy Innovation Center for Energy Economics of Shandong, School of Economics,*
10 *Shandong Technology and Business University, Yantai, Shandong, 264005, PR China.*

11 **Corresponding author at: School of Management and Economics, Beijing Institute of*
12 *Technology, 100081, Beijing, China.*

13 *Tel.: +86 15244505566*

14 *E-mail addresses: Duweijian_ok@sdtbu.edu.cn (W. Du)*

15

16

17 **Acknowledgements**

18 *This research is sponsored by National Natural Science Foundation of China*
19 *(71803102), National Social Science Fund of China (20FJYB012), Science Foundation*
20 *of Ministry of Education of China (18YJC790086) and Shandong Provincial Natural*
21 *Science Foundation (ZR2020QG041).*

22

23

24 Can environmental regulation solve China's employment dilemma:

25 Empirical analysis based on scale and structure effects

26 Abstract

27 Whether the environmental regulation policy can achieve the double dividend of
28 pollution control and employment promotion is a problem worthy of further discussion.

29 This paper studies the effect of environmental regulation on employment scale and
30 employment structure. Based on the matching data, the empirical results show that
31 environmental regulations enhance the employment scale of enterprise. From the
32 perspective of employment structure, labor redistribution, which is caused by
33 environmental regulation, is mainly reflected in the employment creation and
34 employment destruction effects, which lead to the optimization of the employment
35 structure. Further research shows that environmental regulations expand employment
36 scale but have different impacts on the employment structure in the developed and
37 undeveloped regions of China. In addition, internal and external factors, such as
38 enterprise innovation and institutional environment, may affect the relationship of
39 environmental regulation and employment of enterprise. This paper provides
40 theoretical support for the promotion of the construction of ecological civilizations and
41 the solving of the employment dilemma.

42 **Keywords:** environmental regulation; employment scale; employment structure;
43 regional differences; industrial structure; institutional environment

44

45 **1. Introduction**

46 China's rapid economic growth has not brought about a significant increase in
47 employment, and urban unemployment remains high. However, at present, China's
48 demographic dividend is gradually disappearing. The declining birth rate, accelerated
49 aging and peak proportion of the working-age population have worsened the already
50 grim labor market. In addition, environmental degradation has restricted the sustainable
51 development in the world. The pollution problems caused by extensive growth modes
52 are becoming increasingly serious (Cao et al. 2020). The frequent occurrence of haze in
53 large areas of the country also indicates that China's environmental pollution problem
54 has entered a stage of concentrated outbreak. Facing the dual challenges of employment
55 dilemma and environmental pressure, environmental regulation may be an important
56 way in which to achieve the goal of pollution treatment and employment
57 transformation. Therefore, it is necessary to organically combine the research on
58 environmental governance with that on employment (Jiang et al. 2019). Based on
59 highly detailed enterprise data, this paper attempts to open the "black box" of micro
60 enterprise behavior. From the enterprise perspective, we explore whether
61 environmental regulation can drive the dual upgrading of employment scale and
62 employment structure to provide a theoretical basis for solving employment dilemma.

63 The effect of environmental regulation on employment depends on the enterprise
64 behavior (Guo et al. 2020). If environmental regulation intensity is increased, then it
65 is equivalent to the government imposing more stringent environmental constraints on
66 enterprises; that is, the price of enterprises' emission pollution increases. To pursue

67 higher environmental standards, enterprises will increase the cost of pollution control
68 and emission reduction (Pan et al. 2021). In response to this increase in costs,
69 enterprises will adjust their behavior decisions to achieve profit maximization. On the
70 one hand, due to this increase in costs, enterprises will have face increased pressure,
71 which will inhibit their scale expansion to a certain extent (Zhang et al. 2021).
72 Therefore, this increase in costs will reduce the labor demand of enterprises and form
73 a negative "scale effect" (Greenstone & Hanna 2014). On the other hand, in response
74 to the improvement of environmental regulations, enterprises will reallocate variable
75 production factors to maximize profits. Some unclean production factors will be
76 partially replaced by labor factors, and the increase in pollution reduction activities
77 will also raise the demand for labor. Therefore, a positive "factor substitution effect"
78 will be formed. In summary, the effect of environmental regulation on employment is
79 the result of a comprehensive comparison of the "scale effect" and "factor substitution
80 effect". Porter hypothesis support that, with the improvement of environmental
81 regulation intensity, incumbent enterprises will carry out a more optimized allocation
82 of elements and technological innovation and will regain competitive advantage, and
83 the optimal allocation of enterprise resources will slow down the speed of the increase
84 in costs (Porter & Linde 1995, Sun et al. 2021). Therefore, the positive substitution
85 effect of production factors will play a major role. The concept of the double dividend,
86 put forward by the World Labor Report, holds that proper environmental regulation
87 will not reduce the employment level; in contrast, it will improve environmental
88 quality and raise the labor demand to achieve goal of the improvement of the win-win

89 situation and employment optimization. Based on the matching micro data, this study
90 explores whether China can create a double dividend of environmental regulation and
91 employment similar to that of developed countries. Based on the information from
92 enterprises, this paper constructs environmental regulation indicators and examines
93 the effect of such regulation on employment scale and the enterprise structure.
94 Furthermore, this paper discusses internal and external factors for promoting the
95 effect of environmental regulation on employment to provide beneficial policy
96 suggestions for the realization of the double dividend.

97 The foundational theoretical bases of environmental regulation can be tracked to
98 Pigou's externality theory and Coase's property rights theory. [Pigou \(1920\)](#) advocated
99 that the government should optimize resource allocation and solve environmental
100 problems by means of taxation. [Coase \(1972\)](#) suggested that as long as the transaction
101 cost was zero, resource allocation would not be affected by different methods of
102 property rights distribution. However, in reality, due to the negative externality of
103 environmental problems and the ambiguity of environmental property rights, it is
104 difficult to completely solve the environmental pollution problem only through
105 market mechanisms. Environmental problems need to be managed and controlled by
106 the government through economic, administrative and other means, which is one of
107 the theoretical bases for environmental regulation ([Ambec et al. 2013](#), [Blundell et al.](#)
108 [2020](#)). For the connotation of environmental regulation, academic understanding has
109 gone through a process. In the initial stage, environmental regulation mainly refers to
110 the government intervention in the utilization of environmental resources through

111 nonmarket channels, including prohibitions and emission standards. With the
112 continuous enrichment of environmental regulation tools, economic incentive
113 methods are also widely used. Through such incentives, the government intervenes
114 and guides the economic behaviors and activities of market subjects to prevent,
115 reduce and control the negative impact of human economic activities on the
116 ecological environment. In this way, we can achieve the goal of keeping
117 environmental quality in harmony with economic development (Omri et al. 2015).
118 The application of a series of environmental governance measures, such as
119 environmental taxes, subsidies, deposit refunds and economic stimuli, has expanded
120 the scope of environmental regulation.

121 Research on the effect of environmental regulation on employment has been
122 widely conducted. However, the research conclusions are not consistent. Early
123 scholars believed that environmental regulation inhibited employment (Goodstein
124 1996, Morgenstern et al. 2002), that the increase in pollution costs will reduce the
125 competitiveness of enterprises, and that the reduction in production scale will lead to a
126 decrease in the demand for labor. With the deepening of the relevant research, some
127 scholars found that in the face of the increased costs brought about by environmental
128 regulation, the optimal allocation of enterprise resources could create more
129 employment opportunities. The negative effect of environmental regulation on
130 employment is not obvious, and in fact, it may even be positive (Berck & Hoffmann
131 2002, Liu & Wang 2020, Sun et al. 2019). At the industry level, the continuous flow of
132 labor among various industries makes the employment of different industries exhibit a

133 linkage effect. The impacts of environmental regulation on employment in different
134 industries are not the same. Thus, some scholars have studied specific industries, such
135 as the power industry (Ferris et al. 2014) and the manufacturing industry (Sheng et al.
136 2019). At the regional level, due to the higher governance costs and penalty costs
137 faced by enterprises in highly regulated regions, environmental regulation affects their
138 location, thus affecting their level of regional employment (Du et al. 2020). On the
139 one hand, new enterprises will fully consider the influence of regional environmental
140 regulation intensity on cost in decisions regarding site selection (Becker & Henderson
141 2000). On the other hand, the differences in environmental regulation intensity in
142 different areas cause incumbent enterprises to seek pollution shelters; that is, they
143 transfer between regions with different environmental regulations (Li et al. 2021,
144 Walker 2011).

145 The extant literature includes rich research on the effect of environmental
146 regulation on employment, laying a solid research foundation for this paper. However,
147 the research on environmental regulation and employment is mainly focused at the
148 regional or industrial level, and there is little discussion at the enterprise level.
149 Moreover, the existing research is not detailed, and no consistent conclusion has been
150 reached. Compared to existing literatures, the crucial contributions are as follows.

151 First, in terms of the research perspective, although some scholars pay attention
152 to the effect of environmental regulation on employment scale, they ignore its impact
153 on the employment structure. The optimization and upgrading of the employment
154 structure is particularly important for solving the employment dilemma. This paper

155 attempts to combine environmental regulation, employment scale and the employment
156 structure into a unified analysis framework. From the perspective of skill premiums,
157 this paper elaborates the effect of labor redistribution caused by environmental
158 regulation, which is mainly reflected in the employment creation of the skilled labor
159 force and the employment destruction of the unskilled labor force. That is, "brown
160 unemployment" and "green employment" exist simultaneously, which is of great
161 significance for promoting the optimization of employment structure. This paper
162 supplements the existing research from the perspective of scale and structure effects.

163 Second, different from the macro research focused at the national, regional or
164 industrial level, this paper discusses this topic at the micro enterprise level, trying to
165 open the "black box" of enterprise behavior. Studies based at the macro level regard
166 many enterprises as a whole and as micro actors but lack an analysis of enterprise
167 decision making. This paper uses more intuitive micro data to explore the effect of
168 environmental regulation on employment. The subjects of this study are enterprises at
169 the micro level, an approach that is more in line with the main body of environmental
170 regulation and the environmental governance principle of "who pollutes, controls;
171 who develops, protects". This approach can overcome the defects of the macro-level
172 environmental regulation indicators used in existing studies. At the same time, this
173 approach can also more directly reflect the difference in the environmental regulation
174 intensity of each enterprise.

175 Finally, this paper attempts to identify internal and external factors to promote
176 the double dividend of environmental regulation and employment and provides more

177 practical enlightenment. Because relationships are not unchangeable, they can be
178 dynamically regulated. This paper discusses the internal and external factors that
179 promote the double dividend of environmental regulation and employment and adjusts
180 the relationship between these two factors to one that is more favorable through the
181 use of controllable influencing factors. These conclusions can not only provide a
182 quantitative basis for solving the employment dilemma but also help enterprises better
183 utilize the employment effect of environmental regulation to enhance their
184 competitiveness.

185 **2. Research design**

186 *2.1. Data sources and model construction*

187 The samples in this paper are mainly from the China's Enterprise Environmental
188 Investigation and Report Database and China's Industrial Enterprise Database for the
189 years 2000 to 2010. In this paper, the construction of micro environmental regulation
190 indicators in this paper is mainly based on the China's Enterprise Environmental
191 Investigation and Report Database, which includes key polluting enterprises. Those
192 with the top 85% of total emissions in each county are regarded as the key polluting
193 enterprises. The construction of enterprise employment scale, the employment
194 structure and other enterprise production and operation variables is mainly based on
195 China's Industrial Enterprise Database, which includes all state-owned and
196 non-state-owned industrial enterprises above the designated size. These data are
197 obtained by the quarterly and annual reports submitted by the sample enterprises to
198 the local Statistical Bureau.

199 This paper constructs an econometric model as follows:

$$200 \quad Job_{it} = \beta_0 + \beta_1 ER_{it} + \beta_2 X_{it} + \varepsilon_{it} \quad (1)$$

201 Here, subscripts i and t denote the enterprise and year, respectively. Job_{it} is
202 the employment index of the enterprise (explained variable), ER_{it} is the intensity of
203 environmental regulation at the enterprise level (core explanatory variable), X_{it} is
204 the control variable, and ε_{it} is the error term.

205 *2.2. Index selection and statistical description*

206 Enterprise employment indicators. On the one hand, the effect of environmental
207 regulation on employment scale is investigated by using the total number of
208 employees as the explanatory variable. On the other hand, to investigate the effect of
209 environmental regulation on employment structure, the employment structure is
210 measured by the employment change in skilled and unskilled labor in enterprises.
211 Referring to [Chen et al. \(2016\)](#), we select workers with high school education or
212 above as the skilled labor force and other workers as the unskilled labor force.

213 Environmental regulation indicators. At present, most of the measurement
214 indicators of environmental regulation are based at the regional or industrial level,
215 such as the total investment in pollution control ([Levinson 1996](#)), the pollution control
216 level of a certain pollutant ([Lanoie et al. 2008](#)), and the comprehensive index of
217 environmental regulation ([Du & Li 2019](#)). However, when examining the effect of
218 environmental regulation on enterprise-level variables, the method of matching
219 enterprise variables with environmental regulation of the industry or region may lead
220 to a deviation in the research conclusions. Based on the emission side of enterprises,
221 this paper uses chemical oxygen demand (COD) removal rate data to measure the

222 environmental regulation intensity of enterprises. The use of COD can, to a certain
223 extent, avoid the impact of pollutants, which are mainly discharged by large
224 state-owned enterprises in a few industries, on the results (He et al. 2020). In addition,
225 this paper also uses the enterprise output value per unit of energy consumption as an
226 alternative index to measure the environmental regulation intensity (Du & Li 2019).

227 Control variables. On the basis of the existing empirical literature (Brandt et al.
228 2012, Chodorow-Reich 2014), a series of factors affecting employment are selected as
229 control variables to introduce the model. Specifically, *CK* stands for enterprise
230 capital intensity, which is used to investigate the differences between capital- and
231 labor-intensive enterprises in terms of employment characteristics. This study uses the
232 ratio of the net fixed assets to the employees number. *SOE* is a dummy variable for
233 state-owned enterprises, which is used to explore the influence of enterprise
234 ownership characteristics on employment. If the enterprise is a state-owned enterprise,
235 then it takes a value of 1; otherwise, it takes a value of 0. *Age* is the duration (in
236 years) of the enterprise. Because the different stages of the existence of an enterprise
237 may affect its production and operation, the duration of its existence will further affect
238 its employment. This paper calculates *Age* as the difference between the current year
239 and the year when the enterprise was established. *Export* is a dummy variable to
240 control the influence of international trade on the labor market. If the export delivery
241 value in current year is greater than 0, then it takes a value of 1; otherwise, it takes a
242 value of 0. *HHI* represents the Herfindahl-Hirschman Index, which is used to
243 explain the impact of market competition on enterprise employment. Table 1 lists the

244 descriptive statistics of main variables in the model.

245 **Table 1**

246 Statistical description.

Variable	Definition	Observation	Std. Dev.	Mean	Min	Max
<i>Job</i>	Employment	83,672	678.02	1,154.73	24	7,520
<i>ER</i>	Environmental regulation	69,137	0.2621	0.3645	0	1
<i>CK</i>	Capacity intensity	83,534	138.31	217.77	1.58	1,439.03
<i>SOE</i>	State-owned enterprise	83,673	0.2125	0.4091	0	1
<i>Age</i>	Business life	83,619	14.83	15.12	0	68
<i>Export</i>	Export dummy variable	83,673	0.3371	0.4727	0	1
<i>HHI</i>	Herfindahl-Hirschman Index	83,673	0.0337	0.0492	0.0018	1

247 **3. Analysis of research results**

248 *3.1. Effect of environmental regulation on employment scale*

249 The fixed effect analysis is used to regress the benchmark model to test the
250 relationship between environmental regulation and enterprise employment scale.
251 Columns (1) and (2) of [Table 2](#) report the results. Column (1) considers only the
252 binary regression between environmental regulation and employment scale. Column
253 (2) further introduces control variables of enterprise on the basis of column (1). The
254 coefficient of *ER* is significantly positive, indicating that at present, environmental
255 regulation will reduce neither the breadth of employment nor the competitiveness of
256 enterprises. In contrast, environmental regulation can realize the double-dividend of
257 the environment and employment. The coefficient of *ER* in column (2) shows that if
258 the influence of other characteristic factors is not considered, then the promotion
259 effect of environmental regulation on the employment scale may be underestimated.

260 The control variables in the regression analysis are in line with expectations. The
261 coefficients of *CK* are negative and significant, which shows that capital-intensive
262 enterprises have less employment than labor-intensive enterprises. The coefficients of

263 *SOE* are positive and significant; that is, in China, state-owned enterprises are still the
264 main source of employment. The coefficient of *Age* is positive, which indicates that
265 employment scale will increase with the increase in the number of years that an
266 enterprise has been established. The coefficient of *Export* is positive, which indicates
267 that the employment scale of export enterprises is larger than that of domestic
268 enterprises. The coefficient of *HHI* is significantly negative, which indicates that if
269 the regional market concentration is too high, then the employment absorption
270 capacity of enterprises in the region will be reduced to a certain extent.

271 To further study the robustness of the benchmark estimation results, column (3)
272 is based on the input side of the enterprise, taking its output value of per unit energy
273 consumption as an alternative index. The regression analysis also controls the
274 individual characteristics and time fixed effects of enterprises. The coefficient of *ER*
275 is significantly positive, indicating that the environmental regulation can significantly
276 improve the employment scale. In addition, two-way causal relationship between
277 environmental regulation and employment scale may exist; that is, employment scale
278 will also affect the environmental regulation intensity faced by enterprises. Although
279 the relevant factors affecting employment scale are covered in the model as much as
280 possible, employment is affected by many factors, and there may be endogeneity
281 problems caused by missing variables. We aim to use appropriate instrumental
282 variables to regress formula (2) via two-stage least squares (2SLS) regression to solve
283 the estimation error caused by endogeneity problems. According to the method of
284 [Fisman and Svensson \(2007\)](#), we consider the instrumental variable using the average

285 value of the regional variable indicating where the enterprise is located. The main
 286 reason for doing this is that environmental regulation intensity at the macro level will
 287 not be directly affected by the scale of individual employment, but the regional
 288 environmental regulation is closely related to the environmental regulation intensity
 289 of enterprises. Based on the above considerations, in column (4), we introduce the
 290 total investment in controlling regional pollution sources in the current year as an
 291 instrumental variable. On the one hand, the *F*-test is used to examine the correlation
 292 between instrumental variables and explanatory variables. The p value of the *F*-test is
 293 given in column (4) of Table 2. The original hypothesis—that there is a weak
 294 instrumental variable—is rejected. On the other hand, the *Sargan* test is used to test
 295 for the overidentification problem. It can be seen that the regression results cannot
 296 reject the original hypothesis; that is, the instrumental variable regression setting is
 297 appropriate. The results 2SLS regression show that the *ER* variable is significantly
 298 positive at the level of 1%; that is, considering the endogeneity problem, the positive
 299 impact of environmental regulation on employment still exists, which verifies the
 300 robustness of the research conclusion.

301 **Table 2**

302 The influence of environmental regulation on employment scale.

	(1)	(2)	(3)	(4)
	<i>Job</i>	<i>Job</i>	<i>Alternative indicator</i>	<i>IV Method</i>
<i>ER</i>	0.0791*** (0.0122)	0.0894*** (0.0112)	0.0739*** (0.0041)	11.6669*** (2.4100)
<i>CK</i>		-0.1812*** (0.0101)	-0.1403*** (0.0122)	-0.1040*** (0.0306)
<i>SOE</i>		0.0588*** (0.0137)	0.0696*** (0.0161)	0.5331*** (0.0725)
<i>Age</i>		0.0073*** (0.0008)	0.0083*** (0.0009)	0.0332*** (0.0022)

<i>Export</i>		0.0763***	0.0759***	0.0695
		(0.0093)	(0.0118)	(0.0742)
<i>HHI</i>		-0.3423**	-0.0761	3.0925***
		(0.1400)	(0.1822)	(0.3945)
<i>Constant</i>	5.7974***	6.4755***	6.2323***	5.5064***
	(0.0108)	(0.0448)	(0.0534)	(0.0815)
<i>Time fixed effect</i>	Controlled	Controlled	Controlled	Controlled
<i>Observation</i>	69,136	69,006	50,279	68,894
<i>R²</i>	0.0320	0.1077	0.1333	0.7708
<i>F-test</i>				0.0000***
<i>Sargan Test</i>				0.3963

303 *Note:* *, **, and *** are significant at the level of 10%, 5% and 1%, respectively. The numbers in
304 parentheses indicate the standard error. The table of the following estimation results is the same.

305 3.2. *Effect of environmental regulation on the employment structure*

306 Theoretically speaking, environmental regulation affects employment are via a
307 negative scale effect and a positive factor substitution effect. Environmental
308 regulation increases pollution costs, leading enterprises to reduce their scale of
309 production, which results in the elimination of the low-skilled production-oriented
310 labor force, resulting in “brown unemployment”. In addition, with the improvement of
311 environmental regulation, enterprises will reallocate different production factors to
312 achieve profit maximization and use technical labor to replace other pollution factors
313 such as fuel and materials. At the same time, environmental regulation can force
314 technological innovation, which makes enterprises increase their R&D and investment
315 in clean technology. The emission reduction activities will also raise the demand for
316 highly skilled labor, which is more concentrated in the “green employment” of the
317 highly skilled labor force. Due to the role of "brown unemployment" and "green
318 employment", environmental regulation may promote the optimization of
319 employment structure.

320 This paper uses the different education levels of the labor force to measure the

321 employment structure. Workers with a high school degree and above are considered
322 skilled labor for the purposes of measuring green employment, and those with an
323 education below the high school level are used to measure brown employment. The
324 reason for doing this is that areas with low environmental regulation intensity will
325 increase their transferring of pollution-intensive enterprises, such as those dealing
326 with textiles and paper making. This approach will provide more low-end jobs and
327 increase the demand for unskilled workers. Therefore, this paper uses unskilled
328 workers as a measure of brown employment. With the continuous strengthening of
329 environmental regulation, enterprises pay more attention to pollution control and
330 green production and, thus, must introduce new production technology. This kind of
331 clean green work is mostly undertaken by highly skilled labor. Therefore, this paper
332 uses skilled workers to measure green employment. Columns (1) and (2) of [Table 3](#)
333 introduce the employment of skilled labor and unskilled labor as the explained
334 variables. The *ER* variables in column (1) and column (2) are significantly positive
335 and negative, respectively. That is, environmental regulation promote the skilled labor
336 employment and inhibit the unskilled labor employment, thus optimizing and
337 upgrading the employment structure of enterprises.

338 The economic explanation of this conclusion is that environmental regulation can
339 act as a breakthrough for solving the employment dilemma in China and driving the
340 dual upgrading of employment scale and the employment structure. As environmental
341 regulation increases, the cost advantage of enterprises is gradually weakened.
342 Environmental regulation may encourage technological progress by guiding

343 enterprises toward increasing their R&D investment in pollution control and cleaner
 344 production technology, which will, in turn, increase the skill premium and demand for
 345 highly skilled workers. The reduction in pollution production, R&D in pollution
 346 control and cleaning technology will drive the employment structure of enterprises
 347 toward advanced development. These enterprises can use a technology-leading
 348 strategy to regain their competitive advantage in the market and achieve the goal of
 349 profit maximization. Under the dual path of "brown unemployment" and "green
 350 employment", it is of great significance to optimize China's current employment skill
 351 structure, which is necessary for solving the problem of the disappearance of
 352 demographic dividends and promoting the competitiveness of Chinese enterprises.

353 In columns (3) and (4) of [Table 3](#), according to the professional titles of
 354 enterprise workers, those with primary titles or above are regarded as skilled labor
 355 force workers, and the rest of the workers are regarded as unskilled labor force
 356 workers to further test the effect of environmental regulation on the employment
 357 structure. The results show that with environmental regulation increase, the proportion
 358 of skilled workers increases and that of unskilled workers decreases. This finding also
 359 proves that environmental regulation plays an important role in the optimization of the
 360 employment structure, which verifies the robustness of the conclusions.

361 **Table 3**

362 The influence of environmental regulation on employment structure.

	According to education background		According to professional title	
	(1) Skilled labor	(2) Unskilled labor	(3) Skilled labor	(4) Unskilled labor
<i>ER</i>	0.2625*** (0.0390)	-0.1461*** (0.0407)	0.1694*** (0.0341)	-0.2940*** (0.0460)
<i>CK</i>	-0.1871*** (0.0091)	-0.1942*** (0.0094)	-0.0323*** (0.0079)	-0.2697*** (0.0108)

<i>SOE</i>	0.0870*** (0.0293)	0.1656*** (0.0307)	0.0789*** (0.0258)	0.3424*** (0.0338)
<i>Age</i>	0.0149*** (0.0008)	0.0224*** (0.0009)	0.0168*** (0.0007)	0.0280*** (0.0009)
<i>Export</i>	0.5759*** (0.0252)	0.6567*** (0.0263)	0.6545*** (0.0221)	0.3957*** (0.0295)
<i>HHI</i>	-1.6919*** (0.5478)	-7.1321*** (0.5746)	-4.4179*** (0.4819)	-5.3085*** (0.6435)
<i>Constant</i>	5.3525*** (0.0424)	3.5317*** (0.0441)	5.3397*** (0.0370)	1.6662*** (0.0505)
<i>Observation</i>	13,794	14,299	14,314	12,261
<i>R²</i>	0.0878	0.1384	0.1063	0.1694

363 4. Further analysis

364 4.1. Regional heterogeneity

365 Because of the great differences in the development status of different regions in
366 China, further study to investigate the employment effect of environmental regulation
367 in different regions is needed. Regional heterogeneity study can test the robustness of
368 the impact on total employment and is helpful to formulate different environmental
369 policies. The effects of environmental regulation on the employment scale of different
370 regions through grouping regression are reported in columns (1) and (2) of [Table 4](#).
371 The coefficients of *ER* are all significantly positive, which shows that environmental
372 regulations promote employment scale regardless of the region, and verifies the
373 robustness of the conclusions of the benchmark regression.

374 Then, we further explore the regional heterogeneity of the effects of
375 environmental regulation on the employment structure. Columns (3) to (6) examine
376 the influence of environmental regulation on skilled and unskilled labor, respectively,
377 in the economically developed regions and undeveloped regions. The results show
378 that the effect of environmental regulation on the employment structure has

379 significant regional heterogeneity. Specifically, in the economically developed regions,
380 environmental regulation has a significant positive effect on skilled labor and a
381 negative impact on unskilled labor. In the economically undeveloped regions,
382 environmental regulation has a significant positive effect on both skilled and unskilled
383 labor. The economic explanation for this result may be as follows: environmental
384 regulation in the economically developed regions of China leads to the green
385 transformation of enterprises and increases investment in R&D for pollution control
386 and cleaner production technology. Most of the labor force that is eliminated in the
387 process of transformation is unskilled labor, while the demand for skilled labor
388 increases. The coexistence of "brown unemployment" and "green employment" in the
389 developed regions leads to the optimization and upgrading of the employment
390 structure. For the undeveloped regions, due to the large amount of pollution transfer
391 from the developed region, the employment effect of environmental regulation is
392 manifested in the increase in both skilled and unskilled labor. Therefore,
393 environmental regulation in the undeveloped regions of China leads to an increase in
394 the "green employment" and "brown employment" of enterprises.

395 **Table 4**
396 Regional heterogeneity of environmental regulation affecting employment.

	Developed	Undeveloped	Developed		Undeveloped	
	(1)Overall	(2) Overall	(3) Skilled	(4) Unskilled	(5) Skilled	(6) Unskilled
<i>ER</i>	0.0780*** (0.0119)	0.0829*** (0.0271)	0.2206*** (0.0465)	-0.1392*** (0.0489)	0.3220*** (0.0757)	0.3398*** (0.0746)
<i>CK</i>	-0.2230*** (0.0120)	-0.0799*** (0.0178)	-0.2226*** (0.0110)	-0.2019*** (0.0114)	-0.1088*** (0.0162)	-0.1973*** (0.0158)
<i>SOE</i>	0.0232 (0.0144)	0.1134*** (0.0263)	-0.0320 (0.0377)	-0.0102 (0.0399)	0.2470*** (0.0470)	0.2780*** (0.0463)
<i>Age</i>	0.0034*** (0.0007)	0.0112*** (0.0015)	0.0126*** (0.0010)	0.0215*** (0.0011)	0.0182*** (0.0013)	0.0238*** (0.0013)

<i>Export</i>	0.0738*** (0.0099)	0.0927*** (0.0210)	0.6022*** (0.0286)	0.7616*** (0.0301)	0.4425*** (0.0568)	0.6637*** (0.0555)
<i>HHI</i>	-0.2585* (0.1331)	-0.2337 (0.3204)	-1.5647** (0.6449)	-7.7120*** (0.6816)	-1.3463 (1.0363)	-5.9037*** (1.0242)
<i>Constant</i>	6.5938*** (0.0522)	6.3182*** (0.0791)	5.5525*** (0.0527)	3.3416*** (0.0553)	4.9638*** (0.0717)	3.7151*** (0.0703)
<i>Observation</i>	50,526	18,480	9,319	9,634	4,475	4,665
<i>R²</i>	0.1140	0.2246	0.0953	0.1446	0.0898	0.1747

397

398 4.2. Internal and external factors analysis

399 Although there is a double dividend between environmental regulation and
400 employment, the positive impact is not static but rather dynamic and controllable.
401 According to Porter's hypothesis, environmental regulation can lead to enterprise
402 innovation. Enterprises that actively adopt green production technology will increase
403 their market share, and their ability to absorb employment will also be improved. In
404 addition, strengthening the construction of the institutional environment is the basis
405 for the effective implementation of environmental governance to give full play to the
406 backward force mechanism of environmental regulation for improving employment.

407 In [Table 5](#), we introduce the interaction items of environmental regulation and
408 innovation output, and the institutional environment to explore the internal and
409 external factors on the employment effect of environmental regulation. We use the
410 ratio of the output of new products and total output value to measure enterprise
411 innovation ability. The judicial index of official corruption is used in the institutional
412 environment and is measured by the number of corruption, bribery and malfeasance
413 cases per 10,000 public officials. The higher the level of official corruption is, the
414 worse the local institutional environment.

415 From results of [Table 5](#), we can see that the interaction variable $ER*IO$ is

416 significantly positive, and the interaction variable $ER*IE$ is significantly negative.
417 This finding verifies our theoretical analysis; that is, improving innovation ability and
418 optimizing the institutional environment can expand the positive effects of
419 environmental regulation on employment. Enterprises with high innovation
420 investment are more likely to seize the opportunity to adopt green production
421 technology and gain more market share. Moreover, optimizing the construction of the
422 institutional environment can improve the efficiency of environmental regulation and
423 give full play to the forced mechanism of environmental regulation absorbing
424 employment.

425 **Table 5**
426 Analysis on the factors of environmental regulation affecting employment.

	(1)	(2)
	<i>Innovation output</i>	<i>Institutional environment</i>
<i>ER</i>	0.0758*** (0.0133)	0.2578*** (0.0326)
<i>ER*IO</i>	0.2124*** (0.0592)	
<i>ER*IE</i>		-0.0038*** (0.0006)
<i>CK</i>	-0.1764*** (0.0119)	-0.1816*** (0.0101)
<i>SOE</i>	0.0725*** (0.0160)	0.0584*** (0.0136)
<i>Age</i>	0.0080*** (0.0009)	0.0073*** (0.0008)
<i>Export</i>	0.0704*** (0.0102)	0.0766*** (0.0093)
<i>HHI</i>	-0.3489** (0.1480)	-0.3491** (0.1396)
<i>Constant</i>	6.5085*** (0.0522)	6.4784*** (0.0447)
<i>Time fixed effect</i>	Controlled	Controlled
<i>Observation</i>	54,661	69,006
<i>R²</i>	0.1060	0.1087

427

428 **5. Conclusions and policy implications**

429 Based on the matching microdata, this paper empirically tests the effects of
430 environmental regulation on the employment scale and employment structure of
431 enterprises. The conclusions are as follows. First, environmental regulation has a
432 significant positive effect on employment scale, which is more robust for different
433 measurement methods and indicators. From the perspective of skill premiums, the
434 labor redistribution caused by environmental regulation is reflected in the expansion
435 of skilled labor employment and the employment shrinkage of unskilled labor. In
436 other words, the coexistence of "brown unemployment" and "green employment"
437 leads to the optimization of the employment structure. Second, the environmental
438 regulation expand employment scale in different regions of China. However, the
439 effect on the employment structure exhibits regional heterogeneity. In the developed
440 regions of China, environmental regulation increases the proportion of skilled labor
441 and reduces that of unskilled labor. In the undeveloped regions of China,
442 environmental regulation leads to an increase in both skilled and unskilled labor,
443 which is mainly affected by the transfer of polluting enterprises. Third, exploring the
444 internal and external factors that affect the relationship between environmental
445 regulation and employment, we find that the improvement of innovation ability and
446 the optimization of the institutional environment promote the positive effects of
447 environmental regulation on employment.

448 The conclusions of this paper can provide insights for policy makers when
449 dealing with the employment dilemma. Environmental regulation can be used as the

450 driving force to expand employment scale and optimize the employment structure to
451 achieve the goal of environmental protection and job creation.

452 First, reasonable environmental regulation should be implemented. Increasing the
453 intensity of environmental regulation may weaken the competitiveness of enterprises
454 in the short run. In the long run, environmental regulation can improve employment
455 scale and optimize the employment structure. The government should change its
456 traditional cognition of the relationship between environmental regulation and
457 employment, pay attention to the revision and improvement of various environmental
458 laws and regulations, and require all regions and industries to strictly implement
459 quantitative environmental emission standards. It is necessary to strictly control the
460 new pollution-intensive and high-energy-consuming projects, raise the environmental
461 access threshold, and force the production capacity that fails to meet the
462 environmental protection and energy consumption standards to withdraw from the
463 market. At the same time, from the perspective of the labor supply, it is necessary to
464 increase the training of low skilled workers to improve their comprehensive quality
465 and skill level. Under the dual paths of "brown unemployment" and "green
466 employment" caused by environmental regulation, "brown unemployment" can be
467 smoothly transformed into "green employment" to jointly promote the development of
468 the employment structure at a higher level and regard environmental regulation as a
469 breakthrough for solving the employment dilemma.

470 Second, according to the characteristics of different regions, different
471 environmental regulation policies should be implemented to avoid one-size-fits-all

472 policies. The effect of environmental regulation on regional employment is
473 heterogeneous and requires policy makers to implement more targeted environmental
474 policies according to local conditions and the actual situation of each region.
475 Specifically, national environmental protection policies and regulations have a unified
476 normative, but in their implementation process, different regions should formulate
477 implementation rules that are suitable for the local area. Environmental governance
478 must be more targeted and refined. For underdeveloped regions, enterprises cannot
479 blindly pursue economic growth, so their environmental regulation intensity lags
480 behind that of developed regions for a long time. If underdeveloped regions undertake
481 a large number of enterprises with high pollution and high energy consumption, then
482 they will become "pollution shelters". It is necessary for such regions to upgrade the
483 employment structure and improve regional competitiveness through different
484 environmental regulation policies.

485 Finally, to realize the double dividend of environmental regulation and
486 employment, we need to cooperate with other means, such as improving innovation
487 ability and optimizing the industrial structure and institutional environment.
488 Technological progress can reduce the negative impact of economic growth on the
489 environment, improve output efficiency, and provide a basis for absorbing more
490 employment. Therefore, the government should strengthen its guidance for enterprises
491 to develop high-tech products and increase the innovation support of national policies.
492 Industrial structure optimization is conducive to the employment effect of
493 environmental regulation. To form a virtuous circle of the economy and the

494 environment, the government should promote the upgrading of the industrial structure,
495 take a new path toward industrialization, and actively develop the tertiary industry.
496 The institutional environment is the most powerful guarantee for policy
497 implementation and an effective tool for promoting the employment effect of
498 environmental regulation. The government should optimize the institutional
499 environment of environmental law enforcement. Furthermore, it is necessary to clarify
500 the environmental responsibility of government departments, enterprises and
501 individuals.

502 **Ethical approval** This study conforms to the ethical and moral requirements.

503 **Consent to participate** All the authors of this article were consented to participate.

504 **Consent to publish** This study was consented to be published.

505 **Authors' contributions** Mengjie Li was responsible for formal analysis, original
506 draft writing and funding acquisition. Weijian Du was responsible for
507 conceptualization, methodology, software and validation.

508 **Competing interests** The authors declare that there is no conflict of interests.

509 **Funding** This research is sponsored by National Natural Science Foundation of
510 China (71803102), National Social Science Fund of China (20FJYB012), Science
511 Foundation of Ministry of Education of China (18YJC790086) and Shandong
512 Provincial Natural Science Foundation (ZR2020QG041).

513 **Data availability** All the data and materials were freely available in the database of
514 National Bureau of Statistics of China and Ministry of Ecology and Environment of
515 China.

516 **References**

- 517 Ambec S, Cohen MA, Elgie S, Lanoie P (2013): The Porter Hypothesis at 20: Can Environmental
518 Regulation Enhance Innovation and Competitiveness? *Rev Env Econ Policy* 7, 2-22
- 519 Becker R, Henderson V (2000): Effects of Air Quality Regulations on Polluting Industries. *J. Polit.*
520 *Economy* 108, 379-421
- 521 Berck P, Hoffmann S (2002): Assessing the Employment Impacts of Environmental and Natural
522 Resource Policy. *Environ Resour Econ* 22, 133-156
- 523 Blundell W, Gowrisankaran G, Langer A (2020): Escalation of Scrutiny: The Gains from Dynamic
524 Enforcement of Environmental Regulations. *Amer. Econ. Rev.* 110, 2558-2585
- 525 Brandt L, Van Biesebroeck J, Zhang Y (2012): Creative accounting or creative destruction?
526 Firm-level productivity growth in Chinese manufacturing. *J. Devel. Econ.* 97, 339-351
- 527 Cao YR, Liu J, Yu Y, Wei G (2020): Impact of environmental regulation on green growth in
528 China's manufacturing industry-based on the Malmquist-Luenberger index and the system
529 GMM model. *Environ Sci Pollut R* 27, 41928-41945
- 530 Chen B, Li Y, Yin YM (2016): FDI, Industry Heterogeneity and Employment Elasticity in China.
531 *Rev. Devel. Econ.* 20, 189-200
- 532 Chodorow-Reich G (2014): The Employment Effects of Credit Market Disruptions: Firm-level
533 Evidence from the 2008-9 Financial Crisis. *Quart. J. Econ.* 129, 1-59
- 534 Coase RH (1972): The problem of social cost. In: Auld DAL (Editor), *Economic thinking and*
535 *pollution problems.* University of Toronto Press, pp. 113-118
- 536 Du W, Li M (2019): Can environmental regulation promote the governance of excess capacity in
537 China's energy sector? The market exit of zombie enterprises. *J Clean Prod* 207, 306-316
- 538 Du WJ, Wang FM, Li MJ (2020): Effects of environmental regulation on capacity utilization:
539 Evidence from energy enterprises in China. *Ecol Indic* 113, 10
- 540 Ferris AE, Shadbegian RJ, Wolverton A (2014): The Effect of Environmental Regulation on Power
541 Sector Employment: Phase I of the Title IV SO₂ Trading Program. *J. Assoc. Environ.*
542 *Resour. Econ.* 1, 521-553
- 543 Fisman R, Svensson J (2007): Are corruption and taxation really harmful to growth? Firm level
544 evidence. *J. Devel. Econ.* 83, 63-75
- 545 Goodstein E (1996): Jobs and the Environment: An Overview. *Environ Manage* 20, 313-321
- 546 Greenstone M, Hanna R (2014): Environmental Regulations, Air and Water Pollution, and Infant
547 Mortality in India. *Amer. Econ. Rev.* 104, 3038-3072
- 548 Guo W, Dai HJ, Liu XR (2020): Impact of different types of environmental regulation on
549 employment scale: an analysis based on perspective of provincial heterogeneity. *Environ*
550 *Sci Pollut R* 27, 45699-45711
- 551 He GJ, Xie Y, Zhang B (2020): Expressways, GDP, and the environment: The case of China. *J.*
552 *Devel. Econ.* 145, 16
- 553 Jiang Y, Lei YL, Yan X, Yang YZ (2019): Employment impact assessment of carbon capture and
554 storage (CCS) in China's power sector based on input-output model. *Environ Sci Pollut R*
555 26, 15665-15676
- 556 Lanoie P, Patry M, Lajeunesse R (2008): Environmental regulation and productivity: testing the
557 porter hypothesis. *J. Productiv. Anal.* 30, 121-128
- 558 Levinson A (1996): Environmental regulations and manufacturers' location choices: Evidence

559 from the Census of Manufactures. *J. Public Econ.* 62, 5-29

560 Li M, Du W, Tang S (2021): Assessing the impact of environmental regulation and environmental
561 co-governance on pollution transfer: Micro-evidence from China. *Environ Impact Asses*
562 86, 106467

563 Liu YL, Wang J (2020): Environmental pollution, environmental regulation, and labor income
564 share. *Environ Sci Pollut R* 27, 45161-45174

565 Morgenstern RD, Pizer WA, Shih J-S (2002): Jobs Versus the Environment: An Industry-Level
566 Perspective. *J. Environ. Econ. Manage.* 43, 412-436

567 Omri A, Daly S, Rault C, Chaibi A (2015): Financial development, environmental quality, trade
568 and economic growth: What causes what in MENA countries. *Energy Economics* 48,
569 242-252

570 Pan X, Cheng WY, Gao YN, Balezentis T, Shen ZY (2021): Is environmental regulation effective
571 in promoting the quantity and quality of green innovation? *Environ Sci Pollut R* 28,
572 6232-6241

573 Pigou AC (1920): *The economics of welfare.* Macmillan and Co., London

574 Porter ME, Linde Cvd (1995): Toward a New Conception of the Environment-Competitiveness
575 Relationship. *J. Econ. Perspect.* 9, 97-118

576 Sheng JC, Zhou WH, Zhang SF (2019): The role of the intensity of environmental regulation and
577 corruption in the employment of manufacturing enterprises: Evidence from China. *J*
578 *Clean Prod* 219, 244-257

579 Sun WY, Yang Q, Ni Q, Kim Y (2019): The impact of environmental regulation on employment:
580 an empirical study of China's Two Control Zone policy. *Environ Sci Pollut R* 26,
581 26472-26487

582 Sun ZY, Wang XP, Liang C, Cao F, Wang L (2021): The impact of heterogeneous environmental
583 regulation on innovation of high-tech enterprises in China: mediating and interaction
584 effect. *Environ Sci Pollut R* 28, 8323-8336

585 Walker WR (2011): Environmental Regulation and Labor Reallocation: Evidence from the Clean
586 Air Act. *Amer. Econ. Rev.* 101, 442-47

587 Zhang KK, Xu DY, Li SR, Wu T, Cheng JH (2021): Strategic interactions in environmental
588 regulation enforcement: evidence from Chinese cities. *Environ Sci Pollut R* 28,
589 1992-2006

590