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Environmental Legislation, Resource Allocation Efficiency and the Green Growth of Industry: Based on Global Malmquist-Luenberger Productivity Index and Difference-in-Difference Method

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Abstract: Facing with severe environmental constraints, will the promulgation of environmental laws and regulations be conducive to promoting the green growth of industry in developing country? This paper tries to answer it by providing an empirical study of China. Based on the SBM Directional Distance Function, we first calculated the green growth index of industry and its decomposition, and then investigated the heterogeneous effects of environmental legislation on the industrial resource allocation efficiency and the green growth of China's industry. The paper reveals some following findings. First, local environmental legislation is conducive to promoting the green growth of China's industry. Meanwhile the mismatch of resource allocation shows negative effects on it. This result remains robust after considering some controlled variables at the enterprising and regional levels or using different methods. Second, local environmental legislation can alleviate the negative effects of resource allocation mismatch on the green growth of China's industry by presenting positive moderating effects. Third, the effect of local environmental legislation on technological progress is more significant than that of technical efficiency, which implies an obvious anti-driving mechanism of local environmental legislation on the technological innovation. Finally, we propose some policy implications on how to achieve the green growth of industry by implementing efficient environmental legislation and optimizing industrial resource allocation efficiency in transitional economy.

Keywords: Environmental legislation, Industrial resource allocation efficiency, The green growth of industry, The SBM directional distance function, Difference-in-difference method.

1. Introduction

To achieve the dual goal of industrial growth and environmental protection seems to be a paradox for the developing countries. In recent years, in order to control environmental pollution and improve environmental quality, some developing countries tried to legislate local environmental laws, regulations or standards. Taking China as an example, according to the statistics of China Environmental Yearbook in 2017, the total number of effective local environmental laws and regulations in provincial level of China has reached 391 by 2016, which covering the fields of environmental protection duties and responsibilities on water pollution, air pollution and solid waste pollution. After the release of legislative laws of China, the legislative power of environmental legislation has been extended to districts and municipalities. However, according to China Environmental Situation Bulletin 2017, although the environmental quality in China has been improved, the situation of environmental protection is still grim. 239 cities failed to meet national air quality standard, taking up 70.7%. $PM_{2.5}$ was the primary pollutant, with 74.3% percent of cities failed to meet Grade II national air quality standard. Moreover, 32.1% percent of1940 surface water sections failed to meet Grade I~III water quality standard, and 66.6% percent of groundwater at 5,100 monitoring sites had poor or very poor water quality.

The resource allocation mismatch such as the distorted factor price and the low energy utilization rate are considered to be causes of the above environmental pollution problems. In the absence of local environmental legislation, due to the negative externalities of environmental pollution, low-productivity enterprises can easily obtain environmental resources at a low cost to seize market survival opportunities, nevertheless, which hinder the free flow of resources to high-productivity enterprises. This resources mismatch will be no doubt about showing negative externalities to the upgrading of industrial structure and the green growth of industry. Theoretically, local environmental legislation can make up the gap between the private cost and the social cost of pollutant discharge enterprises through the internalization of environmental costs, and improve the efficiency of resource allocation. However, it may also lead to policy distortion and thus the resource allocation due to asymmetric information and transaction costs. The role of local environmental legislation and its mechanism on optimizing the resource allocation has attracted the attention from both academics and policymakers. It is not only conducive to the relationship between government and market, but also conducive to achieving a win-win situation between environmental protection and industrial green growth.

The existing literature has studied the effects of environmental legislation on productivity (Berman and Bui, 2001; Liu, et al., 2017), innovation performance (Lanoieet al., 2011; Wallace, 2017), foreign direct investment (Chung,2014), but most of them neglects the impact or externality of environmental legislation on the industrial resource allocation and the green growth. Tombe and Winterb (2015) had discussed the productivity effect of intensity standards and investigated the relationship between the environmental policy and resource misallocation. However, this paper used the change of average industrial productivity level instead of heterogeneous enterprise productivity difference to measure the effect of environmental policy on resource allocation, which is not accurate meaning of resource allocation. Some other literature studied the relationship between resource misallocation and productivity (David et al.,2016; Restuccia et al.,2017). Although the research fields covered by the above literature are relatively comprehensive, the impact of environmental legislation on industrial resource allocation and green growth is rare, especially in the context of environmental legislation or lack of empirical evidence on micro-level of enterprises from developing countries.

Compared with the existing literature, this paper has contributed some different research contents and methods as follows. Firstly, we are interested in the effect and mechanism of environmental legislation on resource allocation and industrial green growth in developing countries. Previous literature emphasized more on the impact of environmental regulation on the technological progress of enterprises in developed countries, nevertheless, the study of the effect and mechanism of environmental legislation on resource allocation and industrial green growth of transitional countries is relatively inadequate. This paper tries to reveal the heterogeneous effects and mechanisms of local environmental legislation on the industrial resource allocation efficiency and green total factor productivity based on the database of China's industrial enterprises from 1998 to 2007. Secondly, we improve the calculation method of indicators of industrial green growth. The traditional ML method may have some defects such as no solutions(OH,2010). Therefore, this paper applies the GML method to measure the industrial green growth, and decomposes into scale efficiency and technological progress to explore the sources of industrial green growth. Thirdly, this paper takes local environmental legislation as a quasi-natural experiment, uses the method of difference-in-difference (DID) model to investigate the different impacts between the experimental group and the control group before and after environmental legislation, and thus to examine the causal effects of local environmental legislation on the industrial resource allocation and green growth. The empirical design of DID method can effectively overcome the estimation error of endogenous problems in empirical models.

2. Theoretical Framework and Research Hypothesis

2.1. Environmental Legislation and Industrial Green Growth

Some papers have studied the economic effects of environmental legislation not only from the macro-level of regional or industrial pollution emissions, but also from the micro-level of enterprises' economic activities such as innovation or investment. Although they have adopted different methods to achieve different results, generally they have revealed the positive effect of environmental legislation on industrial green growth, which is mainly reflected in two mechanisms. One is the "cost reduction effect". Some literature insisted that the internalization of environmental costs by environmental regulation will increase the production costs and decrease products' competitiveness (Copeland and Taylor, 2004). Conversely, another is the "technology effect". It supports the view of "Porter Hypothesis" that appropriate environmental regulation can stimulate enterprises to improve R&D innovation to obtain product compensation and increase productivity to obtain processing compensation, and thus enhance their competitiveness (Porter and van der Linde,1995). Since the carrying capacity of resources and environment has reached a bottleneck, developing countries have released more and more stringent environmental protection policies. With stronger effects of technology innovation on the internal costs reduction of enterprises, this paper proposes that technological innovation will play a dominant role, and thus, the effect of environmental legislation on industrial green growth would be positive.

Hypothesis 1: *Local environmental legislation has a positive effect on industrial green growth.*

2.2. Industrial Resource Allocation and Industrial Green Growth

In the process of fiscal decentralization reform in developing countries, local governments would probably intensify local protection and hinder the free flow of elements between regions for local economic growth and tax competition to obtain more revenues. Local government competition and its derivatives of local protection and market segmentation will not only restrict the effective and rational flow of factors such as labor, capital and resources and energy in local and national markets, but also aggravate the distortion of regional resource allocation. Meanwhile, the problems of low energy efficiency and severe environmental pollution caused by distorted factors will also bring greater pressure to the industrial sustainable growth. Many early studies assessed the economic and efficiency losses caused by local protection and market segmentation, and confirmed that the mismatch of resources caused by local protection and market segmentation has indeed reduced the quality of green growth of regional industry.

Hypothesis 2: Resource *allocation mismatch has a negative effect on the industrial green growth.*

2.3. Environmental Legislation, Industrial Resource Allocation and the Green Growth

The impact of environmental legislation on industrial resource allocation and the green growth is mainly realized through channels of intra-enterprise resource allocation and inter-enterprise resource allocation. For the former, environmental legislation stimulate the enterprises to adopt cleaner inputs of intermediate goods and cleaner production technology to replace inputs of high energy consuming and high emission and outdated technology. Enterprises are more inclined to substitute intensive technology for the extensive inputs of environmental factors. This change improves the internal resource allocation efficiency and ultimately achieves cleaner production goals in the production process. For the latter, environmental legislation also affects the resource allocation of inter-enterprises, which is manifested in the dynamics of enterprises' behavior of entry and exit, and then affects the resource allocation and green growth of industry. More specifically, environmental regulation can reduce the inflow of low-productivity enterprises while promoting the inflow of high-productivity enterprises, thus regulating the re-allocation of resources between heterogeneous enterprises and the optimization of industrial structure, which is conducive to promoting industrial green growth.

Hypothesis 3: *Local environmental legislation helps to alleviate the negative effects of resource allocation mismatch on the industrial green growth by moderating effects.*

3. Empirical Methodology

3.1. Empirical Model

To identify the effect of environmental legislation on industrial green growth, this paper applies DID (Difference-in-difference model). Firstly, the samples of environmental legislation of 31 provinces in China were collected to reflect the regional environmental legislation. Secondly, industries in the legislative area are divided into high-polluted industries and low-polluted industries according to the pollution intensity. The high-polluted industries are set as experimental group and the low-polluted industries are set as control group. Because of the pollution level of different industries are subject to different levels of environmental legislation, high-polluted industries are subject to stricter environmental legislation control, while low-polluted industries are regulated by relatively loose environmental legislation, so this paper uses the pollution degree of industry to identify the effects of environmental legislation on industrial green growth. Finally, the multiple difference method is used to explore the impact of regional environmental legislation on industrial resource allocation by comparing the changes of resource allocation between high-polluted industries and low-polluted industries before and after legislation.

Therefore, to identify the impact of regional environmental legislation on resource allocation efficiency and industrial green growth, this paper uses the difference-in-difference (DID) model to test the policy effect of local environmental legislation on industrial green growth as follows.

$$\mathrm{GGI_{ijt}} = \mathrm{C} + \alpha_1 \mathrm{EL_{ijt}} + \alpha_2 \mathrm{X_{ijt}} + \varphi_i + \varphi_t + \varepsilon_{ijt} \qquad (1)$$

Inequation(1), i represents an industry, i represents a province, and t represents a year. The dependent variable$\mathrm{GGI_{ijt}}$ represents the green TFP of all enterprises in i industry and jprovince. $\mathrm{EL_{ijt}}(\mathrm{pi_i} \times \mathrm{lel_t})$ represents the key explanatory variable. $\mathrm{pi_i}$ represents the pollution degree of i industry, $\mathrm{lel_t}$ represents the dummy variable of the environmental legislation. The coefficient α_1 measures the green TFP of the experimental group before and after environmental legislation compared with the control group, which reflecting the impact of environmental legislation on the industrial green growth. The control variable $\mathrm{X_{ijt}}$represents the control variables that affects the green TFP of industry, which including the average industrial asset-liability ratio(*debt*), industrial concentration(*hhi*), industry average fixed cost(*fc*), industrial average export tendency(*exp*), industrial average employment logarithm(*lnL*), industrial average wage(*wage*), industrial state-owned capital ratio(*state*), industrial foreign capital ratio(foreign), the average age of enterprises in the industry(*age*), logarithmic of regional economic development(*lnpgdp*), regional economic structure(*str*), logarithmic of regional infrastructure construction(*lnroad*). The fixed effects are also controlled in the model, in which φ_i and φ_t represent the industry fixed effect and time fixed effect respectively.ε_{ijt} represents the random error term.

Simultaneously, we construct an empirical model to test the impact of resource allocation mismatch on industrial green growth.

$$\mathrm{GGI_{ijt}} = \mathrm{C} + \beta_1 \mathrm{ra_{ijt}} + \beta_2 \mathrm{X_{ijt}} + \sigma_i + \sigma_t + \mu_{ijt} \qquad (2)$$

Inequation(2), $\mathrm{RA_{ijt}}$represents the mismatch of industrial resource allocation. The coefficient β_1 measures the effect of resource allocation mismatch on the green growth of industries.σ_i andσ_t represent the industry fixed effect and time fixed effect respectively.μ_{ijt} representsthe random error term.

Furthermore, we evaluate the effect of local environmental legislation on industrial resource allocation efficiency and the green growth of industry by equation(3).

$$\mathrm{GGI_{ijt}} = \mathrm{C} + \theta_1 \mathrm{ra_{ijt}} + \theta_2 \mathrm{EL_{ijt}} + \theta_3 \mathrm{ra_{ijt}} \times \mathrm{EL_{ijt}} + \theta_4 \mathrm{X_{ijt}} + \gamma_i + \gamma_t + \tau_{ijt} \quad (3)$$

Inequation(3), the coefficient $\theta_3$indicates the moderating effects of local environmental legislation on industrial resource allocation efficiency and the green growth of industry.$\gamma_i$andγ_t represent the industry fixed effect and time fixed effect respectively.τ_{ijt} represents the random error term.

Considering the decomposition of $\mathrm{GGI_{ijt}}$, the empirical equation is further set as follows.

$$\mathrm{geffch_{ijt}} = \mathrm{C} + \theta_1 \mathrm{ra_{ijt}} + \theta_2 \mathrm{EL_{ijt}} + \theta_3 \mathrm{ra_{ijt}} \times \mathrm{EL_{ijt}} + \theta_4 \mathrm{X_{ijt}} + \gamma_i + \gamma_t + \tau_{ijt} \quad (4)$$

$$\mathrm{gtech_{ijt}} = \mathrm{C} + \theta_1 \mathrm{ra_{ijt}} + \theta_2 \mathrm{EL_{ijt}} + \theta_3 \mathrm{ra_{ijt}} \times \mathrm{EL_{ijt}} + \theta_4 \mathrm{X_{ijt}} + \gamma_i + \gamma_t + \tau_{ijt} \quad (5)$$

$$\mathrm{gseffch_{ijt}} = \mathrm{C} + \theta_1 \mathrm{ra_{ijt}} + \theta_2 \mathrm{EL_{ijt}} + \theta_3 \mathrm{ra_{ijt}} \times \mathrm{EL_{ijt}} + \theta_4 \mathrm{X_{ijt}} + \gamma_i + \gamma_t + \tau_{ijt} \quad (6)$$

$$\mathrm{gstech_{ijt}} = \mathrm{C} + \theta_1 \mathrm{ra_{ijt}} + \theta_2 \mathrm{EL_{ijt}} + \theta_3 \mathrm{ra_{ijt}} \times \mathrm{EL_{ijt}} + \theta_4 \mathrm{X_{ijt}} + \gamma_i + \gamma_t + \tau_{ijt} \quad (7)$$

3.2. Variable Measurement

3.2.1. Green Growth of Industry

The method of Global Malmquist-Luenberger productivity index was applied to measure the green growth of regional industry. In order to measure the green total factor productivity of provincial industry, we first need to construct a set of production possibilities including both expected and non-expected outputs. Assuming that the industry is a decision-making unit, each industry uses N kinds of inputs$x = (x_1 + x_2 + \cdots + x_N) \in R_+^N$, and obtains M kinds of expected outputs$y = (y_1 + y_2 + \cdots + y_M) \in R_+^M$, and J kinds of unexpected outputs$b = (b_1 + b_2 + \cdots + b_J) \in R_+^J$. Then, the input and output value of the k industry in the T year can be expressed as $(x^{k,t}, y^{k,t}, b^{k,t})$, and then the production possibility set can be constructed as $p^t(x^t) = \{(y^t, b^t): x^t \text{ produce } (y^t, b^t)\}, t = 1,2,\cdots,T$. It is assumed that the production possibility set satisfies the conditions of strong disposability of input and expected output, weak disposal axiom of unexpected output, zero combination axiom of expected output and unexpected output.

Directional distance function is introduced to solve the problem of efficiency evaluation including unexpected output (Chung et al.,1997). The form is $\vec{D}_0(x, y, b, g) = \max\{\beta: (y, b) + \beta g \in P(x)\}$, where g=(y, b) represents the direction vector of horizontal expansion of output and beta is the value of directional distance function. The weight is set as the direction vector, and the expected output (y) is maximized and the unexpected output (b) is minimized. However, the ML index constructed on this basis is not cyclical and transitive, and it is easy to come up with no solution to linear programming when measuring the inter-temporal directional distance.

In this paper, the global directional distance function and global Luenberger index based on SBM are constructed by using the idea of GML index proposed by Oh(2010). That is to say, a global production frontier is constructed by detecting the production technology in the whole period of time, thus effectively avoiding the situation of "technology retrogression" and the problem of linear programming being solvable. The GML index is cyclical. It can not only analyze the short-term changes of technology, but also observe the long-term trend of technological progress.

The global directional distance function of SBM is specified as follows.

$$
\begin{aligned}
&S^{G,K'}\left(x^{t,k} + y^{t,k} + b^{t,k}\right) \\
&\quad = \max_{s_x, s_y, s_b} \frac{1}{2N_n} \sum_{n=1}^{N} \frac{S_{n,x}^{G,k'}}{x_n^{t,k'}} \\
&\quad + \frac{1}{M+J}\left[\sum_{m=1}^{M} \frac{S_{m,y}^{G,k'}}{y_m^{t,k'}} + \sum_{j=1}^{J} \frac{S_{j,b}^{G,k'}}{b_j^{t,k'}}\right] \\
&\text{s.t.} \sum_{t=1}^{T}\sum_{k=1}^{k} z^{t,k} x_n^{t,k} + S_{n,x}^{G,k'} = x_n^{t,k'}; \sum_{t=1}^{T}\sum_{k=1}^{k} z^{t,k} y_m^{t,k} + S_{m,y}^{G,k'} \\
&\quad = y_m^{t,k'}; \sum_{t=1}^{T}\sum_{k=1}^{k} z^{t,k} b_j^{t,k} + S_{j,b}^{G,k'} = b_n^{t,k'} \\
&z^{t,k} \geq 0;\ S_{n,x}^{G,k'} \geq 0;\ S_{m,y}^{G,k'} \geq 0; n = (1, \cdots, N), m \\
&\quad = (1, \cdots, M), j = (1, \cdots, J)
\end{aligned}
$$

$S^{G,K'}$ represents the distance between the decision making unit K' and the global production frontier. The value of 0 represents that the decision making unit is at the production frontier, and there is no technical inefficiency. $S_{n,x}^{G,k'}$, $S_{m,y}^{G,k'}$ and $S_{j,b}^{G,k'}$ represent the element input n, expected output m and relaxation vector for the j unexpected outputs, respectively. The distance measured by $S^{G,K'}$ will actually goes along with the direction of $g = (-x^t, y^t, -b^t)$ to minimize input, increase expected output and reduce unexpected output. Similarly, GML can be decomposed as efficiency change index and technology progress index.

$$
\begin{aligned}
&GGI^{t,t+1}(x^t + y^t + b^t + x^{t+1} + y^{t+1} + b^{t+1}) \\
&= \frac{1 + D^G(x^t, y^t, b^t)}{1 + D^G(x^{t+1}, y^{t+1}, b^{t+1})} \\
&= \frac{1 + D^t(x^t, y^t, b^t)}{1 + D^{t+1}(x^{t+1}, y^{t+1}, b^{t+1})} \\
&\times \frac{(1 + D^G(x^t, y^t, b^t))/(1 + D^t(x^t, y^t, b^t))}{(1 + D^G(x^{t+1}, y^{t+1}, b^{t+1}))/(1 + D^{t+1}(x^{t+1}, y^{t+1}, b^{t+1}))} \\
&= \frac{TE^{t+1}}{TE^t} \times \left[\frac{BPG_{t+1}^{t,t+1}}{BPG_t^{t,t+1}}\right] = EC^{t,t+1} \times TC^{t,t+1} \\
&= geffch \times gtech \times gseffch \times gstech
\end{aligned}
$$

$GGI^{t,t+1}$ denotes the green total factor productivity, geffch denotespure technical efficiency change, gtech denotespure technological change, gseffch denotesscale efficiency change, gstech denotesscale technology change.

3.2.2. Resource Allocation Efficiency

The method of productivity dispersion was applied to measure the degree of resource allocation mismatch (Hsieh and Klenow, 2009). Under the condition of perfect competition, there should be no mismatch of resource allocation. The competition mechanism promotes the flow of resources from low-productivity enterprises to high-productivity enterprises, which is manifested in the continuously decline of productivity dispersion at the enterprise level, and eventually the productivity of all enterprises tend to be equal (Syverson, 2004). Therefore, the higher dispersion of productivity is, the lower resource allocation efficiency is.

3.2.3. Environmental Legislation

Since China has promulgated the basic law on environmental protection in 1979, the legal system of environmental protection has been improving gradually. China's environmental legislation can be divided into central environmental legislation and local environmental legislation according to the division of legislative subjects. Under the framework of central government's environmental legislation, local governments have formulated more and more environmental laws and regulations. We applied the cross term (*industrial pollution density×fictitious variable in legislative period*) to measure the change of productivity dispersion of the experimental group before and after environmental legislation compared with the control group(Li et al., 2018), which reflecting the impact of environmental legislation on the resource allocation efficiency and green growth of industry.

4. Data

The raw data of regional green growth of industry and other variables of regional level mainly comes from the China Statistical Yearbook and the China Environmental Yearbook. The tariff data comes from the WITS database. The raw data of environmental legislation mainly come from the regional policy documents such as environmental protection regulations, environmental pollution prevention and controlling regulations. The data of resource allocation efficiency and control variables of enterprise level are mainly from China's industrial enterprise database. The data are processed according to the methods of Brandt et al. (2012)

and Li et al.(2018).

5. Results

Applying the method of DID (Difference-In-Difference), this paper estimates the impact of environmental legislation on the resource allocation efficiency and industrial green growth. The estimated results are shown in **Table1**. In the first columns, the coefficients of environmental legislation are positive and significant at statistical level of 10%, which implying a positive effect of environmental legislation on the green growth of industry. Furthermore, the industry-level and regional-level controlled variables are added as shown in the second and third columns of **Table 1** to reduce errors in endogenous estimation of possible missing variables, the results remain robust.

We further conduct the robustness check by using the alternative variables of explanatory variables that were calculated without considering undesirable expectations (GGI_1) or were calculated by the method of ML (GGI_2), which are listed in the fourth and fifth columns of **Table 1**. We find that the positive effect of environmental legislation on the green growth of industry is still significant. The above results show that after the implementation of environmental legislation, the green TFP of high-polluted industries is significantly lower than that of low-polluting industries. This result shows that the environmental legislation has significantly enhanced the green total factor productivity of industrial enterprises.

Table 1. Regression results of the impact of environmental legislation on green growth of industry

Variables		GGI		GGI_1	GGI_2
EL	0.0418^{*}	0.0183^{**}	0.0077^{***}	0.0091^{***}	0.0093^{***}
	(1.9175)	(2.3589)	(8.2336)	(9.9415)	(7.2882)
debt		0.0873^{***}	0.0123^{***}	0.0124^{***}	0.0077^{***}
		(4.3156)	(5.3302)	(5.3056)	(3.1023)
hhi		0.1957^{***}	0.0357^{***}	0.0354^{***}	0.0365^{***}
		(4.5853)	(12.9834)	(12.8580)	(13.7852)
fc		0.0374^{***}	-0.0124^{***}	-0.0128^{***}	-0.0078^{*}
		(3.2417)	(-3.9619)	(-4.0336)	(-1.9766)
exp		-0.0358^{***}	-0.0234^{***}	-0.0243^{***}	-0.0265^{***}
		(-4.1673)	(-9.6769)	(-9.9311)	(-9.7728)
lnL		0.0451^{***}	0.0079^{***}	0.0078^{***}	0.0065^{***}
		(4.9203)	(16.5724)	(16.4020)	(13.7743)
age		-0.0004^{**}	-0.0001	-0.0001	-0.0000
		(-2.5590)	(-0.8089)	(-0.7296)	(-0.1283)
state		0.0357^{***}	0.0070^{***}	0.0079^{***}	0.0076^{***}
		(3.9613)	(3.7262)	(4.3010)	(4.6389)
foreign		0.0471^{***}	-0.0267^{***}	-0.0268^{***}	-0.0289^{***}
		(4.0203)	(-11.4475)	(-11.4669)	(-13.0324)
wage		0.0001^{**}	-0.0000^{**}	-0.0000^{**}	-0.0000
		(2.2691)	(-2.1271)	(-2.0855)	(-1.5740)
lnpgdp			0.1321^{***}	0.1310^{***}	0.1314^{***}
			(35.4472)	(35.0559)	(41.2157)
indr			-0.6947^{***}	-0.6796^{***}	-0.4634^{***}
			(-36.5999)	(-35.6683)	(-25.2574)
industry	controlled	controlled	controlled	controlled	controlled
year	controlled	controlled	controlled	controlled	controlled
N	24352	23524	23524	23524	23524
adj. R^2	0.9825	0.9908	0.9980	0.9978	0.9948

Notes: t statistics in parentheses. $^{*}p< 0.10$, $^{**}p< 0.05$, $^{***}p< 0.01$

We then test the differentiated effects of environmental legislation on the decomposition of green growth of industry. The regression results are shown in **Table 2**.The results show that the coefficients of the environmental legislation on the decomposition of green growth of industry are consistent with the results of benchmark regression in **Table 1**, indicating that the results of benchmark regression are robust. Moreover, the promoting effect of environmental legislation on the green technology progress is more significant than that of the green efficiency change. This result provides evidence for the porter hypothesis which verifies the technological progress effect of environmental legislation.

Table 2. Regression results of the impact of environmental legislation on decomposition of GGI_{ijt}

Variables	geffch	gtech	gseffch	gstech
EL	0.0116***	0.0123***	0.0080***	0.0116***
	(8.8632)	(11.5321)	(8.0710)	(10.5748)
debt	0.0100***	0.0146***	0.0125***	0.0135***
	(3.5165)	(5.5851)	(5.4675)	(5.8644)
hhi	0.0387***	0.0413***	0.0373***	0.0437***
	(13.4534)	(13.8348)	(12.0954)	(17.8263)
fc	-0.0152***	-0.0110**	-0.0150***	-0.0111***
	(-3.1334)	(-2.3781)	(-4.4410)	(-3.4958)
exp	-0.0253***	-0.0244***	-0.0258***	-0.0180***
	(-9.5716)	(-9.3910)	(-9.2260)	(-7.2194)
lnL	0.0085***	0.0085***	0.0090***	0.0088***
	(16.1219)	(14.5307)	(15.5442)	(17.4202)
age	-0.0001	-0.0001	-0.0001	-0.0001
	(-0.7259)	(-0.8658)	(-0.7928)	(-0.8668)
state	0.0087***	0.0042*	0.0066***	0.0049***
	(4.5284)	(1.9741)	(3.8379)	(2.9479)
foreign	-0.0309***	-0.0259***	-0.0260***	-0.0257***
	(-10.4738)	(-10.8144)	(-10.0896)	(-10.8215)
wage	-0.0000	-0.0000**	-0.0000*	-0.0000
	(-1.4541)	(-2.2386)	(-1.9536)	(-1.6690)
lnpgdp	0.1428***	0.1161***	0.1166***	0.1338***
	(36.3827)	(29.8112)	(30.2149)	(33.1355)
indr	-0.8024***	-0.5617***	-0.4845***	-0.7633***
	(-38.7009)	(-26.6410)	(-23.5649)	(-35.6670)
industry	controlled	controlled	controlled	controlled
year	controlled	controlled	controlled	controlled
N	23524	23524	23524	23524
adj. R^2	0.9929	0.9944	0.9982	0.9981

Notes: *t* statistics in parentheses. $^{*}p< 0.10$, $^{**}p< 0.05$, $^{***}p< 0.01$

We further investigate the impacts of resource allocation on the green growth of industry and its decomposition. Results are presented in Table 3.It shows that the resource mismatch has statistically significant impact on the green growth of industry and on its decomposition. This suggests that China's market-oriented process is still deepening. Due to the lagging reform of the institution, the enterprises' allocation behavior of labor and land might be restricted or distorted.

Table 3. Regression results of the impact of resource mismatch on the green growth of industry

Variables	GGI	geffch	gtech	gseffch	gstech
ra	-0.0099***	-0.0109***	-0.0105***	-0.0143***	-0.0085***
	(-7.9628)	(-4.4657)	(-5.0274)	(-10.3969)	(-3.7207)
debt	0.0290***	0.0232***	0.0375***	0.0322***	0.0278***
	(7.1798)	(4.1159)	(8.0079)	(6.7491)	(6.1566)
hhi	0.0290***	0.0286***	0.0353***	0.0295***	0.0294***
	(5.9380)	(5.1038)	(6.7329)	(6.1624)	(6.8600)
fc	-0.0039	-0.0035	-0.0042	-0.0075	-0.0039
	(-0.5436)	(-0.3578)	(-0.5833)	(-1.1249)	(-0.5608)
exp	-0.0246***	-0.0275***	-0.0270***	-0.0281***	-0.0199***
	(-5.7148)	(-5.7046)	(-5.8466)	(-6.3945)	(-5.1103)
lnL	0.0087***	0.0089***	0.0098***	0.0104***	0.0093***
	(14.6178)	(15.2454)	(13.7293)	(16.5035)	(16.5577)
age	-0.0002*	-0.0004**	-0.0001	-0.0003*	-0.0002
	(-1.8415)	(-2.4957)	(-0.7535)	(-2.0061)	(-1.6491)
state	0.0048	0.0098**	-0.0017	0.0043	-0.0002
	(1.5338)	(2.5870)	(-0.4796)	(1.2346)	(-0.0488)
foreign	-0.0298***	-0.0335***	-0.0282***	-0.0286***	-0.0265***
	(-9.2491)	(-8.2807)	(-8.1657)	(-9.1532)	(-9.7703)
wage	-0.0001**	-0.0001	-0.0002**	-0.0002**	-0.0001*
	(-2.0806)	(-1.4587)	(-2.3600)	(-2.3479)	(-1.8756)
lnpgdp	0.1326***	0.1431***	0.1163***	0.1153***	0.1357***
	(64.3131)	(63.5634)	(51.6111)	(52.8938)	(64.0853)
indr	-0.6816***	-0.7610***	-0.5549***	-0.4370***	-0.7451***
	(-50.1876)	(-41.3480)	(-37.3907)	(-26.3823)	(-47.3786)
industry	controlled	controlled	controlled	controlled	controlled
year	controlled	controlled	controlled	controlled	controlled
N	10993	10993	10993	10993	10993
adj. R^2	0.9982	0.9940	0.9954	0.9984	0.9984

The results of moderating effects of environmental legislation on the resource allocation and the green growth of industry are further shown in Table 4. Result shows that the effect of environmental legislation on the resource allocation and the green growth of industry are positive but insignificant, while the effects of environmental legislation on GML are substantially different between the decomposition of green growth of industry. First, the results confirm that environmental legislation have become more strengthened, meanwhile it needs more efforts in the future. Second, the results of decomposition reveal that there is substantial heterogeneity in the role of local environmental legislation. Especially the effect of environmental legislation on the scale efficiency improvement is more significant than that of the pure technological progress. This finding indicates that the environmental legislation for the core environmental technology and equipment should also be accelerated.

Table 4. The moderating effects of environmental legislation on resource allocation and green growth of industry

Variables	GGI	geffch	gtech	gseffch	gstech
ra	-0.0103***	-0.0137***	-0.0095***	-0.0162***	-0.0111***
	(-12.2736)	(-8.7853)	(-4.1908)	(-12.4210)	(-6.9275)
EL	0.0105***	0.0114***	0.0139***	0.0072***	0.0111***
	(5.7630)	(3.5784)	(6.7815)	(3.5167)	(10.4961)
*EL*ra*	0.0073	0.0249***	-0.0008	0.0164***	0.0232***
	(1.5210)	(4.0191)	(-0.1351)	(3.2282)	(6.7670)
debt	0.0294***	0.0235***	0.0380***	0.0324***	0.0282***
	(7.3274)	(4.2233)	(8.2715)	(6.8575)	(6.4138)
hhi	0.0286***	0.0277***	0.0350***	0.0289***	0.0286***
	(5.9788)	(5.1078)	(6.8246)	(6.1633)	(6.9586)
fc	-0.0036	-0.0031	-0.0038	-0.0072	-0.0034
	(-0.5074)	(-0.3196)	(-0.5455)	(-1.1076)	(-0.5151)
exp	-0.0236***	-0.0262***	-0.0259***	-0.0273***	-0.0187***
	(-5.5280)	(-5.3778)	(-5.6784)	(-6.2795)	(-4.8497)
lnL	0.0085***	0.0086***	0.0096***	0.0102***	0.0090***
	(14.5260)	(14.8914)	(13.6396)	(16.5140)	(16.3817)
age	-0.0002*	-0.0004**	-0.0001	-0.0003**	-0.0002*
	(-1.9158)	(-2.6106)	(-0.7399)	(-2.0911)	(-1.7179)
state	0.0057*	0.0110***	-0.0007	0.0051	0.0010
	(1.8526)	(2.9758)	(-0.1967)	(1.4964)	(0.3286)
foreign	-0.0291***	-0.0326***	-0.0273***	-0.0280***	-0.0256***
	(-9.3917)	(-8.4144)	(-8.3442)	(-9.3305)	(-9.9613)
wage	-0.0001**	-0.0001	-0.0002**	-0.0001**	-0.0001*
	(-2.0748)	(-1.3766)	(-2.3746)	(-2.3665)	(-1.8632)
lnpgdp	0.1325***	0.1432***	0.1161***	0.1153***	0.1357***
	(63.4077)	(61.9982)	(51.6728)	(52.1278)	(63.2878)
indr	-0.6811***	-0.7615***	-0.5537***	-0.4374***	-0.7454***
	(-49.6951)	(-40.4436)	(-37.5624)	(-26.1570)	(-46.5765)
industry	controlled	controlled	controlled	controlled	controlled
year	controlled	controlled	controlled	controlled	controlled
N	10993	10993	10993	10993	10993
adj. R^2	0.9982	0.9940	0.9954	0.9984	0.9984

As China is experiencing the period of economic transformation, the effects of environmental legislation will be largely influenced by the heterogeneity of local governments. Therefore, the heterogeneity characteristics of local chief officials were incorporated into our analytical framework for robustness check. **Table 5** reports the results for the regression results. We try to observe whether the positive effect of environmental legislation on the resource allocation efficiency and the green growth of industry will be changed in various circumstances of different local officials. First, the results confirm that the effects of environmental legislation on the green growth of industry are stronger when the chief officials' tenures are shorter. Second, the results reveal that the effects of environmental legislation on the green growth of industry are stronger when the chief officials are rotated rather than localized. Third, we find that the effects of environmental legislation are stronger when the chief officials are not native born. Finally, the effect of environmental legislation on the green growth of industry is stronger when the chief officials have accepted longer term of higher education.

Table 5. Regression results of considering heterogeneity characteristics of local chief officials

Variables	GGI							
	tenure>2	tenure<=2	rotation==1	rotation==0	birthplace==1	birthplace==0	education>3	education <=3
ra	-0.008***	-0.009***	-0.004**	-0.010***	-0.005	-0.010***	-0.015***	-0.010***
	(-3.620)	(-9.858)	(-4.254	(-5.161)	(-1.567)	(-9.994)	(-4.401)	(-8.824)
EL	0.008***	0.012***	0.0002	0.0001	-0.012***	0.014***	-0.062***	0.024***
	(3.908)	(5.427)	(0.225)	(0.036)	(-3.570)	(6.541)	(-5.293)	(9.012)
*EL*ra*	0.001	0.008**	0.004*	0.010**	-0.016	0.016***	0.009*	-0.004
	(0.202)	(2.611)	(2.539)	(2.064)	(-1.169)	(3.975)	(1.835)	(-1.011)
debt	0.027***	0.016***	0.011***	0.031***	0.007	0.029***	0.016**	0.029***
	(6.125)	(4.712)	(7.167	(6.510)	(1.397)	(6.756)	(2.254)	(7.754)
hhi	0.024***	0.016***	0.006**	0.026***	-0.006*	0.033***	0.005	0.030***
	(4.202)	(5.781)	(3.280)	(5.268)	(-1.751)	(6.677)	(0.912)	(5.898)
fc	-0.011	-0.013**	0.025***	-0.011	-0.005	0.020**	-0.012	-0.007
	(-1.482)	(-2.094)	(5.425)	(-1.515)	(-0.757)	(2.227)	(-1.386)	(-1.039)
exp	-0.020***	-0.017***	-0.004***	-0.021***	-0.011**	-0.027***	-0.006	-0.022***
	(-3.961)	(-5.960)	(-2.966)	(-5.551)	(-2.601)	(-7.041)	(-1.645)	(-4.772)
lnL	0.010***	0.005***	0.002***	0.006***	0.002***	0.009***	0.004***	0.009***
	(13.532)	(9.804)	(10.680)	(8.677)	(3.345)	(16.684)	(4.121)	(13.265)
age	-0.001***	0.000	0.000	-0.000	-0.001***	-0.000	-0.000	-0.000**
	(-3.468)	(0.511)	(0.231)	(-0.401)	(-9.083)	(-0.642)	(-0.260)	(-2.192)
state	-0.001	0.013**	0.007***	0.003	-0.007**	0.006*	0.020***	0.003
	(-0.311)	(4.618)	(4.437)	(1.077)	(-2.439)	(1.917)	(3.628)	(1.123)
foreign	-0.037***	-0.002	-0.004***	-0.030***	-0.027***	-0.026***	-0.014***	-0.023***
	(-10.421)	(-0.797)	(-4.157)	(-8.840)	(-6.294)	(-8.140)	(-2.889)	(-7.567)
wage	-0.000	-0.000**	-0.000	-0.000	0.000	-0.000**	-0.000	-0.000
	(-0.992)	(-2.518	(-1.125)	(-1.552)	(0.900)	(-2.103)	(-0.790)	(-1.608)
lnpgdp	0.145***	0.128***	0.146***	0.135***	0.162***	0.123***	0.150***	0.132***
	(59.050)	(89.664)	(273.675)	(81.984)	(120.753)	(51.780)	(20.328)	(53.213)
indr	-0.905***	-0.529***	-0.950***	-0.639***	-0.930***	-0.603***	-1.006***	-0.644***
	(-48.892)	(-42.576)	(-146.842)	(-65.672)	(-57.466)	(-27.267)	(-6.443)	(-30.819)
industry	controlled	controlled	controlled	controlled	controlled	controlled	controlled	controlled
year	controlled	controlled	controlled	controlled	controlled	controlled	controlled	controlled
N	5720	5273	4174	6819	3136	7857	2350	8643
adj. R^2	0.9981	0.9991	0.9997	0.9982	0.9986	0.9988	0.9981	0.9988

6. Conclusions and Discussion

With the increasing global temperature and unpleasant climate change, how to achieve stable industrial growth while maintaining green growth has been become a major concern for residents and policy makers. Environmental legislation has been thought to be an effective way for environmental protection. However, there are few empirical experiences on it especially in the context of transitional economies. The answer to this question is not only conducive to the formulation of effective environmental legislation, but also be conducive to promoting the win-win situation of environmental improvement and economic growth, which has important theoretical value and practical significance.

Based on the data of China's industrial enterprises from 1998 to 2007 and the events of local environmental legislation, this paper applies the SBM directional distance function to measure the industrial green growth, and tries to identify the impacts of local environmental legislation on the industrial resource allocation efficiency and green growth of industry. The result verified that local environmental legislation helps to improve resource allocation efficiency and promote industrial green growth. First, the environmental legislation helps to optimize the allocation of resources and improve the green productivity of industrial enterprise. Second, the effects of the environmental legislation on the decomposition of green growth of industry are different. The effects of environmental legislation on the scale efficiency improvement are more significant than that of the pure technological progress, which implies that the environmental legislation for the environmental protection technology and equipment should also be accelerated. Third, the environmental legislation helps to optimize the allocation of industrial resources by restraining the entry of low-productivity enterprises and promoting their withdrawal, and ultimately play a positive role in promoting the industrial green productivity. Based on the above conclusions, the following policy recommendations are proposed.

On the one hand, it is necessary to strengthen the local environmental legislation and optimize the allocation of market resources. This paper proves that the environmental legislation is effective in reallocation of resources and environmental problems. However, the environmental protection laws and regulations in China are still imperfect. Therefore, local governments should take its local characteristics into consideration, and formulate the place-based environmental protection policies on the basis of national legislation. In addition, local governments should pay more attention to environmental governance in high-polluted industries, improve environmental standards and supervision in high-polluted industries, and speed up the elimination of backward production capacity to realize the conversion of clean production resources. The entry and exit of enterprises is an important way to achieve resource allocation in environmental legislation. The high energy consumption, high pollution, low efficiency enterprises are not allowed for admittance. In order to ensure the realization of resource allocation effect of environmental legislation, we should actively eliminate market barriers, accelerate the process of market integration, and eliminate the institutional obstacles that restrict the flow of factors.

On the other hand, industrial enterprises should be encouraged to carry out environmental technology innovation and eliminate some backward production capacity. This study confirms that some strict and appropriate environmental regulation is conducive to the promotion of enterprise productivity, but the technical compensation effect of environmental legislation is heterogeneous. Therefore, local government shouldn't adopt "one-size-fits-all" approach to formulate general environmental legislation, but also should formulate differentiated standards according to the characteristics of the industry. In addition, technological innovation also needs to pay the cost of technology transformation and bear the risk of technology transformation, which may reduce the technological innovation motivation of enterprises, especially those with high pollution and low efficiency. Therefore, local government should provide financial, taxation and technical support to them to encourage the use of cleaner production technology. Furthermore, the market-driven environmental regulations are of priority of use compared with the command-controlled environmental regulation.

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