Proceedings of Business and Economic Studies, 2024, Volume 7, Issue 6
http://ojs.bbwpublisher.com/index.php/PBES
Online ISSN: 2209-265X
Print ISSN: 2209-2641

Impact of Environmental Protection Tax on Enterprise Capital-Labor Allocation in the Context of High-Quality Economic Development

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Abstract: Using a double-difference model, this paper examines the impact of the 2018 Environmental Protection Tax Law of the People's Republic of China on the capital-labor ratio of A-share listed enterprises in China. The results indicate that the implementation of the environmental protection tax significantly increases the capital-labor ratio of firms, leading to a preference for capital-intensive production. The mediating role of total factor productivity (TFP) in this process suggests that the environmental protection tax enhances the capital-labor ratio by fostering TFP growth. Heterogeneity analysis reveals that the effect of the environmental protection tax on the capital-labor ratio is more pronounced in economically developed regions, state-owned enterprises, and enterprises with a longer operational history.

Keywords: Environmental protection tax; Capital-labor ratio; Total factor productivity; Double-difference method; Firm heterogeneity

Online publication: December 23, 2024

1. Introduction

The implementation of environmental taxation as a regulatory tool introduces operational cost pressures and income distribution challenges for various economic agents, including enterprises and individuals. However, certain entities are capable of converting the financial burdens of environmental taxes into growth opportunities through the strategic reallocation of capital resources [1].

As the largest emerging economy globally, China has positioned environmental taxation as a cornerstone of its economic strategy, exemplified by the enactment of the Environmental Protection Tax Law in 2018 [2]. This legislation underscores the nation's commitment to addressing environmental challenges through fiscal and regulatory measures.

Environmental protection taxes exert a measurable inhibitory effect on resolving the negative externalities

generated by enterprises. Moreover, they function as a potent fiscal mechanism for facilitating long-term sustainable transformation and enhancing enterprise capabilities. This raises pertinent questions: How has the pressure of environmental regulations influenced firms' capital allocation decisions? What factors drive these changes in capital allocation? Addressing these questions necessitates further empirical investigation.

2. Theoretical hypothesis

2.1. Environmental protection tax and capital-labor ratio

The implementation of an environmental tax has a significant impact on the process of enterprise green transformation. Environmental taxes effectively promote the ecological transition of corporations by increasing legitimacy pressures and cost stickiness within enterprises [3]. In the context of green transformation, environmental taxation plays a pivotal role in fostering green innovation among enterprises. For instance, investments in research and development (R&D) and the number of patent applications by corporations significantly increase. Thus, under the influence of environmental taxes, it is expected that enterprises will enhance their financial commitments to technological innovation, particularly in environmentally friendly technologies. Technological advancements improve manufacturing productivity, reduce reliance on labor, and optimize production processes [4].

Conversely, some studies suggest that environmental protection taxes impose a greater financial burden on firms, leading to a reduction in short-term investment, including capital investment [5]. Specifically, environmental taxes significantly reduce firms' investments in innovation and productivity, particularly among enterprises that are significant contributors to pollution [6]. Additionally, the eco-conservation levy constrains firms' investment in environmental capital due to financing limitations and the substitution effect of innovation investments [7]. Based on these considerations, the following hypotheses are proposed:

(1) H1a: Environmental taxes increase the capital-labor ratios in corporations.

(2) H1b: Environmental taxes limit the growth of the corporate capital-labor ratio.

2.2. Environmental protection taxes, total factor productivity, and capital-labor ratio

Taxes on pollution have been shown to boost productivity in heavily polluting industries. They improve resource utilization within firms and encourage green innovation [8]. The increase in total factor productivity (TFP) reflects enhanced production efficiency, which strengthens the tendency to replace labor with capital. Under strengthened environmental regulations, enterprises may adopt capital-intensive technologies and equipment to reduce pollution emissions, leading to an increase in the capital-labor ratio [9]. When TFP rises, the capital-labor ratio is often characterized by two primary trends: capital deepening and technological progress [10].

However, if technological progress is labor-biased, meaning it enhances the output efficiency of labor, the capital-labor ratio may decrease. For example, in China's industrial sector, technological progress before 2011 primarily improved the technical efficiency and marginal output of capital. After 2011, technological progress shifted from being capital-biased to labor-biased [11]. Based on this analysis, the following hypotheses are proposed:

(1) H2a: Environmental taxes increase the capital-labor ratio through improvements in total factor productivity.

(2) H2b: Environmental taxes reduce the capital-labor ratio through labor-biased total factor productivity.

3. Research design

3.1. Data sources

The study utilizes data from Chinese A-share publicly traded companies available in the CSMAR database, covering the period from 2016 to 2022. To ensure the accuracy of the results, the dataset undergoes a rigorous cleaning process to exclude anomalous data points:

(1) Data from the financial industry are excluded due to the distinct attributes of asset and liability configurations and the regulatory framework governing this sector.

(2) Companies with a listing status of "ST," "*ST," "Suspended," "Terminated," or "De-listed" are excluded.

(3) Samples that evidently do not conform to accounting standards are removed.

(4) Data with substantial omissions of essential variables are eliminated.

Furthermore, continuous variables are adjusted at the 1st and 99th percentiles to mitigate the influence of outliers on the analysis.

3.2. Model construction: mediating effects model

A difference-in-differences (DiD) method is used to construct Model 1 to evaluate the impact of environmental levies and taxes on the capital-labor ratio of firms. The three-step test proposed by Zhonglin Wen [12] is used to extend this approach, integrating Models 1 through 3 to examine the mediating role of total factor productivity (TFP) in this relationship:

$$CL_{it} = \beta_1 Treat * Post_{it} + \rho_1 X_{it} + \theta_i + v_t + \lambda_{ind} + \epsilon_{it} \quad (1)$$

$$TFP_{it} = \beta_2 Treat * Post_{ut} + \rho_2 X_{it} + \theta_i + v_t + \lambda_{ind} + \epsilon_{it} \quad (2)$$

$$CL_{it} = \beta_3 Treat * Post_{it} + \beta_4 TFP_{it} + \rho_3 X_{it} + \theta_i + v_t + \lambda_{ind} + \epsilon_{it} \quad (3)$$

Here, CL_{it} is the dependent variable, representing the capital-labor ratio, is a critical measure of firms' capital intensity [13]; $Treat*Post_{it}$ is an interaction term between time-grouping variables and experimental grouping variables, serving as a key explanatory variable; X_{it} is a set of control variables; TFP_{it} is the total factor productivity, estimated using the Levinsohn-Petrin (LP) method [14], acting as the mediating variable; and $\in_{it}$ is the model's random error term.

The models also control for firm-specific (θ_i), year (v_t), and industry (λ_{ind}) fixed effects. Parameters β_1–β_4 and ρ_1–ρ_3 are estimated through regression analysis. The detailed definitions of these variables are outlined in **Table 1**.

Table 1. Variable definitions

Type	Variable	Label	Variable definition
Explanatory variable	CL	Capital-labor ratio	Net fixed assets/number of employees
Intermediary variable	TFP	Total factor productivity	Estimated using the LP method
Core explanatory variable	Treat	Experimental grouping variables	High-pollution industries are coded as 1, and low-pollution industries as 0
	Post	Time grouping variable	Takes a value of 1 for 2018 and beyond, and 0 for the years before 2018

Table 1 (Continued)

Type	Variable	Label	Variable definition
Control variable	ky	Capital output ratio	The ratio of net fixed assets to operating income
	cash	Cash flow intensity	The ratio of cash flow from operating activities to total assets
	ci	Capital intensity	The ratio of total assets to total operating revenues at the end of the year
	Top10	Shareholding concentration	The shareholding ratio of the top ten shareholders at the end of the year (%)
	roa	Return on assets	The ratio of net profit to total assets

4. Empirical analysis

4.1. Descriptive analysis

The average capital-labor ratio (CL) is 51.676, with a median value of 29.380, indicating significant variation in the ratio of capital input to labor input among firms in the sample. The standard deviation of 73.531 further highlights the considerable variability across firms. The mean value of the interaction term (Treat*Post) for the experimental and time subgroups is 0.154, indicating that approximately 15.4% of the firms in the sample belong to heavy-polluting industries affected by the environmental tax law. See **Table 2** for further details.

Table 2. Descriptive analysis

VarName	Obs	Mean	Median	SD	Min	Max
Treat	26,095	0.205	0.000	0.404	0.000	1.000
Post	26,095	0.762	1.000	0.426	0.000	1.000
Treat*Post	26,095	0.154	0.000	0.361	0.000	1.000
CL	26,095	51.676	29.380	73.531	0.612	533.673
Top10	26,095	48.448	47.834	15.256	15.762	86.612
ky	26,095	0.441	0.293	0.512	0.004	3.520
cash	26,095	0.049	0.048	0.070	-0.186	0.272
ci	26,095	2.543	1.958	2.077	0.371	16.725
roa	26,095	0.035	0.039	0.078	-0.578	0.234

4.2. Benchmark regression

Table 3. Stepwise inclusion of control variables regression

	(1)	(2)	(3)
	CL	CL	CL
Treat*Post	7.003***	10.79***	10.32***
	(4.34)	(7.15)	(6.97)
Top10		0.124	0.113
		(1.52)	(1.40)

Table 3 (Continued)

	(1)	(2)	(3)
	CL	CL	CL
Ky		49.22***	59.72***
		(17.81)	(18.69)
cash		30.66***	20.12***
		(6.99)	(4.94)
ci			-4.074***
			(-7.92)
roa			16.51***
			(4.87)
_cons	51.68***	19.33**	25.20***
	(5.90)	(2.49)	(3.31)
Control	Yes	Yes	Yes
Company/Year/Ind	Yes	Yes	Yes
N	26,095	26,095	26,095
R^2	0.0935	0.279	0.300

Note: *t* statistics in parentheses. *$P < 0.1$, **$P < 0.05$, ***$P < 0.01$.

In **Table 3**, Column (1) displays the results of a regression analysis without including control variables. The coefficient of the interaction term TreatPost is 7.003, which is statistically significant at the 1% level. These findings indicate that environmental tax legislation has a positive impact on the capital-labor ratio. Columns (2) and (3) incorporate control variables into the regression analysis, where the TreatPost coefficients increase to 10.79 and 10.32, respectively. Both coefficients remain statistically significant at the 1% level, reinforcing the conclusion that the environmental tax policy positively influences the capital-labor ratio.

The benchmark regression results provide robust support for **hypothesis H1a**.

4.3. Robustness check

4.3.1. Parallel trend test

The dual-difference methodology assumes adherence to the parallel trend assumption within the dataset. This assumption posits that, in the absence of policy implementation, the trajectories of the treatment and control groups would converge. In this study, the year immediately preceding policy enactment is designated as the reference year, with correlation coefficients assessed annually. The results, presented in **Figure 1**, confirm that the data satisfy the criteria for the parallel trends test.

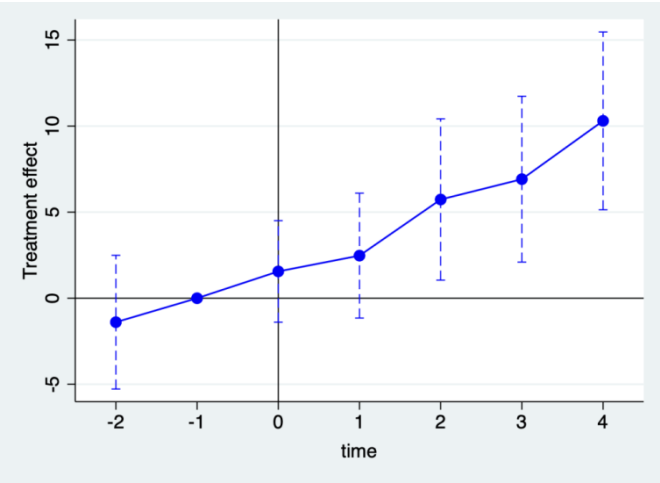

Figure 1. CL parallel trend test

4.3.2. Sham experimentation

To assess robustness, dummy treatment groups were randomly assigned to the sample firms, and 500 simulation tests were conducted. The results (**Figure 2**) indicate that the treatment effect coefficients exhibit a mean value near zero and follow a normal distribution. No dummy effects were identified, and the placebo test was satisfied, confirming the robustness of the underlying regression analysis.

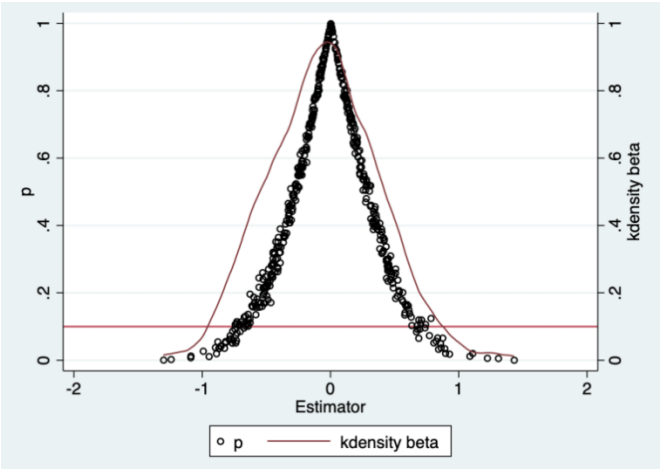

Figure 2. CL sham experimentation

4.3.3. PSM-DID test

The results of propensity score matching (PSM) in **Table 4** demonstrate that the matching process effectively reduces disparities between treatment and control groups, enhancing the reliability of the DID estimation. The selected matching variables are appropriate, reflecting key firm characteristics. The reduction in bias after matching, coupled with a higher matching percentage, confirms the effective application of PSM in this study. The subsequent PSM-DID estimation results, presented in **Table 5**, indicate that the significance of the findings remains consistent and supports the conclusions of the benchmark regression.

Table 4. PSM-scoring results

Var	Unmatched	Mean		%reduct		*t*-test	
	Matched	Treated	Control	%bias	bias	*t*	*P* > |*t*|
Top10	U	48.973	48.31	4.3	67.2	2.83	0.005
	M	48.973	49.19	-1.4		-0.74	0.461
ky	U	0.606	0.399	39.2	89.8	26.78	0.000
	M	0.606	0.627	-4.0		-1.78	0.442
cash	U	0.062	0.046	23.8	66.3	15.34	0.000
	M	0.062	0.068	-8.0		-4.22	0.011
ci	U	2.085	2.661	30.3	89.1	18.22	0.000
	M	2.085	2.148	-3.3		-2.07	0.289
roa	U	0.437	0.033	14.9	80.4	9.19	0.000
	M	0.437	0.046	-2.9		-1.69	0.106

4.3.4. Substitution of the independent variables

To validate the robustness of the benchmark regression results, the labor income share (LS) was employed as a substitute indicator to measure labor distribution. **Table 5** indicates that the original conclusion remains reliable, with no change in the significance of the results.

Table 5. PSM-DID and replacement of explanatory variables regression results

	(PSM)	(Replacement of explanatory variables)
	CL	LS
Treat*Post	5.795***	-0.00211***
	(3.16)	(-4.38)
_cons	45.10	0.0175***
	(1.06)	(3.09)
Control	Yes	Yes
Company/Year/Ind	Yes	Yes
N	26,095	26,095
R^2	0.313	0.235

Note: *t* statistics in parentheses. *$P < 0.1$, **$P < 0.05$, ***$P < 0.01$.

4.4. Mechanical effect

Table 6 presents three models. In column (2), the coefficient for total factor productivity (TFP) is 0.0338 and is statistically significant at the 5% level, indicating that TFP mediates the impact of environmental protection taxes on the capital-labor ratio. In column (3), both interaction terms, Treat*Post and TFP, exhibit positive coefficients that are statistically significant at the 1% level. These findings suggest that environmental levies enhance the capital-labor ratio through TFP, corroborating **hypothesis H2a**.

Table 6. A test of the TFP

	(1)	(2)	(3)
	CL	TFP	CL
Treat*Post	10.32***	0.0338**	9.938***
	(6.97)	(2.47)	(6.78)
TFP			11.28***
			(6.26)
_cons	25.20***	9.232***	78.96***
	(3.31)	(70.80)	(-4.19)
Control	Yes	Yes	Yes
Company/Year/Ind	Yes	Yes	Yes
N	26,095	26,095	26,095
R^2	0.300	0.548	0.311

Note: *t* statistics in parentheses. *$P < 0.1$, **$P < 0.05$, ***$P < 0.01$.

4.5. Heterogeneity analysis

4.5.1. Area heterogeneity

The economically developed provinces along the eastern coast of China hold a pivotal position in the country's regional economic development due to their unique geographic location, abundant natural resource endowments, and advanced economic development [15]. **Table 7** demonstrates that in coastal regions with advanced economic development, the coefficient for Treat*Post is 6.857. In contrast, in other provinces, the coefficient for the interaction term Treat*Post-implementation is 14.00. This indicates that the implementation of the environmental protection tax law positively influences the capital-labor ratio. Moreover, the discrepancy between the two coefficients is statistically significant at the 5% confidence level. These findings reveal that the positive effect of the environmental conservation tax law on the capital-labor ratio is significantly diminished in economically developed coastal provinces compared to other regions.

Table 7. Area heterogeneity grouping regression results

	(Developed)	(Others)	(*P*-value)
	CL1	CL2	CL1–CL2
Treat*Post	6.857***	14.00***	-7.143**
	(4.08)	(5.37)	
_cons	22.11***	42.44**	-20.33
	(2.62)	(2.41)	
Control	Yes	Yes	Yes
Company/Year/Ind	Yes	Yes	Yes
N	17,940	8,155	26,095
R^2	0.360	0.259	

Note: *t* statistics in parentheses. *$P < 0.1$, **$P < 0.05$, ***$P < 0.01$.

4.5.2. Property rights heterogeneity

Enterprises with different property rights structures demonstrate distinct income distribution patterns and capital structures [16]. **Table 8** shows that the coefficient for the interaction term Treat*Post-implementation in non-state-owned enterprises is 6.386, indicating a positive impact of the environmental conservation tax law on the capital-labor ratio. By contrast, in state-owned enterprises, this coefficient is significantly higher at 15.54, emphasizing the stronger influence of the tax law on capital-labor dynamics in these entities. These findings collectively suggest that the environmental tax law has a more pronounced positive impact on the capital-labor ratio in state-owned enterprises compared to non-state-owned ones.

Table 8. Property rights heterogeneity grouping regression results

	(Non-stated)	(Stated)	(*P*-value)
	CL1	CL2	CL1–CL2
Treat*Post	6.386***	15.54***	-9.154**
	(3.91)	(5.45)	
_cons	28.27***	48.58***	-20.31
	(4.06)	(2.68)	
Control	Yes	Yes	Yes
Company/Year/Ind	Yes	Yes	Yes
N	18,612	7,483	26,095
R^2	0.346	0.285	

Note: *t* statistics in parentheses. *$P < 0.1$, **$P < 0.05$, ***$P < 0.01$.

4.5.3. Age heterogeneity

Enterprises of varying ages are likely to adopt different adaptive measures and experience varying outcomes in response to environmental conservation taxes [17]. Enterprises were categorized as "high-age" if established for eight years or more, and "low-age" if established for less than eight years. **Table 9** highlights that the ecological tax law positively affects the capital-labor ratio in both high-age and low-age firms. The difference between the coefficients is statistically significant at the 1% level. These results suggest that the environmental tax law's positive effect on the capital-labor ratio is more pronounced in high-age enterprises.

Table 9. Age heterogeneity grouping regression results

	Higher (≥ 8)	Lower (< 8)	(*P*-value)
	CL1	CL2	CL1–CL2
Treat*Post	14.14***	5.439***	8.701***
	(6.03)	(3.77)	
_cons	32.09***	14.73*	17.36
	(2.64)	(1.69)	
Control	Yes	Yes	Yes
Company/Year/Ind	Yes	Yes	Yes
N	13,832	12,263	26,095
R^2	0.278	0.358	

Note: *t* statistics in parentheses. *$P < 0.1$, **$P < 0.05$, ***$P < 0.01$.

5. Conclusions

Empirical evidence increasingly demonstrates that environmental protection taxes can indirectly enhance the capital-labor ratio within enterprises, particularly in contexts with significant environmental impacts. By improving total factor productivity, these taxes lead to notable gains in efficiency, particularly in capital allocation and green innovation. The effect of environmental conservation taxes on the capital-labor ratio varies significantly by region, property rights structure, and enterprise age. The positive impact is most pronounced in developed coastal regions, state-owned entities, and long-established firms, reflecting the diverse strategies and outcomes of enterprises in adapting to environmental tax policies.

To enhance the effectiveness of environmental conservation taxes in optimizing the capital-labor factor balance, the following measures are recommended:

(1) Governments should consider enterprise heterogeneity when formulating environmental protection policies, and implementing differentiated strategies to promote green transformation and productivity enhancement.

(2) Enterprises should focus on technological innovation, improving capital allocation efficiency, reducing labor dependency, and enhancing the capital-labor ratio to achieve green transformation.

(3) Collaboration between governments and enterprises should be strengthened, including financial subsidies and tax incentives to reduce corporate burdens. This cooperation can establish a mutually beneficial framework that aligns environmental protection goals with economic development objectives.

Funding

National Innovation and Entrepreneurship Training Program for College Students (Project No. S202410497204)

Author contributions

Conceptualization: Zujie Chen, Mengjia Wang
Formal analysis: Zujie Chen, Chaoqiang Zhang
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Writing – review & editing: all authors

Disclosure statement

The authors confirm that no conflicts of interest exist.

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