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The Impact of Accountability for Energy Efficiency Targets on Labor Demand of Enterprises: Evidence from China's Top-1000 Energy-Saving Program

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Abstract: To control energy consumption, China issued the environmental regulation policy of the Top-1000 Energy-Saving Program in 2006, and it remains to be examined whether this policy will impact enterprises' labor demand while promoting energy conservation and consumption reduction. Based on the panel data of Chinese enterprises (2000–2010), this study employs the difference-in-differences (DID) method to investigate the impact of the Top-1000 Energy-Saving Program on the labor demand of enterprises. It is found that the policy significantly reduces enterprises' labor demand, a finding that passes several robustness tests. Second, the effects of the policy show heterogeneity across enterprises of various sizes, ownership structures, and regions. Finally, the mechanism analysis verifies the existence of an output effect leading to a decline in enterprises' labor demand, while the substitution effect manifests itself in the substitution of enterprises' labor demand with the increase of capital and technological innovation. This study provides important empirical evidence for the improvement of energy efficiency policies.

Keywords: the Top-1000 Energy-Saving Program; labor demand; energy saving and emission reduction; difference-in-differences (DID) method

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1. Introduction

The increase in energy consumption and greenhouse gas emissions has intensified global warming [1], which presents a significant risk to human health, survival, and development. The issue of climate change has become one of the most pressing tasks for the international community and one that requires urgent attention. In response to the threat of climate change a number of international policies have been introduced, including the Kyoto Protocol and the Paris Agreement. Furthermore, countries have incorporated carbon reduction targets into their long-term development plans. As the world's largest developing country, addressing climate change represents a significant responsibility for China, both in terms of global leadership and the realization of its own high-quality development and green transformation. China's economic development has benefited from the rapid growth of energy-intensive industries. However, this has also resulted in significant energy consumption and carbon emissions. According to this fact, it is crucial to regulate China's energy consumption in order to reduce greenhouse gas emissions and achieve the "dual carbon" goal. To this end, the government has implemented various environmental regulatory policies with the aim of achieving a mutually beneficial situation for economic development and environmental protection.

Environmental regulation, with the aim of protecting the environment and eliminating the negative externalities of pollution on society, regulates various behaviors that pollute the

public environment [2], which is essentially a trade-off between environmental protection and cost pressures on enterprises [3]. Research on the economic effects of environmental regulation has been a hot academic topic, but existing studies have not reached a unanimous conclusion. According to the neoclassical school, environmental regulation and enterprise performance are mutually constraining. In the face of environmental regulation, enterprises are forced to invest more in pollution control to meet compliance targets, which crowds out beneficial behaviors such as innovative activities and productive investment, weakens enterprises' competitiveness, and hinders their development [4–7]. Different insights are held by scholars such as Porter, who propose that environmental regulation can generate innovation compensation effects [8,9] and effectively promote economic development, such as promoting industrial structure upgrading [10], promoting the green transformation of the economy [11,12], improving enterprise performance [13–20], and so on. In particular, the impact of environmental regulation on employment, which plays an important role in economic development, is also controversial. Some scholars believe that while environmental regulation may squeeze out employment in some industries, it may promote the rise of another part of the industry (e.g., the cleaning industry), thus generating a job creation effect [21–24]. Some scholars take the opposite view, pointing out that, on the one hand, environmental regulation will increase enterprises' production costs and reduce enterprises' production and employment, leading to the unemployment of some workers; on the other hand, environmental regulation will force enterprises to undertake technological innovation, crowding out their investment in production and leading to a decrease in enterprises' labor demand [25–30]. Some studies also point out that the relationship is not clear, such as the existence of a threshold effect [31] or a non-linear relationship [32]. It can be seen that there is heterogeneity in the relationship between environmental regulation and employment by taking different industries as the research object and selecting different sample periods. At this stage, confined to the needs of China's economic development, traditional fossil energy is difficult to be completely replaced in a short period. Therefore, environmental regulatory instruments may still have a place in China's efforts to save energy and reduce emissions. However, the implementation of environmental regulatory policies may also affect economic development, especially in the area of employment, which is a major concern for the livelihood of the nation. As China's economic growth slows down, a large number of rural people move to cities and towns, and the market contraction caused by COVID-19 has not fully recovered, the employment situation in China in recent years has not been optimistic. As a developing country with a huge labor force of about 900 million people, solving the employment problem is always a difficult task for China's economic and social development. Therefore, a comprehensive assessment of the employment effects of environmental regulation is of profound practical significance.

In terms of energy conservation policies, many scholars have conducted research on the effectiveness of energy conservation, emission reduction, and economic performance improvement of enterprises. Regarding developing countries, Chen et al. took the New Energy Demonstration City (NEDC) policy as a basis to study the impact of this policy on the green innovation efficiency of Chinese cities, and the results showed that the policy could significantly improve the green innovation efficiency of pilot cities, and its positive impact continued to increase over time [33]. Zhou et al. focused on China's Low Carbon City Pilot (LCCP) policy and found that the policy significantly reduced coal consumption and coal intensity of enterprises and that energy-intensive enterprises and state-owned enterprises were more affected by the policy [34]. Regarding developed countries, Lott et al. found that the UK's energy system decarbonization policy had a significant impact on improving outdoor air pollution levels [35]. Other studies have found that energy efficiency policies have been well applied in industries such as construction and tourism in Greece [36,37].

The Top-1000 Energy-Saving Program, which is the focus of this study, was an important energy-based environmental policy during the "Eleventh Five-Year Plan" period, which led to the trend of energy conservation in the industrial sector. In 2006, the Development and Reform Commission and other five departments jointly issued the "Implementation

Plan for China's Top-1000 Energy-Saving Program", which aims to alleviate the energy and environmental constraints faced by enterprises in the process of economic and social development through the supervision of key enterprises. The policy takes the total energy consumption of more than 180,000 tons of standard coal in 2004 as the criterion and specifies the target of the regulation as 1008 enterprises in nine key energy-consuming industries, namely, iron and steel, non-ferrous metals, coal, electric power, petroleum and petrochemical, chemical, building materials, textile, and paper. The policy promotes the energy-saving management of key energy-consuming enterprises by setting precise energy-saving targets for each enterprise, which is a typical environmental regulatory tool that puts accountability for energy efficiency targets. Academics have analyzed it from different perspectives. In terms of environmental effects, the policy can lead to significant suppression of polluting gas emissions (e.g., CO_2, SO_2) from regulated enterprises and cause a significant positive carbon leakage effect within the industry [38–40]. In addition, several studies have demonstrated that the Top-1000 Energy-Saving Program has played a significant role in reducing energy consumption [41,42]. In terms of economic effects, some scholars have studied the different directions of the economic performance of enterprises. Shen et al. studied the impact of the policy on the exports of industrial enterprises in China and found that it significantly increased the nominal exports of enterprises in the eastern and central regions [43]. Filippini M et al. examined the impact of the policy on the productivity of China's steel industry. The results showed that the Top-1000 Energy-Saving Program significantly increased the total factor productivity of the Chinese steel industry [44]. In addition, Zhang et al. focused on the impact of the policy on the innovation capacity of enterprises and found that the policy significantly promoted the innovation capacity of regulated enterprises [45]. In general, the energy-consuming industries that are the focus of the Top-1000 Energy-Saving Program are tasked with the dual mission of economic development and employment promotion, and the policy will inevitably have an employment impact on the energy-consuming industries that absorb a large amount of labor. However, by summarizing the existing literature, it is easy to see that there is a lack of research based on a labor market perspective, and there is a need to examine the employment effects of the policy in detail. This study investigates whether the policy affects enterprises' labor demand and the mechanisms involved, with the aim of enriching the quantitative research on the impact of accountability for energy efficiency targets on labor demand and proposing relevant policy recommendations.

The contributions of this study are threefold. First, the impact of environmental regulation is constrained by specific contextual factors and thus needs to be analyzed within the framework of different contextual elements and economic structures of different countries. As the world's largest labor force, China's labor market has recently faced many challenges typical of developing countries, including a declining working-age population due to aging demographics, excess labor supply, and structural shifts in labor demand resulting from industrial restructuring. As a result, China serves as a representative case for research purposes. Based on the current situation of China's labor market, this study examines the employment effect of accountability for energy efficiency targets by studying the impact of the Top-1000 Energy-Saving Program on enterprises' labor demand and theoretically extends the relevant literature on the relationship between environmental regulation and employment. Second, few domestic studies have examined the impact of accountability for energy efficiency targets on labor demand, and this study provides micro-level evidence to assess the effectiveness of implementing accountability for energy efficiency targets in China. Third, this study provides an in-depth discussion of the impact of accountability for energy efficiency targets on labor demand from the perspectives of both output effects and substitution effects, which provides an empirical basis and policy reference for improving the related system of energy conservation and emission reduction category in China.

This manuscript is structured as follows. Following this introduction, Section 2 presents the theoretical analysis of the impact of the Top-1000 Energy-Saving Program on enterprises' labor demand. Section 3 gives the research data and methodology. Section 4

gives the empirical analysis and a series of robustness and heterogeneity tests. Section 5 provides the mechanism analysis. Section 6 gives the conclusion of the manuscript.

2. Theoretical Analysis

Environmental regulation includes market-based type and command-and-control type, and different types of environmental regulation have different effects on employment. Among them, market-based environmental regulation is an effective way to encourage enterprises to take the initiative to reduce emissions. Many scholars have studied this and found that while enterprises respond to political regulation by expanding scale, front-end governance, and technological innovation, they also increase their demand for labor [24,46]. Command-and-control environmental regulation can be divided into two types: one is environmental regulation with mandatory emission reduction restrictions, which generally has a negative impact on employment. For example, Liu et al. found that the Two Control Zone Policy, which strictly controlled SO_2 emissions in China, reduced the demand for labor in the manufacturing sector by 3% [29]. The other type of environmental regulation is weakly incentivized and weakly regulated, such as the Low Carbon City Pilot (LCCP) policy [47], which tends to have greater implementation autonomy and, therefore, may not have a negative impact on employment. For example, Wang and Ge found that the LCCP policy significantly increased employment levels in enterprises [48]. In summary, command-and-control environmental regulations with mandatory emission reduction restrictions are more likely to have a negative impact on labor demand. The Top-1000 Energy-Saving Program, which is the focus of this study, is an environmental policy formulated by the government to serve the energy conservation and emission reduction goals in the social development plan. The policy sets precise energy-saving targets for each enterprise and puts accountability for energy efficiency targets, with the aim of pushing major energy-consuming enterprises to strengthen their energy-saving management. It is a highly binding, command-and-control type of environmental regulation that is likely to have a negative impact on enterprises' labor demand.

How the policy affects enterprises' labor demand depends on the path and means that enterprises choose to comply with the requirements. In general, environmental regulations may affect labor demand through two paths: the output effect and the substitution effect [49]. In this study, we illustrate the mechanism of the impact of the Top-1000 Energy-Saving Program on enterprises' labor demand through Figure 1.

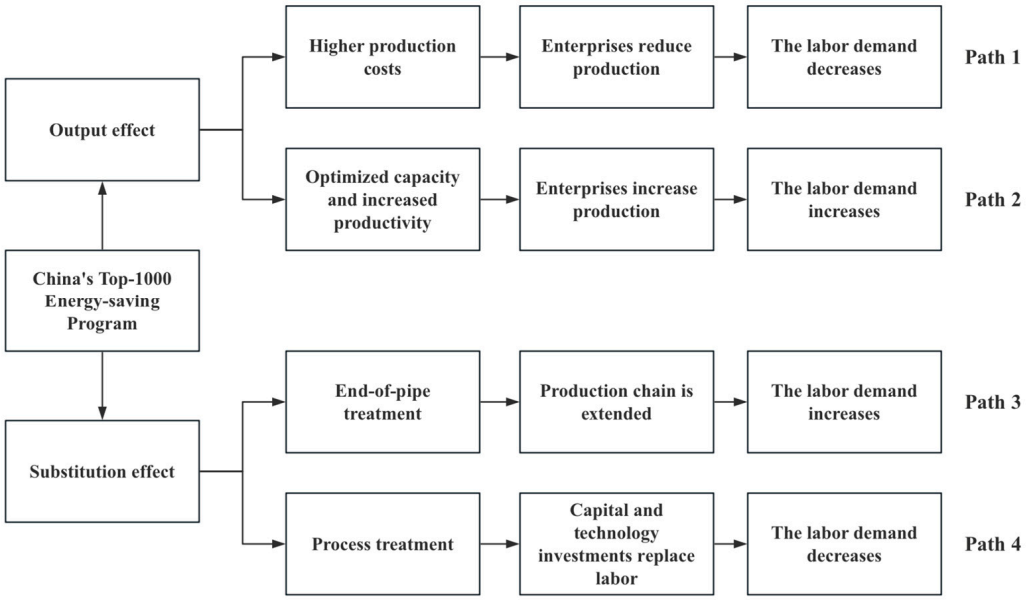

Figure 1. Theoretical analysis.

(i) Output effect

The output effect refers to the fact that the Top-1000 Energy-Saving Program affects the output of enterprises, which in turn affects the labor demand of enterprises. On the one hand, the theory of compliance costs suggests that when there are external environmental regulations, enterprises have to invest in environmental means to reduce pollution. This part of the investment cost of environmental regulation is considered to be the "compliance cost" that enterprises incur in order to comply with environmental regulations. Compliance costs cause enterprises to deviate from optimal production decisions, and enterprises may reduce production due to production cost pressures [29]. In other words, the implementation of the Top-1000 Energy-Saving Program may prompt enterprises to invest in meeting compliance requirements, thereby increasing their production costs. In order to maximize profits, enterprises choose to reduce production and, thus, labor demand (Path 1).

On the other hand, the theory of innovation compensation suggests that environmental regulation will have an innovation compensation effect on enterprises, i.e., environmental regulation will force enterprises to achieve internal transformation and upgrading through technological innovation by generating external innovation pressure and increasing compliance costs [9]. At this point, if the benefits generated by enterprises through technological innovation can compensate for the compliance costs of enterprises to implement emission reduction, the output effect will turn to have a positive impact on the labor demand of enterprises, and enterprises will expand the scale of production, increase the demand for labor, and ultimately enhance the level of employment [50] (Path 2).

(ii) Substitution effect

The substitution effect refers to the fact that the Top-1000 Energy-Saving Program affects the labor demand of enterprises by influencing their investment in environmental governance. Faced with strong external pressure and incentives, enterprises may adjust their internal factor input structure to realize long-term profits and increase their investment in capital and technology to achieve energy-saving targets by reducing energy consumption per unit of output value. The impact of the substitution effect on the enterprises' labor demand will also generate uncertainty due to the different choices made by enterprises. There are two main ways for enterprises to implement environmental government [51]. The first is end-of-pipe treatment, which occurs after production and before emissions, where enterprises reduce pollution emissions by treating the waste generated during the production process. The second is process treatment, which occurs during the production process and generally involves upgrading production equipment to improve productivity and thus reduce pollution emissions.

If an enterprise chooses end-of-pipe treatment to meet compliance targets, such as adding filters, scrubbers, and other purification equipment at the end of the production process to clean and filter pollutants before they are discharged, it will extend the enterprise's production chain, and the enterprise will need to hire more workers to install, repair, and maintain the equipment, which will increase enterprises' labor demand [29,52] (Path 3). If the enterprise chooses process treatment, such as purchasing more environmentally friendly production equipment or investing in cleaner technologies, it will increase the enterprise's production efficiency, and the production management chain can be optimized or shortened, and this process may have an employment-destroying effect, i.e., because of the application of more highly efficient equipment, there is a phenomenon of "machines replacing people", leading to a decline in labor demand [53] (Path 4).

Further quantitative analysis of the impact of the Top-1000 Energy-Saving Program on the labor demand of enterprises and its mechanisms will be presented in the following Sections 4 and 5.

3. Data and Methodology

3.1. Data

Based on micro-panel data from the 2000–2010 China Industrial Enterprises Database (ASIF), this study evaluates the impact of the Top-1000 Energy-Saving Program on labor demand using an empirical analysis method. To avoid the impact of the Top-10000 Energy-Saving Program introduced in 2011 on the original results, this study defines the sample interval as 2000–2010 and further matches the ASIF with the enterprise patent data.

The treatment group selected in this study is the 1008 enterprises in the list published in 2006. The structure of the control group is related to the Top-10000 Energy-Saving Program. In view of the successful implementation of the Top-1000 Energy-Saving Program, China released the implementation plan for the Top-10000 Energy-Saving Program at the end of 2011. Following this program, this study focuses on industrial enterprises that consumed no less than 10,000 tons of standard coal in 2010, a total of about 14,000 enterprises. Since the Top-1000 Energy-Saving Program is similar to the Top-10000 Energy-Saving Program to a certain extent, and the enterprises in the list of the Top-10000 Energy-Saving Program but not in the list of the Top-1000 Energy-Saving Program are not subject to energy-saving restrictions during the "Twelfth Five-Year Plan" period, this paper believes that a reasonable control group can be constructed according to the Top-10000 Energy-Saving Program. Specifically, this study matches the list of the Top-1000 Energy-Saving Program with the list of the Top-10000 Energy-Saving Program according to the legal entity code and enterprise name, removes the overlapping parts, and then matches the two lists with the ASIF database, respectively, and the matched parts constitute the treatment group and the control group.

Considering that there are problems such as missing indicators and anomalies in ASIF, this paper refers to the relevant studies [54–57] and treats some anomalies existing in the database as follows: (1) deleting the number of practitioners, the number of years of practice values that have erroneous statistics samples, such as less than 0 and other cases; (2) deleting samples with total assets less than current assets and total assets less than fixed assets; and (3) deleting samples with negative values of either foreign capital, paid-in capital, or state-owned capital. A total of 55,406 control group samples and 4874 treatment group samples were obtained after matching the relevant data.

3.2. Methodology

Based on the following difference-in-differences (DID) model, this study compares the differential impacts on the control group and the treatment group and examines the average effect of the policy on enterprises' labor demand.

$$y_{it} = \beta_0 + \beta_1 treated_i \times time_t + \lambda X + \mu_i + \gamma_t + \varepsilon_{it} \quad (1)$$

y_{it} is the explanatory variable in this study, referring to Li et al. [58] and Song et al. [59], which measures labor demand in the form of the logarithm of the number of employees in enterprise i in year t. The core explanatory variable is the interaction terms $treated_i \times time_t$ for the policy grouping of the Top-1000 Energy-Saving Program and year. $treated_i$ and $time_t$ are policy grouping and time dummy variables, respectively. If the enterprise belongs to the treatment group, $treated_i = 1$, otherwise 0. If time is not less than 2006, $time_t = 1$, otherwise 0. X denotes a set of control variables, and concerning the existing literature [60,61], this paper controls for enterprise size (Scale), enterprise age (Age), enterprise ownership structure (Eo), cost per capita (Cost1), capital intensity (Ci), labor productivity (Lv), gross profit margin (Mp), return on assets (Roa), residual equity (Ri), equity ratio (Cqr), and debt level (Fz). Detailed definitions of the variables are given in Table 1. μ_i is an individual fixed effect, γ_t is a year fixed effect, and ε_{it} is a random disturbance term.

Table 1. Variable definition table.

Variable	Symbol	Description
Labor demand of the enterprise	Ln (cyrs)	Logarithm of the number of employees
Group	Treated	Grouping dummy variable
Year	Time	Year dummy variable
Enterprise size	Scale	Logarithm of total assets
Enterprise age	Age	Current year minus year of enterprise registration
Enterprise ownership structure	Eo	Dummy variable (If the enterprise is a state-owned enterprise, Eo = 1, otherwise 0)
Cost per capita	Cost1	Per capita overhead
Capital intensity	Ci	Logarithm of fixed assets
Labor productivity	Lv	Gross industrial output value per capita
Gross profit margin	Mp	1-main business cost/Industrial sales value; %
Return on assets	Roa	Net profit/total assets; %
Residual equity	Ri	Total shareholder's equity/gross industrial sales; %
Equity ratio	Cqr	Total liabilities/total shareholder's equity; %
Debt level	Fz	Logarithm of total liabilities

4. Results

4.1. Average Effect of the Policy on Enterprises' Labor Demand

Based on the previously designed model for testing, Table 2 presents the average effect of the policy on enterprises' labor demand. The inclusion of control variables and the application of robust standard errors are indicated in Table 2. The coefficients for the core explanatory variable Treated × time in Columns 1–4 are all significantly negative at the 1% statistical level, with a consistent sign across these columns. This indicates that the Top-1000 Energy-Saving Program has a substantial suppression effect on enterprises' labor demand.

Table 2. Estimation results of the DID model.

	(1)	(2)	(3)	(4)
	Ln (cyrs)	**Ln (cyrs)**	**Ln (cyrs)**	**Ln (cyrs)**
Treated × time	−0.174 ***	−0.174 ***	−0.094 ***	−0.094 ***
	(−13.749)	(−8.726)	(−8.696)	(−6.258)
Constant	6.140 ***	6.140 ***	1.718 ***	1.718 ***
	(525.501)	(371.808)	(26.036)	(12.058)
Control variable	No	No	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Individual fixed effect	Yes	Yes	Yes	Yes
Robust standard error	No	Yes	No	Yes
Observations	60,280	60,280	35,347	35,347
R^2	0.061	0.061	0.283	0.283

The T value is in parentheses; *** $p < 0.01$.

Specifically, according to the most robust result presented in Column 4, the coefficient for the interaction term is −0.094, suggesting that labor demand within the treatment group declines by approximately 9.4% compared to that in the control group; the suppression effect of labor demand is significant.

4.2. Parallel Trend and Dynamic Effect

To further assess whether the treatment group and the control group satisfy the parallel trend assumption—specifically, whether both groups exhibit consistent time trends before policy implementation—this paper constructs a model based on Dustmann et al. [62] while examining the dynamic effects of the Top-1000 Energy-Saving Program.

$$y_{it} = \beta_0 + \sum_{t=2001}^{2010} \beta_t treated_i \times time_t + \lambda X + a_i ttime_t + \mu_i + \varepsilon_{it} \quad (2)$$

$time_t$ represents that year t takes a value of 1, otherwise 0, with 2000 as the base year. $ttime_t$ represents the time trend term. The remaining variables are defined as before. All other variables are defined as previously stated. Additionally, this study controls for province-specific linear time trends. Figure 2 presents the parallel trend test and dynamic effect analysis results.

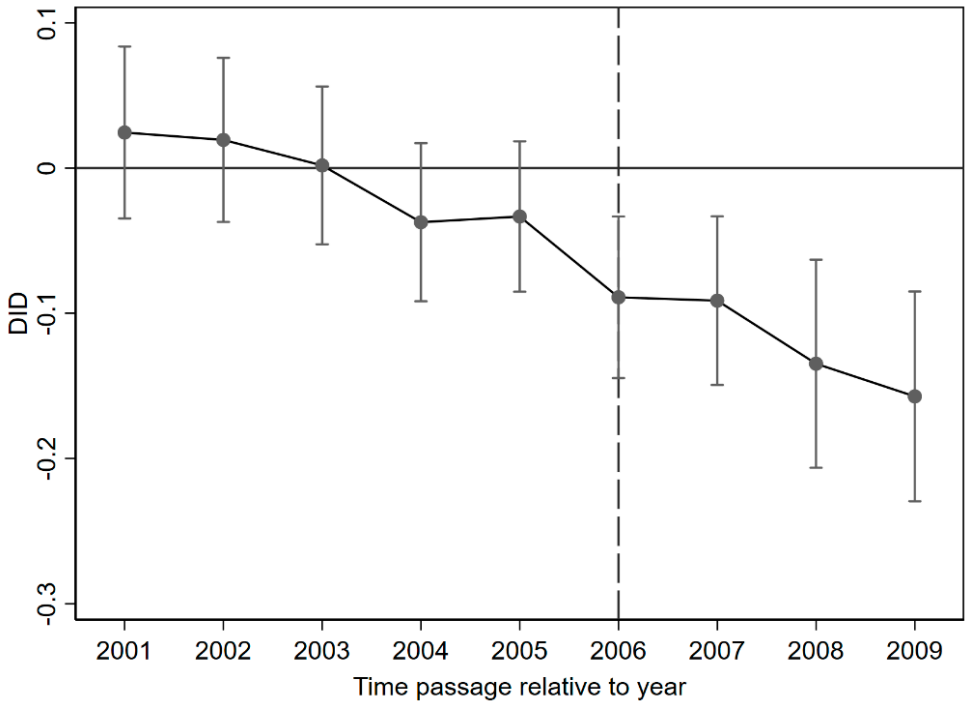

Figure 2. Parallel trend test chart.

According to Figure 2, the regression results are not significant for each year before 2006, indicating that before the implementation of the Top-1000 Energy-Saving Program, there was a consistent change in trends between the treatment group and the control group without notable discrepancies. This result aligns with the conditions necessary for DID estimation.

Furthermore, beyond analyzing the average effect as discussed above, this paper delves into the dynamic effect. If enterprises in the treatment group achieve their energy-saving goals through technological inputs, one might expect a lag in labor demand changes due to inherent delays associated with technological innovation; thus, immediate significant shifts in labor demand are unlikely. Conversely, if enterprises achieve their energy-saving goals through end-of-pipe treatments, such as adding cleaner equipment within a short time, it is more probable that labor demand will experience a substantial decline. From Figure 2, we observe that labor demand among enterprises in the treatment group exhibited a marked year-on-year decrease from 2006 to 2009 when compared to those in the control group (notably excluding data from 2010 due to several missing variables). This suggests that enterprises may have responded to the energy-saving goals by enhancing their focus on technological advancements. Over time, the benefits of the initial investment in technology become increasingly evident, ultimately leading to a substitution effect regarding labor.

Table 3 presents the specific coefficients. As indicated by the results in Column 1, the coefficients for the interaction terms from 2001 to 2005 are all insignificant in the parallel trend test. Column 2 shows the dynamic effect of the policy. The coefficient for the policy period is −0.089, which is statistically significant at the 1% level, indicating that this initiative resulted in an average reduction of approximately 9% in labor demand within the treatment group compared to the control group, peaking at −0.157 in 2009 during the estimable sample period.

Table 3. Parallel trend and dynamic effect test.

	(1) Parallel Trend		(2) Dynamic Effect Test
	Ln (cyrs)		Ln (cyrs)
Treated × time 2001	0.024	Treated × time 2006	−0.089 ***
	(0.810)		(−3.135)
Treated × time 2002	0.019	Treated × time 2007	−0.091 ***
	(0.673)		(−3.082)
Treated × time 2003	0.002	Treated × time 2008	−0.135 ***
	(0.065)		(−3.687)
Treated × time 2004	−0.037	Treated × time 2009	−0.157 ***
	(−1.344)		(−4.266)
Treated × time 2005	−0.033		
	(−1.264)		
Constant		34.745 ***	
		(8.322)	
Control variable		Yes	
Time trend term		Yes	
Province × time trend item		Yes	
Individual fixed effect		Yes	
Robust standard error		Yes	
Observations		35,347	
R^2		0.293	

The T value is in parentheses; *** $p < 0.01$.

4.3. Robustness Tests

4.3.1. Sample Adjustment

Considering that the benchmark results are derived based on unbalanced panel data, in the sample adjustment, the sample adjustment process first excludes enterprises that did not appear consecutively between 2000 and 2010. This step ensures the creation of balanced data containing a consistent set of enterprises across each year, thereby mitigating potential issues arising from the absence of certain enterprises in individual years. The results in Column 1 of Table 4 show that the coefficient for the interaction term Treated × time is significantly negative, indicating that the labor demand of enterprises in the treatment group declines significantly relative to the control group, which is consistent with the benchmark results. Furthermore, as discussed by relevant scholars regarding ASIF applications [63], it is noted that ASIF data before 2008 is considered the most authoritative, with numerous studies within academia relying on this dataset. Additionally, given that the financial crisis of 2008 may have influenced enterprises' labor demand, this study utilizes samples from 2000 to 2007 for testing purposes. The outcomes are illustrated in Column 2 of Table 4 and reveal consistently significant negative results regardless of whether robust standard errors are estimated.

4.3.2. Lagged Effect of Control Variables

Given that this paper incorporates a considerable number of financial indicators as control variables—alongside concerns about potential collinearity—it is essential to assess policy effects by lagging these control variables by one period during regression analysis. The results shown in Column 3 of Table 4 demonstrate that when lagging control variables by one period, the coefficient for Treated × time is −0.088, which is significantly negative at a significance level of 1%, i.e., there is a suppressive policy effect, which is statistically significant and passes the robustness test.

Table 4. Robustness test 1.

	(1)	(2)	(3)	(4)	(5)
	2000–2010 Balance Panel	2000–2007 Samples	A Control Variable with a Lag of One Phase	Control Province Characteristics	
Variables	**Ln (cyrs)**	**Ln (cyrs)**	**Ln (cyrs)**	**Ln (cyrs)**	**Ln (cyrs)**
Treated × time	−0.122 ***	−0.080 ***	−0.088 ***	−0.094 ***	−0.086 ***
	(−3.121)	(−5.832)	(−5.266)	(−6.258)	(−5.548)
Constant	0.952 **	1.622 ***	2.161 ***	1.718 ***	1.481 ***
	(2.354)	(9.944)	(12.470)	(12.058)	(10.207)
Control variable	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Individual fixed effect	Yes	Yes	Yes	Yes	Yes
Robust standard error	Yes	Yes	Yes	Yes	Yes
Province fixed effect	No	No	No	Yes	Yes
Province-year fixed effect	No	No	No	No	Yes
Observations	4911	25,690	26,848	35,347	35,347
R^2	0.381	0.290	0.251	0.283	0.304

The T value in parentheses; *** $p < 0.01$, ** $p < 0.05$.

4.3.3. Control of Provincial Characteristics

Given the inherent variability in development levels, factor endowments, and other characteristics across China's provinces, this study incorporates province-fixed effects to mitigate potential biases arising from provincial differences. It introduces a province-fixed effect to control for the province characteristic factor and a province-year fixed effect to control for the province characteristic factor that varies over time. Columns 4 and 5 of Table 4 present the estimation results controlling for province characteristics. The coefficients in both columns are significantly negative, demonstrating that, controlling for province characteristics, the Top-1000 Energy-Saving Program continues to dampen the labor demand of enterprises in the treatment group, consistent with the benchmark results.

4.3.4. PSM-DID

This paper employs the PSM-DID method to minimize the impact of endogeneity issues that may arise when segmenting enterprises. This is performed by using 1:3 nearest-neighbor matching to match control groups for treatment groups and subsequently using DID to identify the net effect of the policy on enterprises' labor demand based on the true treatment group and the dummy control group. In this study, the propensity score is calculated using both Logit and Probit methods. The covariates selected for analysis include enterprise size (scale), enterprise age (age), ownership structure (Eo), capital intensity (Ci), labor productivity (Lv), return on assets (Roa), and residual equity (Ri). This paper calculates the changes in the outcome variables of the treatment group and the constructed dummy control group before and after the implementation of the policy. By subtracting the change value of the dummy control group from that of the treatment group, we derive the average treatment effect attributable to the policy.

The comparative results of samples before and after matching are presented in Tables 5 and 6, respectively. Table 5 reports the results of the sample comparison of adopting the Logit model to calculate the propensity score. The standardized deviation (%bias) of all variables after matching is less than 5%, and according to the last column, it can be found that the t-test results of the matching are accepted with the original hypothesis, i.e., there is no unsystematic difference between the treatment group and the control group, and the parallel trend assumption is satisfied. Table 6 reports the results of the sample comparison of adopting the Probit model to calculate the propensity score. As can be seen, the results in the %bias columns are all less than 5%, and the t-test results of the matching all accept the original hypothesis according to the last column, indicating that the treatment

group is not systematically different from the control group and that the parallel trend hypothesis is satisfied.

Table 5. Sample comparison before and after nearest neighbor matching (Logit).

Variable	Unmatched / Matched	Mean		%bias	*t*-Test	
		Treated	Control		*t*	$p > \|t\|$
Scale	U	14.375	12.222	137.2	72.28	0
	M	14.375	14.389	−0.9	−0.39	0.693
Age	U	22.574	13.556	34.8	17.03	0
	M	22.574	23.82	−4.8	−0.81	0.418
Eo	U	0.29415	0.09633	51.5	35.34	0
	M	0.29415	0.28607	2.1	0.75	0.456
Ci	U	13.667	11.371	135.6	72.34	0
	M	13.667	13.664	0.2	0.08	0.936
Lv	U	1358.2	959.27	5.3	2.66	0.008
	M	1358.2	1482.4	−1.7	−1.09	0.277
Roa	U	0.0413	0.06324	−16.1	−8.36	0
	M	0.0413	0.3925	1.5	0.81	0.417
Ri	U	0.72867	0.57909	6.5	2.99	0.003
	M	0.72867	0.74677	−0.8	−0.55	0.581

U refers to the samples before PSM, and M refers to the matched samples after PSM.

Table 6. Sample comparison before and after nearest neighbor matching (Probit).

Variable	Unmatched / Matched	Mean		%bias	*t*-Test	
		Treated	Control		*t*	$p > \|t\|$
Scale	U	14.375	12.222	137.2	72.28	0
	M	14.375	14.394	−1.2	−0.56	0.577
Age	U	22.574	13.556	34.8	17.03	0
	M	22.574	23.289	−2.8	−0.54	0.588
Eo	U	0.29415	0.09633	51.5	35.34	0
	M	0.29415	0.28873	1.4	0.5	0.618
Ci	U	13.667	11.371	135.6	72.34	0
	M	13.667	13.658	0.5	0.25	0.804
Lv	U	1358.2	959.27	5.3	2.66	0.008
	M	1358.2	1552.7	−2.6	−1.66	0.097
Roa	U	0.0413	0.06324	−16.1	−8.36	0
	M	0.0413	0.04138	−0.1	−0.03	0.973
Ri	U	0.72867	0.57909	6.5	2.99	0.003
	M	0.72867	0.75624	−1.2	−0.82	0.412

U refers to the samples before PSM, and M refers to the matched samples after PSM.

The specific results of PSM-DID are shown in Table 7. Columns 1 and 2 show the estimation results based on the Logit model, whereas Columns 1 and 2 present the results without and with robust standard errors, respectively, and it can be found that the coefficients of the interaction term Treated × time are all significantly negative. Columns 3 and 4 show the estimation results of the Probit model, and the coefficients of Treated × time are both significantly negative. The dampening effect of the Top-1000 Energy-Saving Program on enterprises' labor demand is robust.

Table 7. Robustness test 2.

Variables	(1)	(2)	(3)	(4)
	Logit		Probit	
	Ln (cyrs)	Ln (cyrs)	Ln (cyrs)	Ln (cyrs)
Treated × time	−0.094 ***	−0.094 ***	−0.094 ***	−0.094 ***
	(−8.696)	(−6.258)	(−8.696)	(−6.258)

Table 7. *Cont.*

	(1)	(2)	(3)	(4)
	Logit		Probit	
Variables	**Ln (cyrs)**	**Ln (cyrs)**	**Ln (cyrs)**	**Ln (cyrs)**
Constant	1.718 ***	1.718 ***	1.718 ***	1.718 ***
	(26.036)	(12.058)	(26.036)	(12.058)
Control variable	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Individual fixed effect	Yes	Yes	Yes	Yes
Robust standard error	No	Yes	No	Yes
Matching mode		Match with 1:3 nearest neighbor		
Observations	35,347	35,347	35,347	35,347
R^2	0.283	0.283	0.283	0.283

The T value in parentheses; *** $p < 0.01$.

4.4. Heterogeneity Analysis

4.4.1. Heterogeneity of Enterprise Size

There are differences in management efficiency and innovation capacity among enterprises of different sizes [64], so this paper will further test the intensity of policy impacts on enterprises of different sizes. Following the ASIF statistical standard, the study constructs a dummy variable for enterprise size and classifies enterprises into three types according to their size: large, medium, and small for group regression. Columns 1–3 of Table 8 represent the results of the regressions for the three sizes of enterprises, respectively. For large enterprises, the coefficient of Treated × time is significantly negative, indicating that the policy has a significant dampening effect on the labor demand of large enterprises. Conversely, for small and medium-sized enterprises, labor demand is not significantly affected. This discrepancy may be attributed to the specific target group identified by the policy; as previously mentioned, the Top-1000 Energy-Saving Program is regulated for enterprises whose total energy consumption exceeded 180,000 tons of standard coal in 2004. Consequently, it becomes evident that larger enterprises are more susceptible to being influenced by the policy. Large enterprises tend to attract greater attention across various regions due to their enhanced capital capabilities and increased likelihood of engaging in technological innovations aimed at improving energy efficiency.

Table 8. Heterogeneity test results.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Enterprise Size			Enterprise Ownership		Enterprise Region		
	Large	**Medium**	**Small**	**State-Owned**	**Non-State-Owned**	**Eastern Region**	**Central Region**	**Western Region**
Variables	**Ln (cyrs)**	**Ln (cyrs)**	**Ln (cyrs)**	**Ln (cyrs)**	**Ln (cyrs)**	**Ln (cyrs)**	**Ln (cyrs)**	**Ln (cyrs)**
Treated × time	−0.087 ***	−0.015	−0.076	−0.045	−0.073 ***	−0.104 ***	−0.086 **	−0.077 **
	(−3.962)	(−0.903)	(−0.523)	(−1.356)	(−4.405)	(−5.080)	(−2.150)	(−2.170)
Constant	1.381 ***	2.211 ***	2.500 ***	1.697 ***	1.714 ***	1.768 ***	1.741 ***	1.325 ***
	(3.133)	(11.351)	(13.655)	(2.589)	(12.433)	(10.550)	(6.450)	(4.140)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Robust standard error	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6004	14,318	11,874	4065	31,282	18,351	9075	9254
R^2	0.374	0.238	0.221	0.367	0.281	0.299	0.292	0.339

The T value in parentheses; *** $p < 0.01$, ** $p < 0.05$.

4.4.2. Heterogeneity of Enterprise Ownership

Differences in ownership structure may lead to differences in enterprise behavior [18]. According to the ASIF criteria, the study considers state-owned, state-associated, state-collective-associated, and wholly state-owned enterprises as state-owned enterprises (SOEs) and the rest of the sample as non-state-owned enterprises (non-SOEs), which are differentiated by constructing a dummy variable for the ownership structure of the enterprises. The regression results are shown in Columns 4 and 5 of Table 8.

Column 4 of Table 8 shows that SOEs are affected by the policy impacts, and Column 5 reports the estimates for non-SOEs. Obviously, the Top-1000 Energy-Saving Program did not have a significant impact on the labor demand of SOEs but significantly reduced the labor demand of non-SOEs. The reason may lie in the fact that, compared with SOEs, non-SOEs are self-financing. They have more freedom to make internal adjustments and reforms under policy pressure, more flexibility in the flow of production factors, and more incentives to innovate. Thus, non-SOEs are more significantly affected by the policy [65]. To achieve energy-saving goals, non-SOEs can initially control production costs by quickly adjusting labor demand and may even be directly eliminated from the market. Conversely, SOEs possess several advantages over non-SOEs across various dimensions. In terms of public relations, SOEs are more likely to secure government subsidies and protection due to their close links with governmental agencies. Compared to non-SOEs, they are less sensitive to the cost pressures that may result from environmental regulations. In terms of daily business operations, SOEs benefit from enhanced resource acquisition capabilities, a superior production and operating environment, and reduced competitive pressures in the market [66]. Consequently, SOEs are in a better position to absorb the escalating costs associated with environmental regulatory policies while fulfilling employment demands for a larger workforce. In terms of market position, SOEs play a crucial role in stabilizing employment; thus, their labor demand remains relatively insulated from external fluctuations. Overall, SOEs appear to be less affected by environmental regulation.

4.4.3. Heterogeneity of Enterprise Region

China is a vast country characterized by uneven economic development across its regions, along with significant differences in the strength of environmental regulations and labor market conditions. To assess the intensity of policy impacts on enterprises in different regions, this manuscript conducts regressions by categorizing the total sample into eastern, central, and western regions based on the classification established by the National Bureau of Statistics (NBS). The regression results are presented in Columns 6–8 of Table 8.

Columns 6–8 present the regression results for the eastern, central, and western regions, respectively. It is evident that the Top-1000 Energy-Saving Program exerts a significant dampening effect on labor demand across all three regions. Notably, labor demand in the eastern region experiences the strongest suppression. This phenomenon may be attributed to the rapid economic growth characteristic of the eastern coastal region, which has benefited from geographical advantages and favorable economic policies. Enterprises in this region encounter more intense market competition compared to their counterparts in central and western regions. Furthermore, the eastern region is likely to attract a higher concentration of high-tech talent and a more educated workforce, and enterprises are inclined towards technological innovation. As a result, labor demand is more likely to be constrained by policy measures in this context. In addition, environmental issues are more prominent in the eastern region. As the government authorities attach great importance to environmental concerns, enterprises operating in this region face stricter environmental regulations, which increases the dampening effect of policy on the labor demand of enterprises.

5. Mechanism Analysis

In the mechanism analysis, based on the theoretical framework established in Section 2, this study determines the ways through which enterprises achieve their energy-saving

goals by examining the effects of the Top-1000 Energy-Saving Program on total industrial output value, industrial sales value, fixed asset investment, and patent counts.

5.1. Output Effect

As previously discussed, whether the output effect exists and the specific direction of the influence depends on paths 1 and 2. Referring to related studies [29,63,67], this study characterizes the output effect in terms of the gross industrial output value. Considering that the sales output value is the actual income earned by enterprises, this study also characterizes the output effect in terms of the industrial sales output value [68]. Specifically, the logarithmic form of industrial gross output value and industrial sales output value are taken as the explanatory variables, respectively, and the regression analysis is conducted concerning the benchmark model. The specific results are shown in Columns 1 and 2 of Table 9. The coefficients of Treated × time are −0.076 and −0.077, respectively, which are significantly negative, i.e., the policy leads to a decrease in the industrial gross output value and the industrial sales output value of enterprises. That is, path 1 plays a dominant role in the output effect, and this policy leads to a decrease in labor demand.

Table 9. Mechanism analysis results.

	(1)	(2)	(3)	(4)	(5)	(6)
	Output Effect			Substitution Effect		
	Ln (The Gross Industrial Output Value)	**Ln (The Industrial Sales Output Value)**	**Ln (The Capital-Labor Ratio)**	**Ln (Investment in Fixed Assets)**	**Ln (The Number of Patent Applications)**	**Ln (The Number of Patents Granted)**
Treated × time	−0.076 ***	−0.077 ***	0.094 ***	0.276 ***	0.049 *	0.052 **
	(−4.781)	(−4.785)	(6.258)	(2.859)	(1.856)	(2.221)
Constant	3.914 ***	3.899 ***	−1.718 ***	−1.494 **	−0.819 ***	−0.437 ***
	(26.327)	(26.144)	(−12.058)	(−2.217)	(−5.704)	(−3.907)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Robust standard error	Yes	Yes	Yes	Yes	Yes	Yes
Observations	35,347	35,347	35,347	20,083	35,347	35,347
R^2	0.655	0.665	0.725	0.097	0.031	0.029

The T value in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5.2. Substitution Effect

Referring to related studies [68], this study measures the level of capital change by the capital labor ratio and the change in the amount of investment in fixed assets, which is measured in the logarithmic form of the ratio of total fixed assets to the number of employees and the logarithmic form of the difference in total fixed assets of the previous year and the current year, respectively. Technological innovation is measured by the logarithm of the number of patent applications and the logarithm of the number of patents granted. A regression analysis is conducted concerning the baseline model to examine the substitution effect of the Top-1000 Energy-Saving Program. Columns 3 and 4 of Table 9 show the results for capital; the coefficient of Treated × time is 0.276, which is statistically significant at the 1% level, indicating that the policy significantly increases enterprises' investment in capital. Columns 5 and 6 show the results for technology. The coefficients of Treated × time are both significantly positive, indicating that the policy promotes technological innovation in enterprises. This conclusion is consistent with the actual situation. When enterprises adopt process treatment to cope with external energy efficiency constraints, innovation is likely to substitute for labor demand. In addition, Zhang et al. applied the PSM-DID method to study the innovation effect of the Top-1000 Energy-Saving Program based on data from 2004–2007 and found that the Top-1000 Energy-Saving Program has led to an increase in the innovative capacity of enterprises by about 40 percent [36]. That is, in the substitution effect,

faced with policy pressures, enterprises increase their investment in green technology, and the investment in green technology substitutes for labor to a certain extent, which ultimately leads to a decrease in the labor demand of enterprises.

6. Conclusions

The Top-1000 Energy-Saving Program was an important energy-based environmental policy during the "Eleventh Five-Year Plan" period, which is of great significance in promoting China's energy conservation and emission reduction efforts, but the policy may have an impact on the labor demand of enterprises during the implementation process. This study takes China's Top-1000 Energy-Saving Program as the object of research and conducts a multifaceted analysis based on China's firm-level data from 2000–2010. The results of the study show that (1) the Top-1000 Energy-Saving Program significantly reduces the labor demand of enterprises and exhibits dynamic change characteristics. The labor demand of policy-regulated enterprises shows a yearly decline during 2006–2009. The likely reason for this result is that enterprises have strengthened technological innovation in response to the energy-saving targets. Over time, the benefits of the initial investment in technology become increasingly evident, ultimately leading to a substitution effect regarding labor. (2) The results of the heterogeneity analysis show that there are significant differences in the labor demand of different types of enterprises under the influence of the policy. In terms of enterprise size, the labor demand of large enterprises is significantly suppressed, while for medium and small enterprises, the labor demand is not significantly affected; in terms of enterprise ownership, the labor demand of SOEs is not significantly affected by the policy, while the policy significantly reduces the labor demand of non-SOEs; in terms of enterprise region, the policy has a suppressive effect on the labor demand of enterprises in all regions, and enterprises in the eastern region are the most affected. (3) The results of the mechanism analysis show that the output effect and the substitution effect are the main factors of the policy affecting the labor demand of enterprises. In the output effect, the policy leads to a decline in the total industrial output value and the industrial sales value of enterprises, which in turn leads to a decrease in labor demand. This suggests that the policy constraints put some cost pressure on enterprises to respond by reducing output. In the substitution effect, enterprises increase their investment in capital and technology in the face of the policy, and capital and technology substitute for labor to some extent.

This study describes the impact of China's Top-1000 Energy-Saving Program on the labor demand of enterprises through a series of theoretical and empirical analyses, but there are some limitations in the research process. First, the Top-1000 Energy-Saving Program, which is the focus of this study, is a policy implemented in 2006, and the data used in the study are outdated. This study fails to extend to the recent energy-saving environmental policies, and there may be some time differences and limitations in the study of the problem. Second, although this study examined the impact of energy efficiency policies on the labor demand of enterprises, it did not differentiate between different types of labor populations, and further in-depth research could be conducted on the impact of energy efficiency policies on the demand for different types of labor populations. Third, the mechanism analysis of this paper finds that enterprises are more likely to innovate through process treatment, thereby crowding out some of the labor force. However, there is a lack of detailed data on end-of-pipe treatment and process treatment by enterprises, and in the future, if data are available, we can examine in more detail the underlying mechanisms. Finally, the employment examined in this paper is only one aspect of economic development, and consideration could be given to analyzing the impact of energy efficiency policies on other economic behaviors. In addition, the relationship between energy efficiency policies and the greening of the economy can also be further explored.

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