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Original Research

Does New Environmental Protection Law Improve Enterprise Labor Investment Efficiency? Evidence from China

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Abstract

This study aims to elucidate the influence of China's new environmental protection law (NEPL) on enterprise labor investment efficiency. The dual combined goals of enhancing the environment and stabilizing employment are central to this investigation. We focus on A-share listed companies between 2010 and 2020. A difference-in-difference (DID) method is applied to experimentally evaluate the NEPL's influence on heavy-polluting enterprise labor investment efficiency. Results indicate a significant enhancement in heavy-polluting enterprise labor investment efficiency after carrying out NEPL. This conclusion remains robust through various rigorous examinations. Additional research reveals that the NEPL's influence on heavy-polluting enterprise labor investment efficiency is mediated through mechanisms such as green technology innovation and overcoming enterprise financial restrictions. The positive influence of the NEPL is more pronounced in regions characterized by lower marketization, reduced labor intensity, and a prevalence of SOEs. Moreover, the NEPL predominantly addresses the issue of labor underinvestment, with less apparent impact on suppressing labor overinvestment. This emphasizes its role in alleviating deficiencies in labor investment rather than curbing excessive allocation. In summary, we provide valuable insights into the NEPL's positive influence on heavy-polluting enterprise labor investment efficiency, particularly in the context of environmental improvement and employment stability.

Keywords: new environmental protection law, labor investment efficiency, green technology innovation, financial restrictions

Introduction

The New Environmental Protection Law (NEPL) serves as a crucial instrument in addressing environmental pollution, enhancing environmental quality, and fostering sustainable growth in both the economy and society. Implemented on January 1, 2015, the NEPL, introduced by the Chinese People's Republic, stands as a foundational framework for preventing and controlling environmental contamination. It functions as a regulatory tool with a focus on order control. Enterprises, integral to

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economic development, are central to the purview of order-controlled environmental regulation. In contrast to its predecessor, the NEPL mandates enterprises to transparently disclose environmental information to the public. It introduces new provisions for daily fines and administrative detention, intensifying the oversight and penalties imposed on enterprises. Simultaneously, the NEPL incentivizes enterprises that proactively reduce emissions in compliance with environmental regulations. Such enterprises are eligible for government subsidies, green financial credits, and additional resource support. These regulatory measures underscore the substantial impact of the NEPL on enterprise production and operational investments, driven by external pressures and incentives. In summary, the NEPL, enacted in 2015, represents a pivotal step in environmental governance, aligning with the nation's commitment to combat pollution and promote sustainable practices within the enterprise sector.

Research indicates that the NEPL positively influences enterprises' inclination toward environmental protection [1, 2]. This inclination manifests in increased procurement of environmental protection equipment and heightened research in green technology [3-6]. Moreover, the NEPL contributes to augmenting the environmental information disclosure level [7] and enhancing investment efficiency [8]. This, in turn, propels enterprise green transformation initiatives [9], bolstering competitiveness [10, 11], and improving total factor productivity [12]. However, the existing literature lacks comprehensive investigations into the NEPL's influence on heavy-polluting enterprise labor costs, particularly regarding labor effectiveness in investing. This research gap underscores the need for further scholarly exploration in this specific domain.

Labor constitutes a pivotal determinant influencing enterprise production and operations [13]. Distinguished by traits of indirectness, longevity, and uncertainty when juxtaposed with other investments [14, 15], labor investments exhibit a heightened degree of liquidity and reversibility [16]. Consequently, enterprises are inclined to accord precedence to the adjustment of labor allocation in their investment strategies [17-19]. The imperatives laid down by the NEPL necessitate enterprises to exert a substantial influence on their production methodologies and resource allocations, aligning with the overarching objective of pollution reduction and waste emission mitigation. In this context, a fundamental inquiry emerges: Can the NEPL influence the heavy-polluting enterprise labor investment efficiency, and if so, which exact mechanisms govern the effect? This poses a critical area for scholarly investigation and warrants elucidation within the extant academic discourse.

Building upon this foundation, we undertake an empirical exploration into the ramifications of the NEPL on heavy-polluting enterprise labor investment efficiency. We introduce distinctive research contributions as follows: Firstly, we extend the knowledge of the economic repercussions of the NEPL for microenterprises from the vantage point of labor investment efficiency. We broaden the scope of current research on the factors influencing labor investment efficiency by including outside environmental regulations as a significant element. Secondly, we perform a heterogeneity analysis from three perspectives: marketization degree, labor intensity, and enterprise nature. This enriches the theoretical understanding of the relationship between regional economic development and the effects of the NEPL, providing a new theoretical basis for the responses of different types of enterprises to the NEPL. Thirdly, we clarify the impact mechanism of the NEPL on enterprises' labor investment efficiency based on the two perspectives of green technology innovation and financial restrictions. The insights garnered contribute to the effective advancement of environmental governance. Moreover, we aid enterprises in formulating judicious labor investment decisions within the confines of stringent environmental regulations. The envisaged outcome is the attainment of the dual objectives of environmental amelioration and employment stabilization.

Theoretical Analysis and Research Hypotheses

The NEPL significantly impacts the heavy-polluting enterprise labor investment efficiency through the dual effects of external pressures and incentives. On the one hand, from the perspective of external pressures, the NEPL requires the government to conduct comprehensive supervision, encourages widespread public participation, and mandates enterprises full disclosure, thus forming a strong supervision mechanism. It also increases the fines for enterprises that illegally discharge pollutants and adds administrative detention as a penalty, exerting significant pressure on heavy-polluting enterprises. According to the Porter Hypothesis, enterprises can proactively respond to the pressure of stringent environmental regulations through technological innovation, thereby generating an innovation compensation effect. Therefore, heavily polluting enterprises will use green production to control pollutant emissions and achieve sustainable development. The transformation and upgrading of production methods can optimize enterprise labor demand structure, thereby enhancing heavy-polluting enterprise labor investment efficiency. On the other hand, from the perspective of external incentives, the NEPL aims to encourage enterprises to phase out production equipment that emits significant pollution and to foster green transformations. It introduces policies and measures in finance, taxation, pricing, and government procurement to support and encourage these initiatives. According to Resource Dependence Theory, there is a close relationship between enterprises and their external environment. Enterprises must obtain external resources to survive. The incentives enable enterprises to obtain sufficient external resources to optimize labor investment during their transformation and upgrading

processes. This enhances the heavy-polluting enterprise labor investment efficiency.

The NEPL catalyzes enterprises to undertake green technology innovations, thereby enhancing heavy-polluting enterprise labor investment efficiency. From a regulatory standpoint, the NEPL mandates enterprise disclosure of environmental information, specifying its content. This stringent regulatory framework substantially amplifies public oversight of enterprise illegal pollution activities. In terms of punitive measures, the NEPL imposes regulations on seizure, detention, and administrative detention for environmental violations, escalating both economic and non-economic costs for heavy-polluting enterprises. These measures unequivocally heighten environmental protection pressures on heavy-polluting enterprises, compelling them to embrace green production and engage in proactive green transformation endeavors, including green technology innovation [20]. Green technology innovation, directed at resource conservation and environmental pollution reduction, bestows competitive advantages upon enterprises [21]. The development of green technology innovation necessitates individuals with innovative thinking, versatile skills, and specialized knowledge. Consequently, enterprises engage more extensively with high-quality labor. Simultaneously, the integration of green technology innovation outcomes updates enterprise production technology and environmental protection equipment, fostering the transformation and upgrading of production methods [22, 23]. This, in turn, reshapes the enterprise's demand for labor from low-skill to high-skill, as high-skilled labor exhibits proficiency in specialized and skilled work, as well as the capacity to perform simple and repetitive unskilled tasks [8, 24]. Consequently, enterprises optimize the efficiency of utilizing high-skilled labor, refine the structure of human capital, curtail ineffective hiring [25], and, thereby, advance heavy-polluting enterprise labor investment efficiency.

The NEPL emerges as a potential mitigator of enterprise financial restrictions, thereby fostering an enhancement in heavy-polluting enterprise labor investment efficiency. The NEPL's mandatory disclosure mandates for enterprise environmental information play a pivotal role in providing investors with a more profound and comprehensive insight into a company's environmental stance and commitment. This heightened transparency attracts increased capital investment. Simultaneously, the NEPL's regulatory provisions, encompassing subsidies and rewards for enterprises demonstrating exceptional achievements in environmental protection, surpassing pollution emission reduction targets, and supporting green credit initiatives [26, 27], collectively serve as incentives that, to a certain extent, facilitate enterprises in securing a more abundant and stable cash flow for operational activities, thereby mitigating financial restrictions. The amelioration of financial restrictions, in turn, equips enterprises with ample funds for executing production and operational investment endeavors, including labor investment. Labor, characterized as a semi-fixed expense for enterprises, involves considerable outlays for recruitment and instruction, alongside adjustment costs such as severance pay during workforce downsizing. The increased capital at the disposal of enterprises serves to offset labor adjustment costs, allowing for an expansion in the recruitment of high-quality labor and the dismissal of low-skilled labor. This strategic maneuver diminishes the likelihood of both enterprise labor underinvestment and overinvestment [28, 29], optimizing the allocation of labor resources and consequently elevating heavy-polluting enterprise labor investment efficiency.

Drawing from this context, we propose the subsequent research hypotheses:

H1: Ceteris paribus, the NEPL enhances heavy-polluting enterprise labor investment efficiency.

H2: Ceteris paribus, the NEPL enhances heavy-polluting enterprise labor investment efficiency by promoting green technology innovation.

H3: Ceteris paribus, the NEPL enhances heavy-polluting enterprise labor investment efficiency by overcoming enterprise financial restrictions.

Experimental Procedures

Sample and Data

We employ a sample comprising China's corporations listed on the A-share market in both Shanghai and Shenzhen across a decade, from 2010 through 2020. To refine the sample, we exclude financial industries, PT, ST, and major variables samples with missing data, resulting in a final dataset comprising 15,380 observations. The financial data utilized is sourced from the CSMAR database, while green patent information is obtained from the CNRDS database. Continuous variables undergo trimming at the 1% and 99% quantiles to mitigate the impact of extreme values. Additionally, enterprise clustering and robust standard errors are employed to enhance the reliability of our analytical results.

Variable Definition and Measurement

Dependent variable: labor investment efficiency (*LABEFF*). Building upon the research by Jung et al. [30], we utilize the absolute residuals from the model (1) to measure labor investment efficiency; a higher residual value indicates reduced efficiency in the enterprise's labor investment. Among them, *Ne_Hire* is the level of employee wage payments, measured by a proportion of funds given by enterprises to and for workers to total revenues; *Sales_Growth* represents the sales revenue growth rate; *ROA* reflects the asset returns; *ΔROA* signifies the variation in asset return value; *Size_R* denotes the annual market capitalization rank

percentage of individual stocks; *Quick* is the liquidity ratio; *ΔQuick* indicates the liquidity ratio's variation; *Lev* measures the ratio of financial leverage; *LossbinX* categorizes the previous year's *ROA* ranging from 0 to -0.025 into five equal intervals of 0.005 each. When the *ROA* falls between -0.005 and 0, *Lossbin1* is assigned a value of 1, else it remains 0.

$$Net\_Hire_{i,t} = \alpha_0 + \alpha_1 SalesGrowth_{i,t-1} + \alpha_2 SalesGrowth_{i,t} + \alpha_3 ROA_{i,t-1} + \alpha_4 ROA_{i,t} + \alpha_5 \Delta ROA_{i,t} + \alpha_6 Size_{R_{i,t-1}} + \alpha_7 Quick_{i,t-1} + \alpha_8 Quick_{i,t} + \alpha_9 \Delta Quick_{i,t} + \alpha_{10} Lev_{i,t-1} + \alpha_{11} Lossbin1_{i,t-1} + \alpha_{12} Lossbin2_{i,t-1} + \alpha_{13} Lossbin3_{i,t-1} + \alpha_{14} Lossbin4_{i,t-1} + \alpha_{15} Lossbin5_{i,t-1} + \varepsilon_{i,t} \quad (1)$$

Independent variable: the net effect of policy ($Treat_i$*$Time_t$). The policy's net effect is the interaction term $Treat_i$ and $Time_t$; we apply the methodology proposed by Fang et al. [4], designating the listed enterprises from industries with heavy pollution as the experimental group ($Treat_i$ = 1) and those from industries with non-heavy pollution as the comparison group ($Treat_i$ = 0). Time serves as an indicator to denote the enactment of the policy. It assumes that if the time is the official implementation of the NEPL in 2015 and later years, then $Time_t$ = 1, otherwise $Time_t$ = 0.

Control variables: we draw on Cui et al. [8] and select a set of control variables: the scale of the enterprise (*Size*), the ratio of assets to liabilities (*Lev*), quick ratio (*Quick*), operating cashflow (*Cashflow*), the net interest rate on total assets (*ROA*), market capitalization (*MB*), enterprise age (*Age*), percentage of independent directors (*Independ*), asset structure (*Tangible*), two positions in one (*Dual*), and variable definitions presented in Table 1.

Model Design

To examine how the NEPL affects heavy-polluting enterprise labor investment efficiency, a two-sided stable difference-in-difference (DID) model was established as follows:

$$LABEFF_{i,t} = \beta_0 + \beta_1 Treat_i * Time_t + \beta_2 Controls_{i,t} + \lambda_t + \mu_i + \varepsilon_{i,t} \quad (2)$$

Among them, $LABEFF_{i,t}$ is the dependent variable, $Treat_i$*$Time_t$ is the independent variable, an interaction term between a grouping dummy ($Treat_i$) and a time dummy ($Time_t$), $Controls_{i,t}$ represents a variety of control factors, λ_t indicates the influences of time-fixed, μ_i denotes the influences of company-fixed, $\varepsilon_{i,t}$ signifies the stochastic error components, and *i* and *t* denote firms and years. β_1 reflects the influence that the NEPL has on enterprise labor investment efficiency. To attenuate the influence of inter-sample correlation, the model clusters standard errors at the level of the individual enterprise.

Results and Discussion

Statistical Descriptions

Table 2 displays the statistical data for the key elements. The highest score for enterprise labor investment efficiency (*LABEFF*) is 0.1210, with a standard deviation of 0.0229 and a mean of 0.0241, demonstrating

Table 1. Main variable definitions.

Category	Symbols	Variable name	Variable description
Dependent variable	*LABEFF*	Labor investment efficiency	Indicated by the absolute magnitude of the residuals from the first model's regression analysis
Independent variable	*Treat* Time*	Policy net effect	Interaction items for *Treat* and *Time*
Control variables	*Size*	Company Size	Ln (total company assets)
	Lev	Financial leverage	Long-term obligations/total assets at the year's commencement
	Quick	Quick ratio	(Current property-net inventory)/current debts
	Cashflow	Operating cash flow	Net cash generated from operational activities / total assets
	ROA	Profitability	Net profit / average total assets
	MB	Market value	Market value/book value
	Age	Company age	Disparities exist between the financial year and the inception date of the corporation
	Independ	Percentage of independent boards	The count of independent boards/entire board
	Tangible	Asset structure	Total fixed assets net of accumulated depreciation/ overall assets
	Dual	Two positions in one	If the two positions of Chairman and CEO are combined into one, it takes 1, otherwise it takes 0

Table 2. Statistical analysis of key factors.

Variable	N	Mean	Std.	Median	Min	Max
LABEFF	15380	0.0241	0.0229	0.0178	0.0001	0.1210
*Treat*Time*	15380	0.1654	0.3716	0.0000	0.0000	1.0000
Size	15380	22.5548	1.2911	22.3700	20.2100	26.4700
Lev	15380	0.1020	0.1251	0.0543	0.0000	0.5782
Quick	15380	1.3580	1.2024	1.0177	0.1752	7.5568
Cashflow	15380	0.0459	0.0661	0.0458	-0.1497	0.2296
ROA	15380	0.0379	0.0545	0.0345	-0.1952	0.1984
MB	15380	1.6182	1.4213	1.2079	0.1397	8.1275
Age	15380	17.7044	5.4881	18.0000	5.0000	32.0000
Independent	15380	0.3733	0.0534	0.3333	0.3333	0.5714
Tangible	15380	0.2322	0.1696	0.1994	0.0019	0.7177
Dual	15380	0.2226	0.4160	0.0000	0.0000	1.0000

that enterprise labor investment efficiency varies greatly. The net effect of the policy ($Treat_i*Time_t$) is quantified by an average of 0.1654, suggesting that the NEPL affects around 2,544 firm-year samples in the sample period, while the remaining variables are inside an acceptable spectrum of values.

Univariate Analysis

The mean difference between groups test was performed to assess the variance in labor investment efficiency (*LABEFF*) among the experimental and comparison groups. Table 3 reveals outcomes: the average amount in the comparison group is 0.0248, and the median is 0.0184, whereas the mean value in the experimental group is 0.0202 and the median is 0.0148, and both the t-test statistic for the mean and the z-test statistic for the median are significant on the 1% degree. This suggests a considerable disparity between the two, with the average level of labor investment efficiency increasing after the NEPL started operating, assuring this quasi-natural experiment's randomization.

Analysis of DID Regression Results

Table 4 details the empirical findings about the NEPL's influence on enterprise labor investment efficiency. The findings show that the net effect coefficient of the policy interaction term ($Treat_t*Time_i$) is statistically negative at the 1% level, no matter whether controls are included. In contrast to listed enterprises in non-severely polluted sectors, the adoption of the NEPL considerably increases the labor investment efficiency of listed enterprises in heavily polluted industries, supporting hypothesis H1.

Robustness Test

Parallel Trend Examination

The DID methodology necessitates a parallel trend, so we set 2015 as the year of policy occurrence (0), 2011 as -4, 2012 -3,2013 as -2, 2014 as -1, 2016 as 1, and so on. Fig. 1 illustrates the outcomes from the analysis of the parallel trend. The results before 2015 are mostly close to 0 and insignificant, which satisfies the hypothesis that both comparison and experimental groups had a similar tendency before the policy was enacted. The experimental group after 2015 significantly shows an upward trend, which verifies the results of the underlying regression, and thus the sample meets the criteria for the parallel trend assessment.

Table 3. Test for difference in means between groups.

Variable	*Treat*Time* = 0		*Treat*Time* = 1		T-test for the mean	Z-test for the median
	Mean	Median	Mean	Median		
LABEFF	0.0248	0.0184	0.0202	0.0148	9.3487***	45.8478***
N	12836		2544			

Note: ***, **, and *indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 4. Basic regression results.

Variable	(1)	(2)
	LABEFF	*LABEFF*
*Treat*Time*	-0.0027*** (-3.18)	-0.0032*** (-3.81)
Size		-0.0027*** (-3.44)
Lev		-0.0059** (-2.28)
Quick		-0.0011*** (-4.11)
Cashflow		-0.0009 (-0.34)
ROA		0.0112** (2.33)
MB		0.0001 (0.53)
Age		-0.0016** (-2.06)
Independ		0.0050 (0.95)
Tangible		-0.0042 (-1.38)
Dual		0.0002 (0.33)
Constant		0.1135*** (5.10)
N	15380	15380
R-squared	0.6575	0.6607
Year/Ind	YES	YES

Note: The t-values calculated for robust standard errors of clustering at the individual level are in parentheses. ***, **, and *indicate significance at the 1%, 5%, and 10% levels, respectively.

Placebo Test

To further scrutinize the robustness of our findings and ascertain whether unobservable factors, beyond the influence of the NEPL, may impinge on the results, we employ a placebo test methodology. Specifically, we construct a distribution of estimated coefficients for the net effect of the policy ($Treat_i$*$Time_t$) by randomly assigning listed enterprises within the heavy pollution industry to placebo tests. Subsequently, we regress the randomly selected experimental and comparison groups following the model (2), iterating this process 500 times. The objective of this iterative procedure is to evaluate whether the array of predicted coefficients indicating the overall impact of the policy ($Treat_i$*$Time_t$) converges around 0. Proximity to 0 in this distribution signifies that crucial influences have not been inadvertently omitted from the model specifications. In essence, it validates that the impact effects observed in the benchmark analysis are attributable solely to the focus on policy occurrence. The reported distribution of estimated coefficients, illustrated in Fig. 2, reveals that the coefficients of the spurious false DID terms are predominantly centered around 0. This outcome indicates an absence of a serious omitted variable problem in the modeling process, strengthening the reliability of the principal results.

The PSM-DID Test

Within the framework of our study, the propensity value matching technique is employed, specifically utilizing the one-to-one closest neighbor matching approach, implemented with no replacement. The outcomes of this matching process reveal that the absolute magnitude of the standard variation for all matched values is under a 10% threshold, attesting

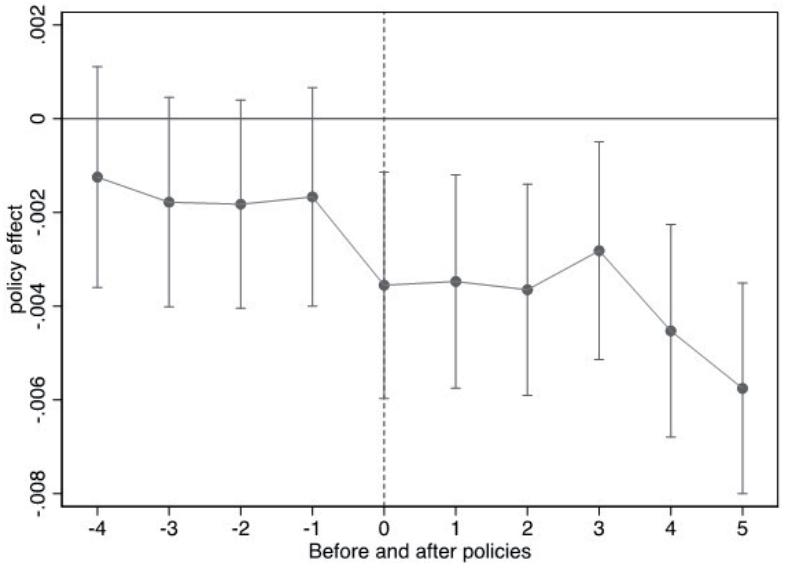

Fig.1. Parallel trend examination.

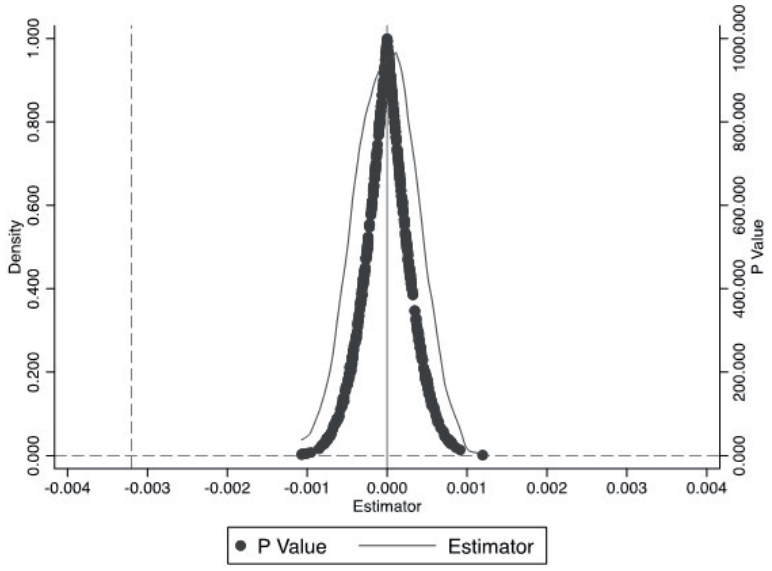

Fig. 2. Placebo test.

to the reasonability and reliability of the matching results. The first column of Table 5 displays the DID results following the matching of the propensity score. Notably, the coefficient associated with the policy's net effect ($Treat_i$*$Time_t$) attains statistical significance at the 1% level, manifesting a significantly negative impact. This outcome aligns cohesively with the original conclusion, reinforcing the robustness and consistency of the findings.

Change the Measurement of the Dependent Variable

Referring to the method of Pinnuck and Lillis [31] for calculating the enterprise labor investment efficiency, we recalculate it by adding the annual return on individual shares (*Return*) of cash dividends to model (1) and then rerun the regression with the model (2). The findings are displayed in the second column of Table 5, and they align with the previous outcomes.

Table 5. Robustness test results.

Variable	(1)	(2)
	LABEFF	*LABEFF*
*Treat*Time*	-0.0030*** (-2.95)	-0.0025*** (-2.83)
Constant	0.1187*** (4.39)	0.1044*** (3.91)
N	7746	14004
R-squared	0.6581	0.6516
Controls/Year / Firm	YES	YES

Note: The t-values calculated for robust standard errors of clustering at the individual level are in parentheses. ***, **, and *indicate significance at the 1%, 5%, and 10% levels, respectively.

Further Analysis

Mechanism Analysis

As mentioned earlier, the NEPL improves heavy-polluting enterprise labor investment efficiency: so does the NEPL improve it through the promotion of green technology innovation and the reduction of enterprise financial restrictions? Based on the research conducted by Wen and Ye [32], we establish a model to investigate the mediation effect for empirical examination:

$$MV_{i,t} = \gamma_0 + \gamma_1 Treat_i * Time_t + \gamma_2 Controls_{i,t} + \lambda_t + \mu_i + \varepsilon_{i,t} \quad (3)$$

$$LABEFF_{i,t} = \theta_0 + \theta_1 Treat_i * Time_t + \theta_2 MV_{i,t} + \theta_3 Controls_{i,t} + \lambda_t + \mu_i + \varepsilon_{i,t} \quad (4)$$

In models (3) and (4), $MV_{i,t}$ is the mediating variable to be tested, which stands for corporate green technology innovation (*INNO*) and financial restrictions (*LOAN*), and the choices of the remaining variables are identical to those in model (2). If coefficients $\gamma_1\theta_2$ of model (3) and model (4) are both significant, or one of them is not significant, but the Bootstrap test range of confidence is not 0, then it demonstrates that $MV_{i,t}$ has a mediating consequence, that is, the enterprise green technology innovation and financial restrictions are the mediating variables of the NEPL to improve heavy-polluting enterprise labor investment efficiency.

Green Technology Innovation

Building upon Liu and Li [33], we adopt the logarithmic transformation (incremented by one) of the number of sanctioned green patents as a metric to

Table 6. Results of mechanism analysis.

variable	(1)		(2)	
	INNO	*LABEFF*	*LOAN*	*LABEFF*
*Treat*Time*	0.0734** (2.27)	-0.0032*** (-3.73)	-0.0020*** (-3.89)	-0.0032*** (-3.77)
INNO		-0.0008*** (-2.73)		
LOAN				0.0092 (0.43)
Constant	-5.3863*** (-6.94)	0.1091*** (4.88)	0.0206 (1.52)	0.1133*** (5.09)
N	15380	15380	15380	15380
R-squared	0.7491	0.6612	0.7432	0.6613
Controls/Year/Firm	YES	YES	YES	YES
F	11.53	6.00	60.6	5.41
Bootstrap confidence interval			-0.0041— -0.0023	

Note: The t-values calculated for robust standard errors of clustering at the individual level are in parentheses. ***, **, and *indicate significance at the 1%, 5%, and 10% levels, respectively.

gauge enterprise green technology innovation. The data presented in the first column of Table 6 indicates that the overall effect of the policy ($Treat_i$*$Time_t$) and the green technology innovation (*INNO*) are considerably positive at a 5% significance level. Additionally, the coefficients of green technology innovation (*INNO*) and labor investment efficiency (*LABEFF*) show high significance at the 1% threshold. Consequently, green technology innovation has a mediating function between the NEPL and the heavy-polluting enterprise labor investment efficiency.

Enterprise Financial Restrictions

Drawing inspiration from Liu et al. [26], we utilize the expenditures of debt financing, measured by the proportion of interest expenditures to average overall obligations, as a metric to gauge the extent of enterprises' financial restrictions. A higher ratio signifies increased restrictions, while a lower ratio indicates reduced restrictions. The corresponding outcomes in the second column of Table 6 reveal that the net effect of policy ($Treat_i$*$Time_t$) and financial restrictions (*LOAN*) is considerably negative. Although the coefficients for financial restrictions (*LOAN*) and labor investment efficiency (*LABEFF*) are positive, their statistical significance is not attained. A supplementary Bootstrap test substantiates that none of the confidence intervals of the regression includes 0. Consequently, the NEPL's influence on heavy-polluting enterprise labor investment efficiency is mediated by financial restrictions.

Heterogeneity Analysis

The Marketization Degree

Employing the approach delineated by Xiao et al. [34], we utilize the Fan Gang marketization index to gauge the level of marketization in distinct regions. The sample is then stratified into lower and higher marketization groups based on the median, with detailed regression outcomes presented in the first column of Table 7. The findings indicate that in the group with lower marketization, the combined policy effect ($Treat_i$*$Time_t$) is positively and significantly correlated with heavy-polluting enterprise labor investment efficiency, with a 1% level of statistical significance. Conversely, in the higher marketization grouping, the coefficient of the net effect of policy ($Treat_i$*$Time_t$) and the heavy-polluting enterprise labor investment efficiency do not hold statistical significance. Crucially, the between-group differences in coefficients attain significance at the 1% level, underscoring regional variations in how the NEPL affects labor investment efficiency. This divergence can be attributed to the premise that higher degrees of marketization correspond to more robust market trading systems and environmental legal protection frameworks. Enterprises in these regions exhibit a proclivity to augment investment in green technology innovation for sustainable development, thereby reducing the constraining influence of the NEPL on their investment efficiency. Conversely, regions with lower marketization degrees often feature less developed capital factor markets and stringent government regulations. Resource dependence theory emphasizes that organizational behavior is largely influenced by the external resources on which it depends [35]. Faced

Table 7. Heterogeneous analysis results.

Variables	(1)		(2)		(3)	
	Low marketization level	High marketization level	Lesser labor intensity	Greater labor intensity	Non-SOEs	SOEs
*Treat*Time*	-0.0041*** (-3.47)	-0.0007 (-0.52)	-0.0039*** (-4.25)	-0.0003 (-0.19)	-0.0013 (-1.13)	-0.0037*** (-3.03)
Constant	0.0236*** (110.34)	0.0253*** (135.45)	0.0203*** (116.37)	0.0287*** (126.54)	0.0266*** (139.65)	0.0221*** (106.02)
N	7699	7378	7450	7433	8147	7146
Controls/Year/Firm	YES	YES	YES	YES	YES	YES
R-squared	0.6461	0.6731	0.6012	0.7171	0.6782	0.6321
Coefficient of difference between groups	0.0030***		0.0040***		0.0020***	

Note: The t-values calculated for robust standard errors of clustering at the individual level are in parentheses. ***, **, and *indicate significance at the 1%, 5%, and 10% levels, respectively.

with elevated environmental violation costs, enterprises in these areas disclose environmental information publicly, enhance investment in green production to align with NEPL requirements and seek resource support from the government, investors, and consumers. This strategic approach provides a financial cushion, allowing for optimal labor investment and, eventually, increasing heavy-polluting enterprise labor investment efficiency.

Labor Intensity

Drawing insights from Kim [36], we employ the proportion of cash compensation for workers to sales revenue as a measure of labor intensity. The collected data is segmented into categories of greater and lesser labor intensity using the median as a benchmark, with the corresponding regression analyses detailed in the second column of Table 7. The outcomes reveal a strong and substantial association, with a confidence level of 1%, between the coefficient of the net effect of policy ($Treat_i*Time_t$) and the heavy-polluting enterprise labor investment efficiency with low labor intensity. In contrast, the coefficient of the net effect of policy ($Treat_i*Time_t$) and heavy-polluting enterprise labor investment efficiency is deemed insignificant within greater labor-intensive enterprises. Critically, the coefficients of intergroup differences between the lesser and greater labor intensity groups attain significance at the 1% level, indicative of discernible variations in how the NEPL influences the heavy-polluting enterprise labor investment efficiency across labor-intensive companies. This observed divergence can be elucidated by the fact that enterprises with higher labor intensity necessitate increased labor investment, exhibit heightened reliance on labor, and witness labor costs constituting a larger proportion of production costs. The non-significant effect of NEPL implementation on heavy-polluting enterprise labor investment efficiency in companies with greater labor intensity can be explained by the inherent challenges of adjusting labor investment decisions. Elevated labor adjustment costs, coupled with the substantial impact of labor protection on labor-intensive companies, render it arduous for such enterprises to modify their existing labor investment decisions. Technological innovation theory emphasizes that by introducing advanced production equipment and technologies, enterprises can improve production efficiency and reduce dependence on traditional labor [28]. Conversely, enterprises with lesser labor intensity have reduced their dependence on labor by incorporating advanced production equipment and technology, thereby achieving automation and mechanization in the production process. Consequently, after the adoption of the NEPL, these enterprises demonstrate more agility in adjusting their labor force structure, leading to improved labor investment efficiency.

Enterprise Ownership

According to the enterprise's actual controller, we separate the sample into state-operated enterprises (SOEs) and non-state-operated enterprises (non-SOEs). The findings are shown in the third column of Table 7. The regression analysis reveals that, for non-SOEs, the policy's net effect ($Treat_i*Time_t$) and heavy-polluting enterprise labor investment efficiency do not achieve statistical significance. Conversely, in SOEs, the policy's net effect ($Treat_i*Time_t$) and heavy-polluting enterprise labor investment efficiency exhibit a positive correlation at the 1% level of significance. The intergroup coefficient variation among the two ownership types is significant at the 1% level, suggesting that the NEPL's effect on enterprise labor investment efficiency varies depending on ownership. A plausible explanation for this disparity lies in the fact that SOEs have the government as their

Table 8. Analysis of labor investment efficiency types.

Variable	*OverLI*	*UnderLI*
*Treat*Time*	-0.0025 (-1.52)	-0.0032*** (-3.76)
Constant	0.1869*** (6.05)	0.0158 (0.89)
N	6447	8245
Controls/Year/Firm	YES	YES
R-squared	0.7601	0.6120
Coefficient of difference between groups	-0.0020***	

Note: The t-values calculated for robust standard errors of clustering at the individual level are in parentheses. ***, **, and *indicate significance at the 1%, 5%, and 10% levels, respectively.

actual controller and environmental performance serves as a pivotal assessment metric for both the government and its principals. Consequently, the government is inclined to transfer environmental pressure onto SOEs, compelling them to adhere more rigorously to NEPL provisions. Resource dependence theory emphasizes that in order to survive and develop, enterprises need to obtain key resources from the external environment [35]. Compared to non-SOEs, SOEs exhibit a heightened focus on fulfilling their social responsibilities, actively engaging in green technology innovation activities, and are more adept at securing the necessary funds and resources for development. Consequently, the NEPL's influence on SOEs' labor investment efficiency becomes more apparent.

Types of Labor Investment Efficiency

Building upon the insights of Jung et al. [30] and utilizing the regression outcomes of the model (1), we further dissect labor investment efficiency (*LABEFF*) into labor overinvestment (*OverLl*) and labor underinvestment (*UnderLl*) based on the residuals' positive and negative values. Positive residuals signify that the actual employment level of enterprises surpasses expectations, indicating labor overinvestment. Conversely, negative residuals denote that the actual employment level falls short of expectations, signaling labor underinvestment. Subsequently, the dependent variable of the model (2) is sequentially substituted for regression, and then the outcomes are elaborated in Table 8. The policy's net effect ($Treat_i$*$Time_t$) and heavy-polluting enterprise labor overinvestment (*OverLl*) do not attain statistical significance. However, the coefficients of the net effect of policy ($Treat_i$*$Time_t$) and heavy-polluting enterprise labor underinvestment (*UnderLI*) exhibit an obvious positive connection at the 1% level. This suggests that the NEPL mitigates heavy-polluting enterprise labor underinvestment, while its impact on suppressing heavy-polluting enterprise labor overinvestment is not statistically significant. The substantial alleviation of enterprise labor underinvestment under the NEPL is attributed to its compulsion for heavy-polluting enterprises to innovate in green technology and employ highly educated and qualified talents. Additionally, the resource support policies accompanying the NEPL furnish enterprises with ample funds for labor investment. Conversely, the limited role of the NEPL in curbing excessive labor investment may be attributed to the reinforcement of worker protection through the Labor Contract Law enacted in China in 2007. This enhanced protection has augmented the difficulty for heavy-polluting enterprises to terminate labor contracts during layoffs, intensifying the stickiness of labor costs. Consequently, the heightened labor protection impedes enterprises from implementing effective measures to reduce staff and enhance efficiency in response to the NEPL.

Conclusions

We collect data from China's corporations listed on the A-share market in both Shanghai and Shenzhen across a decade, from 2010 through 2020. The research sample divides listed enterprises in heavy pollution industries into the experimental group and those in non-heavy pollution sectors as the comparison group. Employing an empirical approach with a constructed DID model, the investigation delves into the NEPL's influence on enterprise labor investment efficiency. The main conclusions may be succinctly described as follows: The NEPL's implementation significantly enhances the heavy-polluting enterprise labor investment efficiency. This finding has been confirmed by several rigorous tests to ensure its validity. Further analysis discerns that the NEPL predominantly influences heavy-polluting enterprise labor investment efficiency by fostering green technology innovation and reducing financial restrictions. Moreover, the NEPL exerts a more pronounced effect on the heavy-polluting enterprise labor investment efficiency in locations with low levels of marketization and low labor intensity and among state-owned enterprises (SOEs). Notably, the NEPL's influence on heavy-polluting enterprise labor investment efficiency is primarily shown by the reduction of labor underinvestment.

We put forth the subsequent recommendations:

Firstly, governmental entities should bolster environmental regulation legislation and enhance enforcement and oversight mechanisms. The notable improvement in heavy-polluting enterprise labor investment efficiency and the alleviation of labor underinvestment resulting from the implementation of the NEPL underscore its effective application, particularly within heavily polluting listed enterprises. It is advised that law enforcement and regulatory authorities rigorously uphold NEPL measures and

embrace a regulatory framework aligned with the principles of sustainable development. Simultaneously, the government ought to amplify its support for corporate resources. The NEPL's capacity to enhance enterprise labor investment efficiency by mitigating enterprise financial restrictions implies that, alongside stringent regulation, the government should augment resource support for enterprises in compliance with the NEPL. This approach aims to bolster enterprises' willingness to actively engage in environmental governance, fostering a realization of sustainable development.

Secondly, government departments should institute tailored environmental regulatory policies for enterprises based on varying degrees of marketization, labor intensity, and property rights. The pronounced favorable effect on heavy-polluting enterprise labor investment efficiency is predominantly observed in regions characterized by low marketization, low labor intensity, and SOEs. This implies that in further developing more precise environmental regulations, the government should take into account the marketization dynamics across diverse regions and the labor resource characteristics of enterprises. This strategic strategy seeks to attain a mutually advantageous result for both environmental and economic goals.

Thirdly, enterprises are encouraged to augment research and development investments in green technology innovation while fostering an ethos of "green technology innovation drives sustainable development". Our results suggest that the NEPL enhances the effectiveness of allocating human resources by encouraging the advancement of innovative green technologies in businesses. Consequently, enterprises are advised to align with the trajectory of China's green development, uphold independent green innovation, and swiftly and adeptly transition into environmentally friendly green enterprises. This proactive stance not only facilitates improvements in enterprise labor investment efficiency but also promotes the realization of sustainable economic development for enterprises.

Theoretical and practical significances:

We empirically analyze the impact of the NEPL on heavy-polluting enterprise labor investment efficiency based on the perspectives of green technology innovation and financial restrictions. This not only enriches the existing literature on the effects of the NEPL on corporate behavior but also provides theoretical support for policymakers, helping to understand the specific mechanisms by which the NEPL enhances the enterprises' labor resource allocation efficiency.

From the government's perspective, the NEPL improves environmental quality and enhances heavy-polluting enterprise labor investment efficiency, thereby contributing to the goal of stable employment. This conclusion provides empirical support for the government, indicating that environmental policies can balance both environmental protection and economic development goals. From the corporate perspective, this conclusion helps enterprises to make reasonable labor investments through appropriate means when facing strict environmental regulations, thereby ensuring stable labor investment efficiency. Moreover, our results help enterprises avoid penalties for violating environmental policies, reducing environmental costs. This promotes and supervises enterprises to take on more environmental responsibilities in turn, which is significant for their sustainable development.

Limitations and future directions:

Firstly, the exploration of the impact mechanism of the NEPL on heavy-polluting enterprise labor investment efficiency is not thorough enough. There are multiple pathways through which the NEPL affects heavy-polluting enterprise labor investment efficiency. We only explore from the perspectives of green technology innovation and financial restrictions, which may not fully cover all potential mechanisms. Future research can further explore aspects such as corporate risk-taking and management incentives to enrich the research content on the impact mechanism of the NEPL on heavy-polluting enterprise labor investment efficiency. Secondly, in analyzing the impact of heterogeneity, only the degree of marketization, labor intensity, the nature of enterprises, and types of labor investment efficiency were considered to explore the impact of their heterogeneity on the economic benefits of the NEPL. In the future, more macroeconomic or microenterprise factors can be included in the research for more detailed heterogeneity analysis.

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The Authors declare that there is no conflict of interest.

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Credit Author Statement

Mei Xue: Conceptualization, Formal analysis, Methodology, Writing-review & editing. Jiejing Ma: Conceptualization, Validation, Formal analysis, Writing-

original draft, Data curation, Writing-Empirical results, Empirical analysis, Writing-review & editing.

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