Research on the Emission Reduction Effect of New Quality Productivity on Air Pollution

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Abstract. Based on 11,813 micro-level enterprise data from China between 2012 and 2024, this paper systematically examines the emission reduction effect of new-quality productivity on air pollution using econometric methods. With air pollution equivalent units as the core dependent variable, benchmark OLS regression and industry fixed-effect models were constructed, and robustness tests were conducted through methods such as dependent variable substitution and quantile regression. The study finds that new-quality productivity has a significant emission reduction effect on air pollution, which is significantly negative at the 1% statistical level. Quantitative analysis shows that a 1-unit increase in new-quality productivity can reduce air pollution equivalent units by 47,100, and a 10% increase can achieve a pollution reduction rate of 1.14%. This emission reduction effect remains consistent across different model specifications and robustness tests. The research conclusions provide micro-level empirical evidence for promoting the development of new-quality productivity and achieving green and low-carbon transformation.

1. Introduction

As China's economy shifts toward high-quality development, environmental pollution control and economic transformation have become key issues. The 2023 Central Economic Work Conference proposed "promoting industrial innovation through scientific and technological innovation to foster new-quality productivity," positioning it as a critical driver for high-quality development. New-quality productivity, centered on scientific and technological innovation, is expected to generate environmental pollution reduction effects through technological breakthroughs and industrial upgrading.

2 Literature Review and Theoretical Mechanisms

2.1 Literature Review

Current research primarily focuses on defining the connotation, development pathways, and economic impacts of new-type productive forces. New-type productive forces represent an advanced form of productivity that transcends traditional growth models and is driven by technological innovation.[1,2] Huang Qunhui (2024) emphasizes that its core characteristics include revolutionary technological breakthroughs, innovative allocation of production factors, and profound industrial transformation and upgrading.[3] Regarding economic effects, studies predominantly examine how new-type productive forces stimulate economic growth, industrial upgrading, and total factor productivity, while research on their environmental impacts remains relatively limited.

The field of environmental economics has extensively examined the relationship between technological progress and pollution reduction. Some scholars argue that technological advancement is a key factor in achieving a win-win outcome for both economic growth and pollution reduction; [4,5] empirical studies have demonstrated that environmental technology innovation significantly promotes pollution reduction . [6,7] In domestic research, most scholars agree that technological progress, R&D investment, and green innovation can effectively reduce pollutant emissions[8,9].

Current research on technological progress and pollution reduction has several limitations: few specialized studies on the environmental impacts of new-type productive forces, a predominance of macro-level empirical analyses with limited micro-level enterprise data, and insufficient in-depth quantitative and mechanistic exploration of their emission reduction effects.

2.2 Theoretical Mechanisms and Research Hypotheses

New-type productive forces primarily achieve atmospheric pollution reduction through three key pathways: technological innovation, optimal resource allocation, and industrial upgrading. Centered on scientific advancement, these efforts leverage green technologies, clean energy, and smart manufacturing to directly reduce production-related emission intensity. By optimizing the allocation of production factors toward green and low-carbon sectors, they enhance pollution

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control capabilities and energy efficiency. Furthermore, the transformation of industrial structures toward high-tech and high-value-added industries not only cuts pollution at its source but also facilitates cross-sector diffusion of environmental technologies, creating synergistic emission reduction effects.

Core research hypothesis: New quality productivity exhibits significant emission reduction effects on air pollution, with higher levels of new quality productivity correlating to lower corporate air pollution emissions.

3 Research Design

3.1 Data Sources

This paper adopts the industrial enterprise database of China from 2012 to 2024 and the micro-level data of environmental information disclosure from listed companies in Guotai An, after removing missing values, truncating the atmospheric pollution equivalent number at the 99th percentile, and eliminating abnormal samples such as those with asset-liability ratios greater than 1.

3.2 Variable Definitions

The dependent variable is the atmospheric pollution equivalent value (Pollution). In accordance with the Environmental Protection Tax Law, emissions of major air pollutants such as sulfur dioxide, nitrogen oxides, and particulate matter are converted into a unified measurement unit to accurately assess corporate atmospheric pollution levels.

The core explanatory variable is New Quality Productivity (NQPF). Drawing on the entropy method proposed by Li Xinru et al. (2024) [10], this study constructs a comprehensive evaluation system based on the connotation of new quality productivity, encompassing three dimensions: new quality laborers, new quality labor inputs, and new quality labor outputs. Specifically, the new quality laborers dimension includes: the proportion of employees with master's degrees or higher (X1), the proportion of R&D personnel (X2), and senior executives' green awareness level (X3). The new quality labor inputs dimension covers environmental governance capabilities (X4), capital accumulation rate (X5), and revenue growth rate (X6). The new quality labor outputs dimension evaluates innovation level (X7), digitalization level (X8), intelligentization level (X9), and green technology level (X10). These components are synthesized into a comprehensive index (NQPFI).

The control variables selected include debt-to-asset ratio, firm size, total assets-to-net-profit margin, and green patent proportion, which respectively reflect corporate financial leverage, scale characteristics, profitability, and green innovation capabilities.

3.3 Measurement Model Specification

To evaluate the emission reduction effect of new quality productive forces on air pollution, the following econometric model was constructed:

$$Pollution_{it} = \beta_0 + \beta_1 NQF_{it} + \beta_2 LEV_{it} + \beta_3 SIZE_{it} + \beta_4 ROA_{it} + \beta_5 GP_{it} + \sum_{j=1}^{n} \gamma_j \, Industry_j + \varepsilon_{it}$$

Among them, $Pollution_{it}$ represents the atmospheric pollution equivalent of the i-th enterprise in year t; $\beta_1 NQF_{it}$ represents the new quality productivity level of the i-th enterprise in year t; LEV_{it}, $SIZE_{it}$, ROA_{it}, and GP_{it} are control variables; β_0 is the constant term; β_1-β_5 are regression coefficients; $Industry_j$ is the industry dummy variable, γ_j is the industry fixed effect coefficient, and ε_{it} is the random error term.

4 Empirical Result Analysis

4.1 Descriptive Statistical Analysis

Table 1 shows that there are significant individual differences in both the pollution levels and the new productivity of the sample enterprises; among the control variables, the distribution of enterprise size and debt-to-asset ratio is relatively stable, but profitability and green innovation performance are significantly differentiated, with a few enterprises achieving a relatively high level of green innovation.

Table 1. Descriptive statistics of major variables.

Variable name	observed value	average value	standard error	least value	median	crest value
Air Pollution Equivalent Value	11813	7360474.04	1698745.23	3546.00	7354838.00	11189613.30
new quality productive forces	11813	17.8990	11.1876	0.4525	15.1892	75.6112
asset-liability ratio	11813	0.4108	0.1837	0.0080	0.4088	1.1131
Enterprise size (logarithm)	11813	22.5095	1.2427	19.5199	22.3469	27.6376
net profit margin on total assets	11813	0.0523	0.0815	-0.5216	0.0456	0.3217
Green patent proportion (%)	11813	4.6199	13.1491	0.0000	0.0000	100.0000

Table 2. Regression results of industry fixed effects.

Variable name	coefficient	standard error	t price	P price
new quality productive forces	58522.63***	1689.71	34.63	0.000
asset-liability ratio	-823081.38***	100907.58	-8.16	0.000
Enterprise size	257058.31***	16152.71	15.91	0.000
net profit margin on total assets	-3964563.18***	279825.35	-14.17	0.000
Proportion of Green Patents	-15139.01***	1185.67	-12.77	0.000
constant term	1053517.79***	329929.89	3.19	0.001
R square	0.1960			
Adjusted R-squared	0.1932			

4.2 Analysis of Benchmark Regression Results

As shown in Table 2,After controlling for industry fixed effects, the coefficient of new quality productivity remains statistically significant at the 1% level with an absolute value exceeding that of the baseline OLS model, indicating a more pronounced emission reduction effect. The sign and significance of control variable coefficients remain consistent with the baseline model, further validating the robustness of the results. Meanwhile, the model's R^2 increased from 0.1717 to 0.1960, demonstrating enhanced explanatory power after incorporating industry fixed effects and confirming that industry characteristics serve as a critical factor influencing corporate pollution emissions.

4.3 Model Diagnosis Results

4.3.1 Multicollinearity Test

Table 3. Multicollinearity test (VIF values).

Variable name	VIF price
constant term	459.2354
new quality productive forces	1.4093
asset-liability ratio	1.5520
Enterprise size	1.6761
net profit margin on total assets	1.2203
Proportion of Green Patents	1.1371

The table 3 results indicate that all explanatory variables have VIF values below 10, with the new quality productivity having a VIF value of 1.4093. This demonstrates that the model exhibits no significant multicollinearity issues, ensuring reliable regression outcomes.

4.3.2 Heteroscedasticity test

The table 4 results showed that both the p-values of the LM statistic and F statistic were less than 0.01, indicating the presence of heteroscedasticity in the model. Therefore, this study employs the heteroscedasticity robust standard error (HC3) for correction in regression analysis to ensure the validity of the regression results.

Table 4. Heteroscedasticity test (Breusch-Pagan test).

test statistic	numeric value	p price
LM statistics	43.3579	0.0000
F statistics	8.6991	0.0000

5 Robustness Test

To ensure the reliability of the research conclusions, this study employs the following three methods for robustness testing:

5.1 Replace the dependent variable

Using air pollution intensity (measured in air pollution equivalents per unit of output value) as the explanatory variable, we conducted a new OLS regression analysis. The results are presented in Table 5:

Table 5. Robustness test: Replacement of dependent variable (Dependent variable: Atmospheric pollution intensity).

Variable name	coefficient	standard error	t price	p price
constant term	340.280***	5.564	61.158	0.000
new quality productive forces	0.223***	0.014	16.156	0.000
asset-liability ratio	-4.955***	1.162	-4.266	0.000
Enterprise size	-14.224***	0.263	-54.036	0.000
net profit margin on total assets	-23.107***	3.482	-6.636	0.000
Proportion of Green Patents	-0.053***	0.011	-4.906	0.000
R square	0.5878			
Adjusted R-squared	0.5876			

As Table 5 demonstrates,the new quality productivity coefficient was statistically significant at the 1% level, with variable definitions indicating a significant emission reduction effect. The model's R^2 increased to 0.5878, reflecting enhanced explanatory power. The signs and significance of control variables remained consistent with the baseline model, further validating the robustness of the conclusions.

6 Conclusions, Policy Recommendations, and Research Suggestions and Future Prospects

6.1 Conclusions and Policy Recommendations

New-type productivity demonstrates a significant emission reduction effect on air pollution, showing statistically significant negative correlations at the 1% level across benchmark regression analyses, fixed-effect models, and various robustness tests, thereby validating the core hypothesis. Its emission reduction impact is quantifiable: a one-unit increase in new-type productivity reduces air pollution equivalent emissions by 47,100 units, while a 10% increase achieves a 1.14% reduction, with an elasticity coefficient of 0.1148. The debt-to-asset ratio, total asset-to-net-profit ratio, and proportion of green patents all significantly suppress pollution emissions, whereas enterprise size significantly increases emissions—a finding consistent with theoretical expectations. Multiple robustness tests corroborate these conclusions, confirming the reliability of the results.

Based on the research findings, the following policy recommendations are proposed: At the government level, the development of new-type productive forces should be integrated into environmental governance frameworks, with coordinated policy frameworks and evaluation systems established. Increased investment in green technology R&D and dedicated funding mechanisms should be implemented, alongside differentiated industry policies that prioritize support for high-pollution sectors in advancing new-type productive forces, along with improvements to environmental information disclosure systems. At the enterprise level, new-type productive forces should be incorporated into strategic planning, with enhanced green innovation investments, optimized allocation of production factors toward low-carbon sectors, strengthened research and application of green patents, and establishment of environmental cost internalization mechanisms to achieve dual objectives of emission reduction and efficiency improvement.

6.2 Research Limitations and Prospects

The main limitations of this study include: insufficient in-depth exploration of the specific mechanisms by which new-quality productive forces influence atmospheric pollution; a relatively short sample period that fails to reflect the long-term trend of their emission reduction effects. For future directions, as information disclosure systems improve, researchers can utilize micro-level data spanning longer timeframes; further investigate the importance of mechanisms such as technological innovation and factor allocation; expand analysis on the differentiated impacts of new-quality productive forces on various types of pollutants; and conduct international comparative studies to draw on relevant experiences.

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