THE EFFECT OF THE ENVIRONMENTAL PROTECTION TAX LAW ON NEW QUALITY PRODUCTIVE FORCES: EMPIRICAL EVIDENCE FROM PREFECTURE-LEVEL CITIES IN CHINA

ZHENG, H.[1*] – HE, Y.[2]

[1]*School of Economics and Management, Chongqing Jiaotong University, Chongqing 400074, PR China*

[2]*School of Finance, Chongqing Technology and Business University, Chongqing 400067, PR China*

**Corresponding author*
e-mail: huan.zheng@cqjtu.edu.cn; phone: +86-152-2310-1834

(Received 13th Sep 2025; accepted 15th Dec 2025)

Abstract. To address the ecological crisis and achieve sustainable development, the Chinese authorities put forward new quality productive forces and have announced a series of environmental policies in recent years. This study employs a spatial difference-in-differences approach to explore whether the Environmental Protection Tax Law affects new quality productive forces by using panel data for 273 prefecture-level cities in China during 2014-2021. The findings demonstrate that the Environmental Protection Tax Law has a positive (negative) direct (spillover) impact on new quality productive forces, and this result holds following several robustness tests. Our additional tests further reveal that (a) the Environmental Protection Tax Law exhibits significant temporal dynamics, with stably persistent effects throughout the study period; (b) in the heterogeneity analysis, the Environmental Protection Tax Law has a positive direct effect in both high and low administrative-level cities and a positive (negative) indirect impact in high (low) administrative-level cities; (c) the Environmental Protection Tax Law affects new quality productive forces through industrial structure upgrading; and (d) there is an increasing marginal influence of the Environmental Protection Tax Law on new quality productive forces when technology innovation is considered. This study has scientific reference value for improving China's environmental legal system and promoting sustainable development.
Keywords: *sustainable development, industrial structure upgrading, technology innovation, spatial difference-in-differences approach, mediating effect analysis*

Introduction

Over the past 40 years of reform and opening up, China's economy has achieved rapid growth. However, the traditional development model that only focuses on economic benefits and ignores the overall ecological balance has also led to a series of environmental issues and energy waste, severely hindering the process of urban sustainable development. With growing constraints on resources and the ecological environment, Chinese authorities recently replaced traditional productive forces with new quality productive forces (NQPF). Unlike the traditional productive forces, NQPF emphasizes the integrated development of "new" and "quality", meaning advanced productive forces driven by innovative reallocation of production factors, revolutionary technological breakthroughs, and deep industrial transformation and upgrading. Developing new quality productive forces is the inherent requirement and an important focus of promoting sustainable development, and its core lies in restructuring the tripartite equilibrium among productive forces, production relations, and natural relations through scientific and technological innovation. Furthermore, the authorities have implemented a

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

series of coordinated economic and environmental policies to promote sustainable development, with the Environmental Protection Tax Law (EPTL) serving as a pivotal economic-environmental policy. Its implementation plays a significant role in environmental protection and improvement, pollutant emission reduction, ecological civilization advancement, and achieving sustainable economic growth.

Existing literature has explored the influencing mechanisms of NQPF from multiple dimensions, including technological innovation (Tang, 2024; Wang et al., 2025), public data openness (Zhong et al., 2025), new-type urbanization (Gao et al., 2025), and digital economy (Zheng et al., 2025). The EPTL is the first special tax law which reflecting the “green tax system” in China, and its implementation opens a new chapter in the construction of ecological civilization. Nevertheless, few studies, as far as we know, have discussed such an important policy’s impact pathways on NQPF. Furthermore, prior research has confirmed that environmental regulations exert spatial spillover effects (Song et al., 2021; Yang et al., 2025). To address this research gap, this study employs a spatial difference-in-differences (SDID) approach to investigate how the EPTL affects NQPF.

As for the empirical analysis, we first examine the spatiotemporal evolution trend of NQPF during the study period and find that the overall NQPF level maintained a steady upward trend between 2014 and 2021. Specifically, the spatial agglomeration effect was further enhanced due to the formation of more concentrated high-value clusters; the east-west development gap narrowed moderately; and a distinct north-south gap became increasingly prominent in the spatial distribution of NQPF, with the southern region outperforming the northern region. Subsequently, we apply the SDID approach to investigate whether and how the EPTL influences NQPF of 273 cities during 2014-2021. According to the EPTL, local tax rates are set by local governments. For the SDID analysis, we thus categorize the 158 (115) cities with increased (maintained) tax rates as the treated (control) group. Through the parallel trend test, we confirm that the SDID model is appropriate for our research. The main test demonstrates that the EPTL has a significant positive direct impact on NQPF while exerting a significant negative indirect (spatial spillover) impact. This finding remains robust after several robustness tests. Furthermore, we conduct several additional tests to investigate the EPTL’s effects under various situations: (a) a dynamic effect analysis shows that the EPTL exhibits significant temporal dynamics, with stably persistent effects throughout the study period; (b) a heterogeneity analysis indicates that the EPTL exerts a promotional direct impact on NQPF in both high and low administrative-level cities, while generating a positive indirect impact in high administrative-level cities and a negative indirect impact in low administrative-level cities; (c) a mediating effect analysis demonstrates that industrial structure upgrading serves as a mediating channel through which the EPTL influences NQPF; (d) a threshold effect analysis demonstrates an increasing marginal impact of the EPTL on NQPF when technology innovation is considered.

Our study makes five key contributions: (a) to our knowledge, few studies has explicitly investigated the impact of the EPTL on NQPF. Existing relevant literature mainly focuses on two separate strands: one explores the impacts of the EPTL on traditional economic indicators, such as green total factor productivity (Yang et al., 2024) and low-carbon total factor productivity (Kong et al., 2024b), while the other investigates the determinants of NQPF from perspectives including technological innovation (Tang, 2024; Wang et al., 2025) and digital economy (Zheng et al., 2025). However, empirical research directly linking EPTL to NQPF remains scarce, and this study fills the critical

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

gap by systematically exploring this understudied yet important relationship; (b) our findings enrich the macro-level empirical testing of the Porter Hypothesis by revealing the spatial correlation between the EPTL and NQPF, thereby providing a novel theoretical framework for investigating the economic impacts of environmental policies; (c) we identify the mediating role of industrial structure in the effect of the EPTL on NQPF, suggesting that industrial structure upgrading serves as a viable policy lever for promoting NQPF; (d) our threshold effect analysis confirms the existence of a threshold effect of technology innovation in the impact of the EPTL on NQPF, which provides a reference for local governments to optimize the scale and direction of technology innovation investment; (e) our findings may inspire other emerging markets to implement environmental policies similar to the EPTL for promoting NQPF.

Policy and literature review

Policy review

To address environmental pollution challenges and promote sustainable development, the Chinese authorities introduced the Pollution Discharge Fee in 1982. Despite two revisions in 2003 and 2014, the policy's effectiveness in environmental governance remained limited over nearly four decades, primarily due to low fee standards and weak legal enforcement. In order to solve this problem, the Chinese authorities enacted the EPTL on December 25, 2016, which was officially implemented on January 1, 2018.

According to the EPTL, the primary taxpayers are entities and individuals that directly discharge taxable pollutants into the environment, including solid waste, Noise pollutants, atmospheric pollutants, and water pollutants. Furthermore, the central government only sets floating rate ranges for taxable items, while local governments determine specific tax rates based on regional environmental carrying capacity. Compared with the pollution discharge fee, the EPTL implementation has resulted in divergent rate adjustments across provinces and municipalities: some have significantly increased tax rates to align with stricter environmental objectives, and others have maintained the original fee levels to balance economic development and ecological considerations. Therefore, this study classifies prefecture-level cities that have increased tax rates as the treated group and those that have maintained rates as the control group. The details of these two groups are presented in *Figure 1*.

Literature review

Exploring whether the EPTL can promote NQPF is crucial for the sustainability of economic growth. Scholars have conducted numerous studies on the EPTL's policy effect, with a primary focus on its influence on environmental quality and economic development.

From the perspective of environmental quality, some scholars have asserted that the EPTL may notably improve environmental quality, including Hu et al. (2019), Wang and Li (2019), Han and Li (2020), Gao et al. (2022), Xu et al. (2023), Xu and Li (2025), and Wei et al. (2024). For instance, Gao et al. (2022) detected that the EPTL plays a critical role in enhancing the synergistic effects of carbon emission reduction and pollution control. Han and Li (2020) proved that the EPTL contributed to a measurable reduction in annual PM2.5 concentrations. Hu et al. (2019) demonstrated that the EPTL effectively reduces air pollutants emissions. Xu et al. (2023) discovered that the EPTL has a spillover

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

impact on reducing pollutant emissions. Moreover, Wei et al. (2024) and Xu and Li (2025) found that the EPTL notably reduces corporate carbon emissions. However, other scholars have argued that increasing environmental protection tax rates does not necessarily lead to greater emission reductions, as there is an inverted U-shaped relationship between tax rates and pollutant emission (Li et al., 2021).

***Figure 1.** Treated and control groups*

From the perspective of economic development, some scholars have mostly investigated the beneficial effects of the EPTL in terms of energy efficiency (Kong et al., 2024a; Jin et al.,2024), green total factor productivity (Yang et al., 2024), industrial ecology efficiency (Kong et al., 2025), low-carbon total factor productivity (Kong et al., 2024b), and labor demand (Xu et al.,2025). Nonetheless, other scholars have stated that the EPTL exerts a significant negative impact on green total factor energy efficiency (Su and Li, 2025) and aggravates economic inequality between cities (Wang et al., 2021).

Moreover, some scholars have also conducted research at the microeconomic level, showing that the EPTL might introduce positive effects on enterprises' total factor productivity (He et al., 2022; Yang et al., 2023), firm performance (Zhao et al., 2022), corporate environmental investment (Liu et al., 2022), corporate ESG (He et al., 2023; Li and Hua, 2024), and enterprises' green technology innovation (Wang et al., 2024; Su et al., 2025). On the contrary, some other studies have proposed that the EPTL might impair corporate performance. To be specific, Long et al. (2022) observed a harmful effect of the EPTL on heavy polluter productivity. Cheng et al. (2022) demonstrated that the EPTL has an inhibiting influence on corporate environmental investment. Xie et al. (2023) found that the EPTL significantly reduces enterprises' investment efficiency.

To sum up, existing literature predominantly focuses on the EPTL's impacts on environmental quality and economic development. However, a critical research gap persists regarding the relationship between the EPTL, a representative market-based environmental regulation policy, and NQPF. Given that NQPF has emerged as a core

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

indicator of high-quality economic development, investigating the EPTL's impact on NQPF is an essential dimension for evaluating the policy's comprehensive effectiveness. Moreover, prior studies (Song et al., 2021; Yang et al., 2025) have confirmed that environmental regulation exhibits spatial spillover effects, yet the direction and mechanism of such effects in the context of NQPF remain unexamined.

To address this gap, this study employs panel data of 273 prefecture-level cities in China from 2014 to 2021, treats the EPTL's implementation as a quasi-natural experiment, and adopts the SDID method to empirically explore the spatial effects of the EPTL on NQPF. From a theoretical perspective, the EPTL's core policy logic lies in internalizing environmental costs to impose regulatory pressure on the industrial sector. As noted in existing research (Zhao et al., 2025), this policy-induced cost pressure forces high-pollution, low-efficiency enterprises to withdraw from the market or adopt clean production technologies. This process drives the green and intelligent transformation of traditional industries and promotes industrial structure upgrading. Furthermore, industrial structure upgrading can foster NQPF through three key channels. The first is technological penetration, which refers to the integration of advanced technologies into industrial production. The second is factor restructuring, involving the reallocation of production factors toward high-value-added sectors. The third is industrial synergy, which denotes the coordinated development of upstream and downstream industries in the green and digital value chains.

From the perspective of direct effects, the Porter Hypothesis suggests that environmental regulation can induce enterprises to engage in technology innovation and efficiency improvement to offset compliance costs. This mechanism implies that the EPTL may exert a positive impact on NQPF in policy-implementing regions. From the perspective of spatial spillover effects, inter-regional pollution haven effects may arise. Policy-implementing regions may transfer high-pollution, low-efficiency industrial sectors to neighboring areas with relatively looser environmental constraints, which could inhibit NQPF development in the neighboring regions. Additionally, regarding the transmission path, the EPTL aims to impose regulatory pressure on the industrial sector by increasing pollution costs and increasing pollution compliance burdens. This pressure forces the withdrawal of inefficient production capacity and encourages enterprises to adopt clean technologies, thereby promoting the green and intelligent upgrading of industrial structure. In turn, industrial structure upgrading enhances resource allocation efficiency and strengthens technology innovation capabilities, which may further contribute to NQPF development.

Based on the above theoretical analysis and research context, the following testable hypotheses are proposed:

H1: The EPTL has a significant positive direct effect on NQPF in policy-implementing regions and a significant negative indirect effect on NQPF in neighboring regions.

H2: Industrial structure upgrading plays a mediating role in the impact of the EPTL on NQPF.

Materials and methods

Methods

To clarify the core logic of the empirical study, a sketch summarizing the research framework is presented in *Figure 2*. This framework visually illustrates the multi-dimensional analytical design, including the core relationship between the EPTL and NQPF,

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

as well as the spatial spillover effect captured by the spatial econometric model, the mediating role of industrial structure upgrading, and the threshold effect of technology innovation.

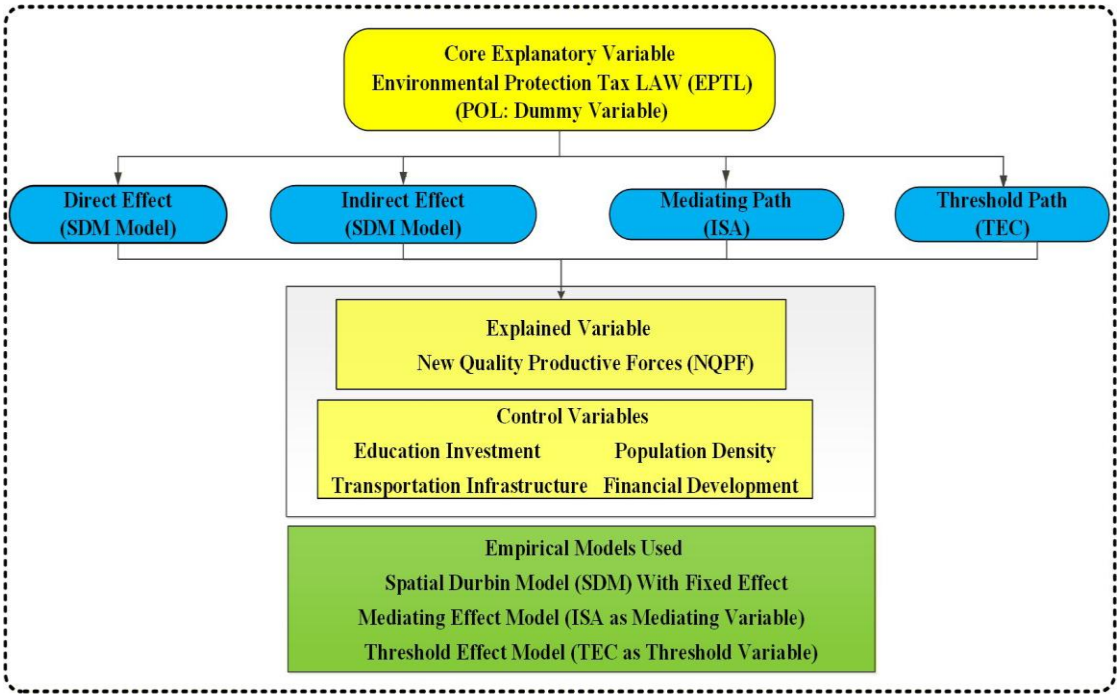

Figure 2. *Research framework of the empirical study*

Spatial Durbin model (SDM)

Considering the significant spatial autocorrelation of NQPF, our study adopts the spatial econometric method for data analysis. Based on model selection tests' results, we employ the SDM with fixed effect to examine how the EPTL affects NQPF. *Equation 1* is specified as follows:

$$NQPF_{i,t} = \beta_0 + \rho\sum_{j=1}^{273} w_{ij} NQPF_{i,t} + \beta_1 POL_{i,t} + \beta_2 X_{i,t} + \theta_1 \sum_{j=1}^{273} w_{ij} POL_{i,t} + \theta_2 \sum_{j=1}^{273} w_{ij} X_{i,t} + \mu_i + v_t + \varepsilon_{i,t} \quad \text{(Eq.1)}$$

where *i and t* stand for city and year, and *j* denotes nearby cities (*i≠j*), respectively; *NQPF* (new quality productive forces) measured by a comprehensive evaluation index system consisting of 11 indicators across 3 dimensions: new quality labor forces, new quality labor objects, and new quality labor materials; *POL* is a dummy variable assigned a value of 1 if a city is located in provinces or municipalities with tax rate increases and the observation year is 2018 or later, and 0 otherwise; *X* represents the control variables, including education input, population density, transportation infrastructure, and financial development; *ρ* (spatial autocorrelation coefficient) reflects the spatial spillover intensity; β_1 and β_2 denotes the direct impacts, which are defined as the effect of *POL* on *NQPF* of city *i* itself. In contrast, the indirect effects (θ_1, θ_2) are derived from the interaction between the spatial autocorrelation coefficient (*ρ*) and the direct effect coefficients, measuring the spatial spillover effect of the policy on nearby cities *j*, following the spatial

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

econometric framework proposed by Lesage and Pace (2009); v_t denotes the time fixed effect, included to control for macroeconomic shocks and time-varying factors common to all cities; μ_i represents the individual fixed effect, added to eliminate unobservable city-specific characteristic; $\varepsilon_{i,t}$ denotes the random disturbance term; w_{ij} stands for the economic-geographical nested matrix, which is constructed to capture the dual spatial correlations of economic links and geographical proximity. Following He et al. (2024), the specific form of this matrix is defined in *Equation 2* as follows:

$$w_{ij} = \begin{cases} \frac{1}{d_{ij}} * \frac{1}{\left|\overline{pgdp_i} - \overline{pgdp_j}\right|} & i \neq j \\ 0 & i=j \end{cases} \quad \text{(Eq.2)}$$

where d_{ij} refers to the geographical distance between region *i* and region *j*; $\overline{pgdp_i} = \sum_{t=T_0}^{T} pgdp_{i,t} / (T - T_0)$.

Mediating effect model

This research investigates how the EPTL affects NQPF when the industrial structure is considered. In specific, we employ industrial structure as a mediating variable and construct a three-step mediation model, with the specific equations presented as *Equations 3*, *4*, and *5* below:

$$NQPF_{i,t} = \beta_0 + \beta_1 POL_{i,t} + \beta_2 X_{i,t} + \mu_i + v_t + \varepsilon_{i,t} \quad \text{(Eq.3)}$$

$$ISA_{i,t} = \beta_0 + \beta_1 POL_{i,t} + \beta_2 X_{i,t} + \mu_i + v_t + \varepsilon_{i,t} \quad \text{(Eq.4)}$$

$$NQPF_{i,t} = \beta_0 + \beta_1 POL_{i,t} + \beta_2 ISA_{i,t} + \beta_3 X_{i,t} + \mu_i + v_t + \varepsilon_{i,t} \quad \text{(Eq.5)}$$

In the above equation, *ISA* stands for industrial structure upgrading, and other variables are consistent with those described in *Equation 1*.

Threshold effect model

We further investigate how the EPTL affects NQPF by incorporating technology innovation as a threshold variable, employing a threshold effect model specified in *Equation 6* as follows:

$$\begin{aligned} NQPF_{i,t} &= \alpha_{i,t} + \beta_{i,t}^{1} POL_{i,t} * I(TEC_{i,t} \leq \delta_1) + \beta_{i,t}^{2} POL_{i,t} * I(\delta_1 \prec TEC_{i,t} \leq \delta_2) + \ldots \\ &+ \beta_{i,t}^{n} POL_{i,t} * I(\delta_{n-1} \prec TEC_{i,t} \leq \delta_n) + \beta_{i,t}^{n+1} POL_{i,t} * I(TEC_{i,t} \succ \delta_n) + \theta_{i,t} X_{i,t} + \mu_i + v_t + \varepsilon_{i,t} \end{aligned} \quad \text{(Eq.6)}$$

In the above equation, *I(·)* refers to an indicator function. *NQPF* is the threshold dependent variable, *POL* is the threshold independent variable, and *TEC* (technology innovation) stands for the threshold variable, with other variables consistent with *Equation 1*.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

Variable selection

Explained variable: NQPF

Following the relevant studies (Gao et al., 2025; Zheng et al., 2025), we establish a new evaluation system of NQPF with 11 factors in 3 dimensions, including new quality labor forces, new quality labor objects, and new quality labor materials. In this study, the entropy method is employed to determine the weight of each indicator. Details of the NQPF evaluation index system are reported in *Table 1*.

Table 1. *NQPF index system*

Dimensions	Component indicators	Explanation of indicators	Direction
New quality labor forces	Number of employees in emerging industries	Total workforce of listed companies in strategic emerging industries and future sectors	+
	Employee personal ability	Average wage of workforce on the job	+
	High quality of employee	Number of higher education institutions	+
New quality labor objects	Infrastructure	Number of broadband internet subscribers	+
		Total telecommunications business volume	+
	Ecological environment	Investment in environmental pollution control	+
		Carbon trading, energy use rights trading, and emission rights trading activities	+
		Harmless disposal rate of household garbage	+
	Future development	Robot installation density	+
New quality labor materials	Technology research and development	Science research expenditure/fiscal expenditure	+
	Innovation output	Annual number of invention patent applications	+
		Annual number of utility model patent applications	+
	Intelligentization	Number of Artificial intelligence enterprises	+
	Green	Annual number of green invention patent applications	+
		Annual number of green utility model patent applications	+
	Elements of data	Data element utilization level (logarithm of the word frequency related to data assets of listed companies +1 is taken and aggregated to the prefecture-level city based on the enterprises' registered locations)	+
		Existence of a data exchange platform (assigned a value of 1 if a city has data exchange, otherwise 0)	+

Core explanatory variable: POL

Our primary objective is to quantify the EPTL's policy effect on NQPF from 2014 to 2021. As noted above, the EPTL was implemented on January 1, 2018, and different provinces chose to either increase their tax rates or maintain the original levels. Therefore, this study classifies 2014-2017 as the pre-policy period and 2018-2021 as the post-policy

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

period; provinces that increased tax rates are designated as the treated group, while those that maintained tax rates serve as the control group. Based on the basic principles of the DID method and the characteristics of the EPTL, we construct a dummy variable *POL*, which takes a value of 1 if a city is located in a province or municipality that increased tax rates after 2018, and 0 otherwise.

Mediating variable: industrial structure upgrading (ISA)

The EPTL may exert a more substantial impact on NQPF of cities with more advanced industrial structures. Thus, this research adopts ISA as a mediating variable to explore how the EPLT affects NQPF through the channel of industrial structure. We measure ISA using the ratio of the value added of the tertiary sector to that of the secondary sector (Zhang et al., 2019; Wang and Wang, 2021).

Threshold variable: technology innovation (TEC)

TEC serves as the threshold variable in our study. Drawing on Zheng and He (2022), we measure TEC using the ratio of government expenditure on science and technology to total government expenditure.

Control explanatory variables

Drawing on Zheng and He (2022), Wan et al. (2022), Yang et al. (2022), and He et al. (2024), this study controls for four additional factors: education investment (EDU), population density (POP), transportation infrastructure (TRA), and financial development (FAD). Specifically, EDU is measured as the proportion of education expenditure in total government expenditure; POP is measured as the natural logarithm of population per square kilometer of land area; TRA is measured by the natural logarithm of road area per capita; FAD is measured by the ratio of the sum of deposit and loan balances to GDP.

Data sources and summary statistics

The research data mainly come from the Statistical Bulletin on National Economic and Social Development of each city, the EPS Database, the China City Statistical Yearbook, the annual reports of listed companies, the National Patent Office, and disclosures on municipal government portals. Missing values are supplemented using linear interpolation. All continuous variables are winsorized at the 1% level to mitigate the impact of extreme values.

Considering data availability, our study includes 273 cities in China. Moreover, the sample period is set as 2014-2021 for two reasons: (a) to avoid potential impacts from the 2014 revision of the Pollution Discharge Fee (i.e., the predecessor of the EPTL); and (b) to ensure a 4-year observation window both before and after the EPTL implementation. *Table 2* presents the summary statistics of key variables. For he explained variable (*N*QPF), the maximum value is 0.6182, the minimum value is 0.0038, and the mean value is 0.0587. These results indicate that the NQPF level remains relatively low across most sample cities. The core explanatory variable (POL) has a mean of 0.2894, implying that approximately 28.94% of the sample observations fall within the post-policy period. Moreover, the mean values of EDU, POP, TRA, and FAD are 0.1712, 0.0454, 2.8608, and 2.6867, respectively.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

Table 2. *Summary statistics*

Variables	Observation	Mean	Standard deviation	Min	Max	Median
NQPF	2,184	0.0587	0.0799	0.0038	0.6182	0.0283
POL	2,184	0.2894	0.4536	0.0000	1.0000	0.0000
EDU	2,184	0.1712	0.0361	0.0850	0.2620	0.1717
POP	2,184	0.0454	0.0345	0.0019	0.2178	0.0378
TRA	2,184	2.8608	0.4010	1.5709	3.7413	2.8710
FAD	2,184	2.6867	1.1715	1.1822	7.0547	2.3642

NQPF = New Quality Productive Forces (explained variable, measured by a comprehensive index with 3 dimensions and 11 indicators); POL = Environmental Protection Tax Law (EPTL) dummy variable (core explanatory variable, 1 for cities with tax rate increases after 2018, 0 otherwise); EDU = Education investment; POP = Population density; TRA = Transportation infrastructure; FAD = Financial development

Empirical results

Spatiotemporal evolution trend of NQPF

This study first examines the spatiotemporal evolution trend of China's NQPF in 2014 and 2021. As illustrated in *Figure 3*, NQPF in 2014 was highly concentrated in eastern China, particularly in key economic clusters such as the Yangtze River Delta and Beijing-Tianjin-Hebei region, while most western areas exhibited relatively low NQPF levels, indicating a substantial east-west development disparity. By 2021, the cluster of high-NQPF regions had expanded significantly: central regions including parts of Hubei and Henan achieved remarkable NQPF advancement, effectively narrowing the development gap with eastern areas. Southern regions, encompassing the Pearl River Delta and inland southern provinces, witnessed a more prominent rise in NQPF characterized by intensified agglomeration of high-value segments, ultimately surpassing the northern region where growth momentum remained relatively sluggish. Additionally, scattered high-NQPF agglomerations emerged in parts of the western region, predominantly in core regional central cities, though the majority of western areas still lagged behind in overall NQPF development. In summary, the overall NQPF level demonstrated a consistent upward trend across the country between 2014 and 2021. Specifically, the spatial agglomeration effect was further strengthened with the formation of more concentrated high-value clusters; the east-west development disparity moderated moderately; and a distinct north-south gap became increasingly prominent in the spatial distribution of NQPF, with the southern region outperforming the northern region.

Model selection and parallel trend test

The SDID method integrates spatial analysis with the traditional DID approach, and its valid application relies on two core prerequisites: (a) the parallel trend assumption must be satisfied between the treated and control groups; and (b) the dependent variable must exhibit spatial autocorrelation. As presented in *Table 3*, the NQPF demonstrates strong spatial autocorrelation over the sample period (2014-2021), which provides empirical support for the adoption of a spatial econometric model in this study.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

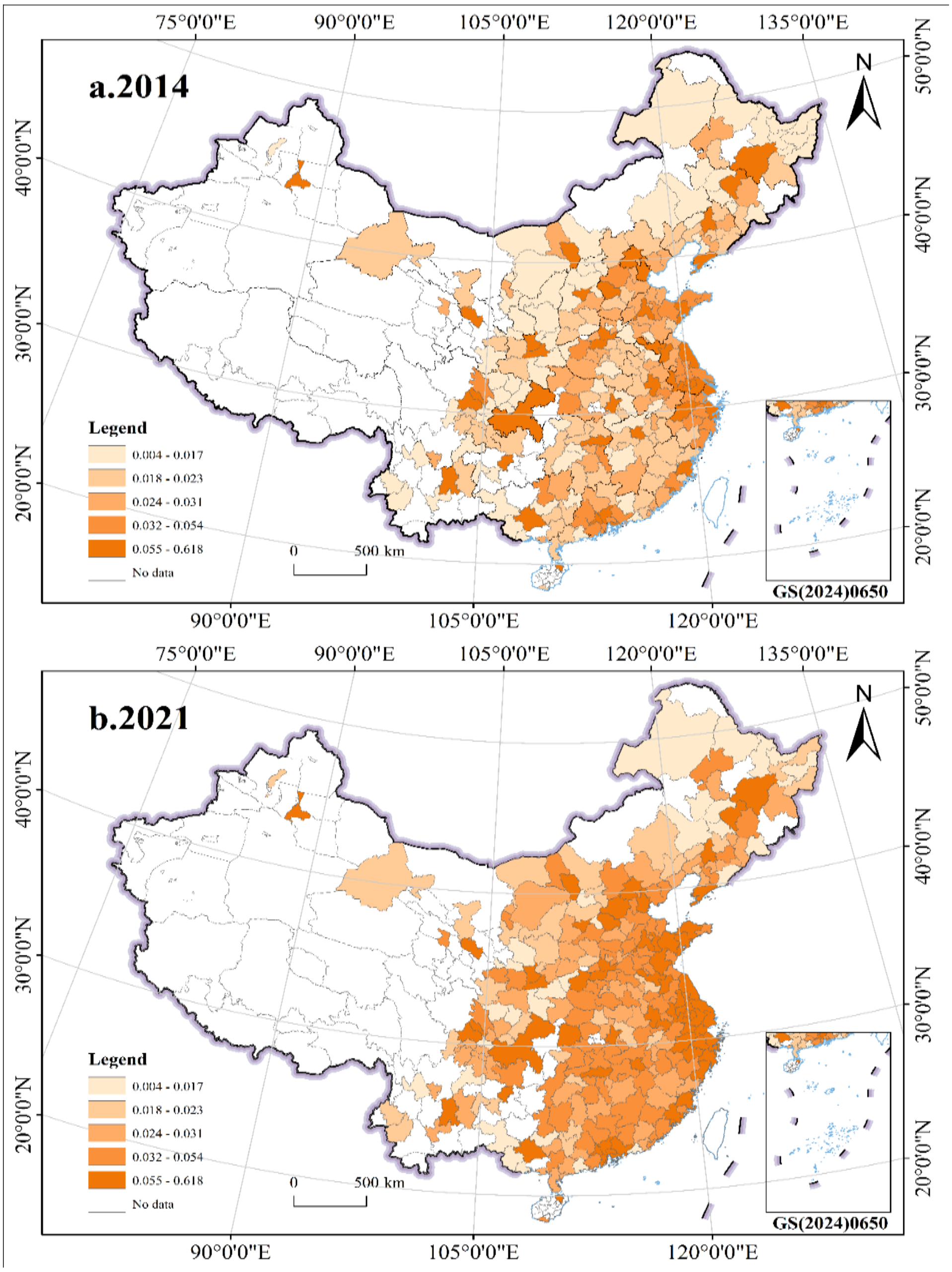

Figure 3. Spatiotemporal evolution trend of NQPF in 2014 and 2021

Table 3. *Global Moran's I indexes*

NQPF			NQPF		
Year	**Moran's I**	**P value**	**Year**	**Moran's I**	**P value**
2014	0.232***	0.000	2018	0.279***	0.000
2015	0.251***	0.000	2019	0.282***	0.000
2016	0.262***	0.000	2020	0.289***	0.000
2017	0.273***	0.000	2021	0.274***	0.000

Undefined abbreviations are consistent with *Table 1*; ***, ** and * stand for the significance of 1%, 5% and 10% levels

This study further employs the Wald and LR tests to identify the most appropriate spatial econometric model. As per *Table 4,* the test results indicate that the SDM cannot be simplified to either the Spatial Autoregressive Model (SAR) or the Spatial Error Model (SEM). Additionally, the Hausman test results reject the null hypothesis of random effects, leading this study to adopt the fixed-effect SDM for subsequent empirical analysis.

Table 4. *Model selection test*

Test type	Observation	Statistics	Results
Wald test spatial lag Wald test spatial error	SDM can be simplified to SEM or SAR	100.23*** 106.41***	SDM
LR test spatial lag LR test spatial error	SDM can be simplified to SEM or SAR	98.86*** 105.73***	SDM
Hausman test	Random effect	24.54***	Fixed effect

SDM = Spatial Durbin Model; SEM = Spatial Error Model; SAR = Spatial Autoregressive Model; LR test = Likelihood Ratio test; Wald test = Wald statistical test; ***, ** and * stand for the significance of 1%, 5% and 10% levels

Furthermore, we conduct a parallel trend test to examine whether the treated and control groups exhibit common (discrete) trends before (after) the implementation of the EPTL. As presented in *Figure 4*, the test results show that the estimated coefficients of the pre-policy period (2014-2017) are statistically insignificant and fluctuate around zero. This indicates that the treated and control groups had parallel development trends in NQPF before the EPTL implementation. In contrast, during the post-policy period (2018-2021), the coefficients gradually deviate from zero and become statistically significant, reflecting the heterogeneous impacts of the EPTL on the two groups. Collectively, these findings confirm that the SDID method is empirically appropriate for analyzing the relationship between the EPTL and NQPF in this study.

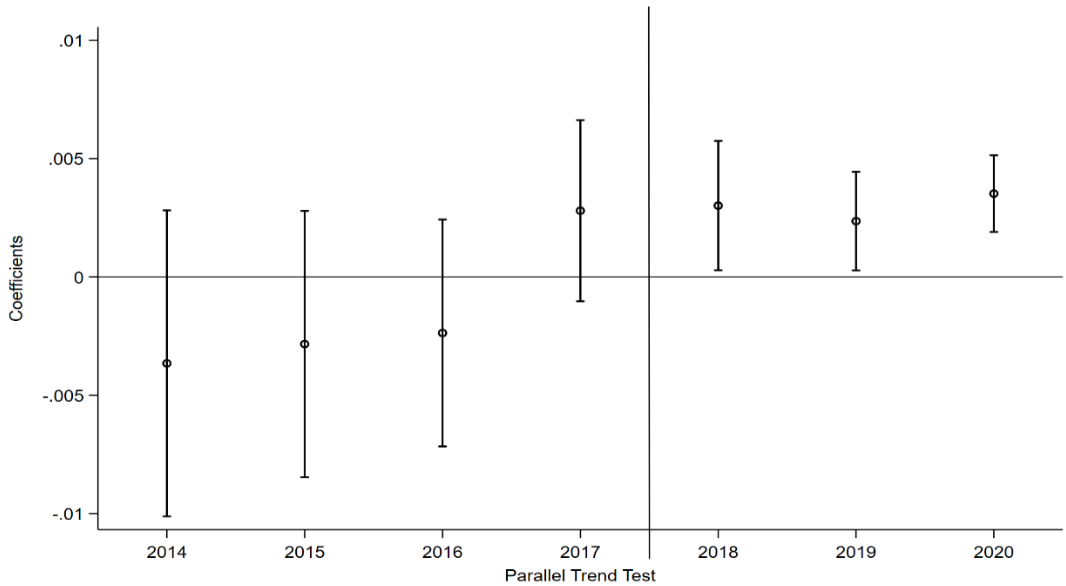

Figure 4. *Parallel trend test*

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

Main test: SDID

Table 5 presents the empirical results of the SDID estimation. Column 1 of *Table 5* shows that the spatial autoregression coefficient (ρ) is significantly positive, indicating that local NQPF significantly affects NQPF in neighboring regions. As noted by Lesage and Pace (2009), the coefficient estimates in Columns 1 and 2 fail to fully capture the spatial spillover mechanisms of explanatory variables. Therefore, this study employs the partial differential method to decompose the direct effect, spillover effect (indirect effect), and total effect. The decomposition results are reported in Columns 3, 4, and 5 of *Table 5*.

In terms of the direct effect, the coefficient of POL is positive and significant, demonstrating that the implementation of the EPTL significantly promotes local NQPF. Additionally, the indirect effect of POL is negative and significant, indicating that the EPTL exhibits a negative spatial spillover effect on NQPF in neighboring regions. These findings collectively provide strong empirical support for H1 of this study.

Regarding the control variables, EDU is positively correlates with local NQPF, indicating that improving the education level can boost local NQPF. POP is positively correlated with NQPF in terms of both direct and spillover impacts, which implies that population density not only accelerate local NQPF but also benefits NQPF in neighboring regions. TRA exerts negative direct and indirect impacts on NQPF, suggesting that transportation infrastructure inhibits NQPF in both local and neighboring regions. FAD has a positive direct impact but a negative indirect impact on NQPF, meaning that financial development can boost local NQPF while reducing NQPF in neighboring regions.

Table 5. *Main test: SDID*

Variables	Main	Wx	LR-Direct	LR-Indirect	LR-Total
POL	0.0058*** (0.000)	-0.0160*** (0.000)	0.0053*** (0.000)	-0.0197*** (0.000)	-0.0143*** (0.001)
EDU	0.1087*** (0.000)	-0.0867 (0.106)	0.1061*** (0.000)	-0.0772 (0.316)	0.0289 (0.727)
POP	0.6219*** (0.000)	0.5778*** (0.006)	0.6516*** (0.000)	1.0296*** (0.000)	1.6812*** (0.000)
TRA	-0.0057*** (0.000)	-0.0269*** (0.000)	-0.0066*** (0.000)	-0.0388*** (0.000)	-0.0454*** (0.000)
FAD	0.0018** (0.016)	-0.0145*** (0.000)	0.0014* (0.056)	-0.0191*** (0.000)	-0.0176*** (0.000)
R-squared	0.1912				
Log-likelihood	6566.6067				
ρ	0.2893*** (0.000)				
σ^2	0.0001*** (0.000)				
Obs	2,184				

LR-Direct = Direct effect of the variable (marginal effect decomposition result, reflecting the impact of the EPTL on the local region's NQPF); LR-Indirect = Indirect effect (spatial spillover effect) of the variable (marginal effect decomposition result, reflecting the impact of the EPTL on neighboring regions' NQPF); LR-Total = Total effect of the variable (sum of direct effect and indirect effect); Undefined abbreviations are consistent with *Table 1*; P values are in parentheses; ***, ** and * stand for the significance of 1%, 5% and 10% levels

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

Robustness tests

Alternative spatial weight matrix

To ensure the robustness of the empirical results, this study re-examines the empirical analysis by replacing the spatial weight matrix with an economic distance weight matrix, and the corresponding spatial econometric model is specified in *Equation 7* as follows:

$$w_{ij} = \begin{cases} \dfrac{1}{\left|\overline{pgdp_i} - \overline{pgdp_j}\right|} & i \neq j \\ 0 & i=j \end{cases} \quad \text{(Eq.7)}$$

where $\overline{pgdp_i}$ and $\overline{pgdp_j}$ stand for the GDP per capita of city *i* and city *j*.

Table 6 shows that the sign and significance level of the POL coefficient remain consistent with those reported in *Table 5*. This confirms the robustness of the main findings after replacing the weight matrix.

Table 6. *Alternative spatial weight matrix*

Variables	LR-Direct	LR-Indirect	LR-Total
POL	0.0038*** (0.000)	-0.0187*** (0.000)	-0.0149*** (0.002)
EDU	0.1059*** (0.000)	-0.0097 (0.906)	0.0961 (0.281)
POP	0.6881*** (0.000)	0.8266*** (0.000)	1.5147*** (0.000)
TRA	-0.0072*** (0.000)	-0.0347*** (0.000)	-0.0419*** (0.000)
FAD	0.0003 (0.643)	-0.0188*** (0.000)	-0.0184*** (0.000)
R-squared	0.1699		
Log-likelihood	6535.3572		
ρ	0.2527*** (0.000)		
σ^2	0.0001*** (0.000)		
Obs	2,184		

Undefined abbreviations are consistent with *Tables 1* and *5*; P values are in parentheses; ***, ** and * stand for the significance of 1%, 5% and 10% levels

Policy implementation time

As mentioned above, we establish a common and discrete trend before and after the EPTL implementation, indicating that the policy effect should only emerge after 2017. To further verify the robustness of our main findings and rule out the interference of unobserved confounding factors, we conduct a placebo test by adjusting the sample period to 2014-2017 and setting January 1, 2016, as the hypothetical policy implementation date (with 2014-2015 defined as the pre-hypothetical-policy period and

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

2016-2017 as the post-hypothetical-policy period). As shown in *Table 7*, the coefficient of POL becomes statistically insignificant. This result suggests that there is no spurious causal relationship between the EPTL and NQPF, thereby further confirming the robustness of our core empirical findings.

Table 7. *Policy implementation time*

Variables	LR-Direct	LR-Indirect	LR-Total
POL	-0.0001 (0.892)	-0.0041 (0.300)	-0.0043 (0.279)
EDU	0.0058 (0.717)	-0.0412 (0.626)	-0.0353 (0.695)
POP	1.7643*** (0.000)	0.3087 (0.350)	2.0729*** (0.000)
TRA	-0.0028* (0.073)	-0.0268*** (0.006)	-0.0296*** (0.000)
FAD	-0.0008 (0.369)	-0.0137*** (0.000)	-0.0144*** (0.000)
R-squared	0.1841		
Log-likelihood	3993.1534		
ρ	0.4375*** (0.000)		
σ^2	0.0001*** (0.000)		
Obs	2,184		

Undefined abbreviations are consistent with *Tables 1* and *5*; P values are in parentheses; ***, ** and * stand for the significance of 1%, 5% and 10% levels

Additional tests

Dynamic effect analysis

The preceding analysis may not fully capture the time-varying effect of the EPT. Additionally, the parallel trend test was conducted based on a standard panel regression model rather than a spatial econometric framework. To address these limitations, we employ *Equation 8* to assess the dynamic spatial effect of the EPTL implementation.

$$\begin{aligned} NQPF_{i,t} &= \beta_0 + \rho\sum_{j=1}^{273} w_{ij} NQPF_{i,t} + \beta_1 POL2018_{i,t} + \beta_2 POL2019_{i,t} + \beta_3 POL2020_{i,t} \\ &+\beta_4 POL2021_{i,t} + \beta_5 X_{i,t} + \theta_1 \sum_{j=1}^{273} w_{ij} POL2018_{i,t} + \theta_2 \sum_{j=1}^{273} w_{ij} POL2019_{i,t} + \\ &\theta_3 \sum_{j=1}^{273} w_{ij} POL2020_{i,t} + \theta_4 \sum_{j=1}^{273} w_{ij} POL2021_{i,t} + \theta_5 \sum_{j=1}^{273} w_{ij} X_{i,t} + \mu_i + v_t + \varepsilon_{i,t} \end{aligned} \quad \text{(Eq.8)}$$

In *Equation 8*, the dummy variable POL2018 is assigned a value of 1 if a city is located in a province or municipality that implemented tax rate increases in 2018, and 0 otherwise, with the same logic applied to subsequent years. As shown in *Table 8*, both the direct and spatial spillover effects of the EPTL exhibit a gradual and continuous increase over time, which indicate that the ETPL demonstrates significant temporal dynamics, with stably persistent impacts throughout the study period.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

Table 8. *Dynamic effect analysis*

Variables	LR-Direct	LR-Indirect	LR-Total
POL2018	0.0031* (0.093)	-0.0145** (0.029)	-0.0114* (0.070)
POL2019	0.0043** (0.015)	-0.0162** (0.016)	-0.0119* (0.62)
POL2020	0.0056*** (0.001)	-0.0178*** (0.005)	-0.0122* (0.048)
POL2021	0.0084*** (0.000)	-0.0303*** (0.000)	-0.0219*** (0.002)
EDU	0.1061*** (0.000)	-0.0821 (0.262)	0.0240 (0.760)
POP	0.6614*** (0.000)	1.0317*** (0.000)	1.6931*** (0.000)
TRA	-0.0067*** (0.000)	-0.0402*** (0.000)	-0.0468*** (0.000)
FAD	0.0014* (0.061)	-0.0192*** (0.000)	-0.0179*** (0.000)
R-squared	0.1879		
Log-likelihood	6570.5557		
ρ	0.2951*** (0.000)		
σ^2	0.0001*** (0.000)		
Obs	2,184		

POL2018/POL2019/POL2020/POL2021 = Year-specific EPTL dummy variables (assigned 1 if a city is in a province or municipality with tax rate increases and the observation year is the corresponding year (2018/2019/2020/2021), otherwise 0; Undefined abbreviations are consistent with *Tables 1* and *5*; P values are in parentheses; ***, ** and * stand for the significance of 1%, 5% and 10% levels

Heterogeneity analysis

To explore the administrative-level heterogeneity of the EPTL, this study defines municipalities directly under the Central Government and provincial capital cities as high-administrative-level cities, while the remaining cities are classified as low-administrative-level cities. As presented in *Table 9,* POL exerts a significantly positive direct effect on NQPF in both high and low administrative-level cities, which is consistent with the main findings. Regarding the indirect (spatial spillover) effect, we identify a positive and significant indirect impact in high-administrative-level cities, whereas a negative and significant indirect effect is observed in low-administrative-level cities.

Mediating effect analysis

To examine the mediating role of ISA in the relationship between the EPTL and NQPF, we incorporate ISA as a mediating variable into our analytical framework. As illustrated in Columns (2), (3), and (4) of *Table 10*, the regression results reveal three key findings: first, POL is significantly positively associated with NQPF; second, POL exerts

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

a significantly positive impact on ISA; and third, ISA is itself significantly positively correlated with NQPF.

Furthermore, the Sobel test's results formally confirm that ISA plays a statistically significant mediating role in the effect of the EPTL on NQPF. The indirect effect accounts for 23.00% of the total effect, providing robust support for H2. This result indicates that the EPTL can effectively promote NQPF by facilitating industrial structure upgrading.

Table 9. *Heterogeneity analysis*

Panel A: High-administrative-level cities			
Variables	**LR-Direct**	**LR-Indirect**	**LR-Total**
POL	0.0147** (0.039)	0.1102*** (0.003)	0.1249*** (0.003)
EDU	0.2408* (0.077)	-1.1181 (0.133)	-0.8773 (0.282)
POP	-0.0591 (0.671)	-0.8059 (0.442)	-0.8650 (0.446)
TRA	0.0041 (0.656)	-0.0401 (0.404)	-0.0360 (0.498)
FAD	-0.0079* (0.068)	-0.0471** (0.024)	-0.0550** (0.019)
R-squared	0.1200		
Log-likelihood	596.4002		
ρ	0.4453*** (0.000)		
σ^2	0.0003*** (0.000)		
Obs	240		
Panel B: Low-administrative-level cities			
Variables	**LR-Direct**	**LR-Indirect**	**LR-Total**
POL	0.0039*** (0.000)	-0.0158*** (0.000)	-0.0119*** (0.000)
EDU	0.0669*** (0.000)	-0.0384 (0.384)	0.0285 (0.547)
POP	1.9053*** (0.000)	0.3652** (0.029)	2.2705*** (0.000)
TRA	-0.0041*** (0.000)	-0.0131*** (0.001)	-0.0172*** (0.000)
FAD	0.0008 (0.168)	-0.0096*** (0.000)	-0.0088*** (0.000)
R-squared	0.2237		
Log-likelihood	6515.8065		
ρ	0.1280*** (0.000)		
σ^2	0.0001*** (0.000)		
Obs	1,944		

Undefined abbreviations are consistent with *Tables 1* and *5*; P values are in parentheses; ***, ** and * stand for the significance of 1%, 5% and 10% levels

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

Table 10. *Mediating effect analysis*

Variables	NQPF	ISA	NQPF
POL	0.0087*** (0.003)	0.2443*** (0.000)	0.0067** (0.027)
ISA			0.0082*** (0.007)
Controls	Yes	Yes	Yes
Cons	-0.0242* (0.057)	0.9113*** (0.000)	-0.0316** (0.015)
Sobel test			0.002 (z = 2.649; p = 0.008)
Bootstrap test			0.0067
(Direct effect)			(z = 2.14; p = 0.032)
Bootstrap test (Indirect effect)			0.0020 (z = 2.37; p = 0.018)
Proportion of indirect effect			23.00%
R-squared	0.4254	0.4130	0.4274
Obs	2,184	2,184	2,184

ISA = Industrial structure upgrading (mediating variable); Undefined abbreviations are consistent with *Tables 1* and *5*; P values are in parentheses; ***, ** and * stand for the significance of 1%, 5% and 10% levels; The Bootstrap test sampling 1000 times

Threshold effect analysis

We further apply *Equation 6* to explore how the EPTL affects NQPF when TEC is considered.

As presented in *Table 11*, the threshold effect test results show that TEC passes the single-threshold and double-threshold tests at the 1% and 5% significance levels, respectively. This indicates that when accounting for the impact of technology innovation, the EPTL exerts a significant “double threshold effect” on NQPF.

Table 11. *Threshold effect test*

Threshold variables	Threshold test	P-value	F-value	Estimated thresholds	95% confidence interval
TEC	Single	0.000	265.01***	0.0264	[0.0236,0.0270]
	Double	0.020	67.99**	0.0394	[0.0380,0.0407]
	Triple	0.567	13.04		

TEC = Technology innovation (threshold variable); ***, ** and * stand for the significance of 1%, 5% and 10% levels; The F value and P value were estimated through 300 repeated sampling using the Bootstrap method

As presented in *Table 12*, the marginal impact of the EPTL (proxied by POL) on NQPF demonstrates a progressive upward trend with the improvement of TEC. Specifically, POL exerts a significant positive impact on NQPF when TEC is below the first threshold (0.0264), with a corresponding coefficient of 0.0051. As TEC crosses the first threshold and falls within the intermediate range (0.0264 < TEC < 0.0394), the coefficient of POL rises to 0.0209. When TEC exceeds the second threshold (0.0394), the coefficient further increases to 0.0436. Consequently, we recommend that relevant authorities sustain increased investment in technology innovation, as this can amplify the facilitative effect of EPTL on NQPF.

Table 12. *Threshold effect analysis results*

Variables	NQPF	Variables	NQPF
POL (TEC < 0.0264)	0.0051*** (0.000)	POL (0.0264 < TEC < 0.0394)	0.0209*** (0.000)
POL (TEC > 0.0394)	0.0436*** (0.000)	EDU	0.0583 (0.235)
POP	0.6921 (0.134)	TRA	0.0030 (0.174)
FAD	0.0070** (0.000)	F value	43.97***
R-squared	0.3779	Obs	2,184

Undefined abbreviations are consistent with *Tables 1* and *5*; P values are in parentheses; ***, ** and * stand for the significance of 1%, 5% and 10% levels

Discussion

This study investigates the spatial effect of China's EPTL on NQPF with a SDID approach. A systematic review of existing literature reveals a critical research gap: few studies have explicitly unpacked the spatial spillover mechanisms of the EPTL on NQPF, particularly the heterogeneous effects across administrative hierarchies, the mediating role of ISA, and the threshold effect of TEC. By addressing this gap, our findings provide nuanced insights into the interplay between environmental policies and NQPF.

First of all, our results confirm that EPTL exerts a significantly positive direct effect on local NQPF, which aligns with the "Porter Hypothesis" (Porter and van der Linde, 1995). This positive impact can be attributed to two interrelated channels: first, the cost-pressuring effect and innovation-incentivizing mechanism of EPTL compel enterprises to reduce pollutant emissions by adopting cleaner production technologies or upgrading equipment and stimulating green innovation (Wang et al., 2024; Su et al., 2025), and thereby further promote local NQPF. Second, the EPTL accelerates industrial structure upgrading by phasing out high-pollution, low-efficiency sectors and promoting the agglomeration of high-tech and service industries (Zhao et al., 2025), further consolidating the foundation for local NQPF growth.

In contrast, we identify a significantly negative indirect effect of EPTL on NQPF in neighboring regions, which reflects the "pollution haven hypothesis" (Copeland and Taylor, 2017) in the context of China's regional development. That is, the implementation of the EPTL may induce pollution transfer effect, form a phenomenon of "pollution havens". Specifically, when local region increases its environmental tax rates, high-pollution and energy-intensive industries face rising compliance costs, prompting them to relocate to neighboring regions with laxer environmental constraints. This "pollution migration" not only degrades the ecological environment of neighboring areas but also hinders their NQPF development through two channels: (a) the inflow of polluting industries crowds out resources that could otherwise be allocated to high-value-added sectors, inhibiting industrial upgrading; and (b) the deterioration of the ecological environment reduces the region's attractiveness to green technology enterprises and high-

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

skilled labor, creating a "low-quality development trap." This finding is consistent with the "race to the bottom" hypothesis (Oates and Schwab, 1988), where inter-regional competition for economic growth may lead to the relaxation of environmental regulations, ultimately undermining sustainable development.

Secondly, the EPTL's positive direct effect on NQPF is consistent in both high-administrative-level cities and low-administrative-level cities, but the spatial spillover effects differ substantially. For high-administrative-level cities, the positive indirect effect of EPTL on neighboring NQPF can be explained by their comparative advantages: (a) stronger fiscal capacity allows these cities to invest more in environmental infrastructure and green R&D subsidies, which not only supports local enterprises' green transformation but also generates technology spillover effects; (b) as regional economic and innovation hubs, high-administrative-level cities attract high-quality factors of production, and the agglomeration of green innovation ecosystems can drive the coordinated development of NQPF in the surrounding areas. This aligns with the "core-periphery theory" (Krugman, 1991), where core regions play a leading role in promoting regional integration and high-quality development.

In contrast, low-administrative-level cities exhibit a negative indirect effect of EPTL on neighboring NQPF. This can be attributed to two key constraints: (a) weak innovation capacity of low-administrative-level cities often lack sufficient R&D investment, technological talent, and innovation platforms, making it difficult for them to absorb and convert green technologies spillovers from high-administrative-level cities. Instead, they become "pollution receptors" for relocated high-pollution industries, which further crowds out their limited resources for green development; (b) the "siphoning effect" of high-administrative-level cities, leaving low-administrative-level cities with insufficient support for NQPF development. When the EPTL is implemented, the cost pressure on local enterprises in low-administrative-level cities intensifies, while their lack of innovation capacity prevents them from transitioning to green production, leading to a decline in their own NQPF and a negative spillover effect on neighboring low-level cities.

Thirdly, our analysis further confirms that industrial structure upgrading serves as a key mediating channel through which EPTL promotes NQPF. Specifically, the EPTL influences industrial structure upgrading through dual mechanisms: the cost-pressuring effect forces low-efficiency, high-pollution enterprises to exit the market or upgrade their production processes, while the innovation-incentivizing effect encourages the development of green industries and the digital transformation of traditional industries (Jin et al., 2024; Kong et al., 2024a). This structural transformation injects "green genes" into NQPF by improving resource allocation efficiency, enhancing technological content, and reducing environmental externalities, ultimately achieving a win-win situation for economic growth and ecological protection.

Furthermore, the effect of EPTL on NQPF exhibits increasing marginal returns with the growth of technology innovation investment. This suggests that technology innovation investment acts as a "catalyst" that amplifies the positive impact of EPTL on NQPF. The underlying mechanism lies in the formation of a virtuous cycle: as R&D investment increases, enterprises are better able to respond to EPTL-induced emission reduction pressures by developing and applying green technologies, which not only reduces compliance costs but also enhances product competitiveness. In turn, the improvement of NQPF further supports enterprises' R&D investment capacity, forming a "emission reduction pressure-technology innovation- industrial structure upgrading-NQPF enhancement" feedback loop.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

Conclusion

In response to the ecological crisis and in pursuit of sustainable development, the Chinese government has prioritized the transition from traditional productive forces to NQPF, complemented by a series of economic and environmental policies designed to foster this new development paradigm. This study employs panel data of 273 prefecture-level cities spanning 2014-2021 and adopts a SDID approach to explore how the EPTL affects NQPF.

Our analysis reveals several key findings: First, the overall NQPF level maintained a steady upward trend nationwide from 2014 to 2021. Specifically, its spatial distribution exhibited enhanced agglomeration effect, characterized by the formation of more concentrated high-value clusters. While the development gap between eastern and western regions narrowed moderately, a distinct north-south disparity became increasingly prominent, with southern regions consistently outperforming northern counterparts. Second, the Moran's I index of NQPF is significantly positive during the sample period, confirming strong spatial autocorrelation. With the SDID approach, this study demonstrates that the EPTL exerts a significantly positive direct effect on local NQPF while generating a significantly negative spatial spillover effect (indirect effect) on neighboring regions. These core findings are robust to a series of robustness tests. Third, the dynamic effect analysis reveals that the impact of EPTL exhibits significant temporal dynamics, with its positive direct effect and negative spillover effect remaining stably persistent over the study period. Fourth, the heterogeneity analysis demonstrates that that EPTL's positive direct effect on NQPF is consistent across both high and low administrative-level cities. However, the spatial spillover effects differ substantially: high administrative-level cities generate positive indirect effects on neighboring regions, whereas low administrative-level cities exhibit negative indirect effects. Fifth, the mediating effect analysis confirms that industrial structure upgrading serves as a key mediating channel through which the EPTL promotes NQPF. Finally, the threshold effect analysis reveals that the impact of EPTL on NQPF exhibits increasing marginal returns with the deepening of technology innovation investment. This study holds important practical implications for optimizing China's environmental legal system and advancing sustainable development. It also provides scientific reference for other emerging economies in formulating environmental policies and promoting high-quality, sustainable growth.

Acknowledgements. This study was supported by the National Social Science Fund of China [grant number: 22XJY008].

REFERENCES

[1] Cheng, Z., Chen, X., Wen, H. (2022): How does environmental protection tax affect corporate environmental investment? Evidence from Chinese listed enterprises. – Sustainability 14(5): 2932.

[2] Copeland, B. R., Taylor, M. S. (2017): North-South trade and the environment. – International trade and the environment: 205-238. Routledge.

[3] Gao, X., Liu, N., Hua, Y. (2022): Environmental Protection Tax Law on the synergy of pollution reduction and carbon reduction in China: evidence from a panel data of 107 cities. – Sustainable Production and Consumption 33: 425-437.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

[4] Gao, X., Yan, X., Song, S., Xu, N. (2025): The impact and mechanism of new-type urbanization on new quality productive forces: empirical evidence from China. – Sustainability 17(1): 353.
[5] Han, F., Li, J. (2020): Assessing impacts and determinants of China's environmental protection tax on improving air quality at provincial level based on Bayesian statistics. – Journal of Environmental Management 271: 111017.
[6] He, Y., Zhu, X., Zheng, H. (2022): The influence of environmental protection tax law on total factor productivity: evidence from listed firms in China. – Energy Economics 113: 106248.
[7] He, Y., Zhao, X., Zheng, H. (2023): How does the environmental protection tax law affect firm ESG? Evidence from the Chinese stock markets. – Energy Economics 127: 107067.
[8] He, Y., Zhang, Y., Deng, J. (2024): Path to sustainable development: the effect of China's innovative industrial clusters pilot policy on prefecture-level cities' green total factor productivity. – Journal of Cleaner Production 478: 143988.
[9] Hu, X., Sun, Y., Liu, J., Meng, J., Wang, X., Yang, H., et al. (2019): The impact of environmental protection tax on sectoral and spatial distribution of air pollution emissions in China. – Environmental Research Letters 14(5): 054013.
[10] Jin, X., Wang, L., Xie, Q., Li, Y., Liang, L. (2024): Taxing for a green future: how China's environmental protection tax law drives energy efficiency. – International Journal of Environmental Research 18(2): 33.
[11] Kong, L., Wang, S., Xu, K. (2024a): The impact of environmental protection tax reform on total factor energy efficiency. – Clean Technologies and Environmental Policy 26(4): 1149-1164.
[12] Kong, L., Li, Z., Liu, B., Xu, K. (2024b): The impact of environmental protection tax reform on low-carbon total factor productivity: evidence from China's fee-to-tax reform. – Energy 290: 130216.
[13] Kong, L., Yao, Y., Xu, K. (2025): Can environmental regulation improve the industrial ecology efficiency? Evidence from China's environmental protection tax reform. – Journal of Environmental Management 373: 123792.
[14] Krugman, P. (1991): Increasing returns and economic geography. – Journal of Political Economy 99(3): 483-499.
[15] LeSage, J., Pace, R. K. (2009): Introduction to Spatial Econometrics. – Chapman and Hall/CRC, New York.
[16] Li, P., Lin, Z., Du, H., Feng, T., Zuo, J. (2021): Do environmental taxes reduce air pollution? Evidence from fossil-fuel power plants in China. – Journal of Environmental Management 295: 113112.
[17] Li, Y., Hua, Z. (2024): Environmental protection tax law and corporate ESG performance. – Finance Research Letters 64: 105423.
[18] Liu, G., Yang, Z., Zhang, F., Zhang, N. (2022): Environmental tax reform and environmental investment: a quasi-natural experiment based on China's Environmental Protection Tax Law. – Energy Economics 109: 106000.
[19] Long, F., Lin, F., Ge, C. (2022): Impact of China's environmental protection tax on corporate performance: empirical data from heavily polluting industries. – Environmental Impact Assessment Review 97: 106892.
[20] Oates, W. E., Schwab, R. M. (1988): Economic competition among jurisdictions: efficiency enhancing or distortion inducing? – Journal of public economics 35(3): 333-354.
[21] Porter, M. E., van der Linde, C. (1995): Toward a new conception of the environment-competitiveness relationship. – Journal of Economic Perspectives 9(4): 97-118.
[22] Song, Y., Zhang, X., Zhang, M. (2021): The influence of environmental regulation on industrial structure upgrading: based on the strategic interaction behavior of environmental regulation among local governments. – Technological Forecasting and Social Change 170: 120930.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

[23] Su, S., Li, S. (2025): Energy efficiency suppression and spatial spillover effect: a quasi-natural experiment based on China's environmental protection tax law. – Environment, Development and Sustainability 27(3): 6397-6422.
[24] Su, X., Huang, C., Mirza, S. S., Zhang, C. (2025): From pollution to solution: How environmental protection tax shapes green technological innovation? – Clean Technologies and Environmental Policy: 1-33.
[25] Tang, J. (2024): New quality productivity and China's strategic shift towards sustainable and innovation-driven economic development. – Journal of Interdisciplinary Insights 2(3): 36-45.
[26] Wan, G., Wang, X., Zhang, R., Zhang, X. (2022): The impact of road infrastructure on economic circulation: market expansion and input cost saving. – Economic Modelling 112: 105854.
[27] Wang, J., Lin, J., Feng, K., Liu, Y., Jiao, X., Ni, R., et al. (2021): Towards reducing inter-city economic inequality embedded in China's environmental protection tax law. – Environmental Research Letters 16(12): 124007.
[28] Wang, J., Qiao, L., Zhu, G., Di, K., Zhang, X. (2025): Research on the driving factors and impact mechanisms of green new quality productive forces in high-tech retail enterprises under China's Dual Carbon Goals. – Journal of Retailing and Consumer Services 82: 104092.
[29] Wang, X. H., Li, G. (2019): Calculation and policy responses of thermal power carbon emissions in 1995-2015 in Shaanxi province, China. – Applied Ecology & Environmental Research 17(4).
[30] Wang, X., Wang, Q. (2021): Research on the impact of green finance on the upgrading of China's regional industrial structure from the perspective of sustainable development. – Resources Policy 74: 102436.
[31] Wang, X., Wang, S., Wu, K., Zhai, C., Li, Y. (2024): Environmental protection tax and enterprises' green technology innovation: evidence from China. – International Review of Economics & Finance 96: 103617.
[32] Wei, R., Wang, M., Xia, Y. (2024): Environmental protection tax and corporate carbon emissions in China: a perspective of green innovation. – Clean Technologies and Environmental Policy 26: 2625-2641.
[33] Xie, L., Zuo, S., Xie, Z. (2023): Environmental protection fee-to-tax and enterprise investment efficiency: evidence from China. – Research in International Business and Finance 66: 102057.
[34] Xu, S., Huang, J., Zheng, K. (2025): Create or squeeze out? The effect of environmental protection tax on labor demand and labor demand transfer: evidence from China. – Clean Technologies and Environmental Policy 27: 3825-3840.
[35] Xu, W., Li, M. Z. (2025): Green tax system and corporate carbon emissions—a quasi-natural experiment based on the environmental protection tax law. – Journal of Environmental Planning and Management 68: 2092-2122.
[36] Xu, Y., Wen, S., Tao, C. Q. (2023): Impact of environmental tax on pollution control: a sustainable development perspective. – Economic Analysis and Policy 79: 89-106.
[37] Yang, J., Guariglia, A., Peng, Y., Shi, Y. (2022): Inventory investment and the choice of financing: Does financial development play a role? – Journal of corporate finance 74: 102139.
[38] Yang, J., Guan, Y. F., Mei, J. P., Zhu, Y. L., Zhou, J., Wang, R. (2025): Exploring the role of digital economy and environmental regulation in urban green logistics efficiency in the context of energy transition: empirical evidence from 30 Chinese provinces from 2013-2022. – Applied Ecology and Environmental Research 23(4): 7279-7304.
[39] Yang, S., Wang, C., Lyu, K., Li, J. (2023): Environmental protection tax law and total factor productivity of listed firms: promotion or inhibition? – Frontiers in Environmental Science 11: 1152771.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328

[40] Yang, Z., Zeng, Q., Wang, Y. (2024): The impact of environmental protection tax on green total factor productivity: China's exceptional approach. Environment, – Development and Sustainability: 1-28.
[41] Zhang, G., Zhang, P., Zhang, Z. G., Li, J. (2019): Impact of environmental regulations on industrial structure upgrading: an empirical study on Beijing-Tianjin-Hebei region in China. – Journal of Cleaner Production 238: 117848.
[42] Zhao, A., Wang, J., Sun, Z., Guan, H. (2022): Environmental taxes, technology innovation quality and firm performance in China—a test of effects based on the Porter hypothesis. – Economic Analysis and Policy 74: 309-325.
[43] Zhao, Q., Yuan, C. H. (2025): Research on the dual effects of environmental protection tax law on green transformation of China's industry. – Frontiers in Environmental Science 13: 1602644.
[44] Zheng, H., He, Y. (2022): How does industrial co-agglomeration affect high-quality economic development? Evidence from Chengdu-Chongqing Economic Circle in China. – Journal of Cleaner Production 371: 133485.
[45] Zheng, M., Yan, S., Xu, S. (2025): Digital economy, industry–academia–research collaborative innovation, and the development of new-quality productive forces. – Sustainability 17(1): 318.
[46] Zhong, Y., Lai, H., Zhang, L., Guo, L., Lai, X. (2025): Does public data openness accelerate new quality productive forces? Evidence from China. – Economic Analysis and Policy 85: 1409-1427.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_23052328