Renewable Energy 246 (2025) 122916

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

Benefits of establishing new energy consumption cities: Evidence from industrial enterprises sustainability

Peihao Shi [a,*], Jianhui Liu [b]

[a] School of Economic and Management, Wuhan University, Wuhan, Hubei, 430072, China
[b] School of Economics and Management, Southwest University, Chongqing, 400715, China

ARTICLE INFO

Keywords:
New energy consumption
Enterprises sustainability
Energy structure
Pollution abatement

ABSTRACT

The transition to renewable energy consumption is a key priority for advancing global sustainable development. This study investigates the impact of the Renewable Energy Consumption Demonstration City (NECDC) policy on industrial enterprise sustainability. Employing a difference-in-differences design, this paper documents that the NECDC policy significantly raises industrial enterprise sustainability, yielding dual benefits in environmental governance and income growth. The effect is primarily driven by substantial green innovation and lowered financing constraints. Moreover, the NECDC policy is particularly effective in cities facing high environmental pressures, with its positive effects most pronounced in large industrial firms, heavily polluting sectors, and enterprises with solid developmental foundations. These findings provide valuable insights for policymakers worldwide seeking to develop policies that optimize energy structures for sustainable development.

1. Introduction

Energy and environmental challenges pose critical dilemmas in the 21st century, attracting considerable attention from both academia and policymakers [1]. As depicted in Fig. 1, global energy consumption remains heavily reliant on traditional fossil fuels, with new energy sources accounting for a relatively small share, indicating a persistent dependence on fossil fuels. The dominance of oil, natural gas, and coal in energy consumption releases harmful gases, causing severe environmental degradation [2], jeopardizing human health [3], and hindering global sustainable development [4]. To deal with this dilemma, nations worldwide are opting for the development and utilization of new energy sources [5], such as nuclear power, wind power, and biomass energy. As the world's largest primary energy consumer, China experiences rapid energy consumption growth (see Fig. 1A of the Appendix), bringing about considerable hurdles to global carbon peaking and ecological development [6]. To accelerate the shift towards a low-carbon and clean energy structure, China has implemented a new energy development plan, aiming to increase the share of clean energy and boost energy efficiency for sustainability. Therefore, accurately assessing the economic welfare effects of the New Energy Consumption Demonstration Cities (NECDC) policy is crucial for advancing global energy carbon reduction efforts and fostering sustainability.

Extant literature on the NECDC policy and sustainable development primarily focuses on its impact on environmental pollution [7], carbon emissions [8], and green economic growth [9]. These studies typically examine how the NECDC policy mitigates pollution via green investment [10], improved resource efficiency [11], and eased energy consumption [12]. While existing literature provides insights into the effects of the policy, several gaps remain. First, current works mainly emphasize pollution reduction, with limited exploration of its broader impact on sustainability, including both environmental and economic performance. Second, the research available primarily focuses on macro-level outcomes, leaving a gap in micro-level evidence regarding its effects on sustainability. Additionally, there is a paucity of analysis regarding the mechanisms through which the NECDC policy affects the economic activities of individual enterprises. Most existing studies tend to overlook the micro-level pathways of impact.

To fill this void, this study utilizes a sample of industrial enterprises from publicly traded companies in China, spanning the period from 2011 to 2021. Employing a difference-in-differences setup (DID), this paper seeks to discern the impact of the NECDC policy on industrial enterprise sustainability. Given that the industrial sector accounts for approximately 65 % of China's total energy consumption, the analysis focuses exclusively on publicly traded industrial enterprises to mitigate potential biases when evaluating the economic advantages of the

* Corresponding author.
E-mail address: peihaoshi@whu.edu.cn (P. Shi).

https://doi.org/10.1016/j.renene.2025.122916
Received 11 July 2024; Received in revised form 14 March 2025; Accepted 15 March 2025
Available online 17 March 2025

NECDC policy. Theoretically, this study aims to address the following inquiries: (1) Does the NECDC policy affect industrial enterprise sustainability, and if so, to what extent? (2) What are the underlying mechanisms through which the NECDC policy influences industrial enterprise sustainability? (3) What factors shape the relationship between the NECDC policy and industrial enterprise sustainability?

The potential contributions of this paper are in three key areas. First, it integrates NECDC policy and sustainability into an analytical framework, expanding the research perspective. While existing literature primarily focuses on the policy's impact on pollutant emissions [5], it lacks a systematic exploration of its effects on sustainability. In contrast, this paper delineates sustainability in terms of both environmental and economic performance, evaluating the impact of the NECDC policy on sustainability and extending research on its economic consequences. Second, this paper examines the effect of the NECDC policy on the sustainability of microenterprises, deepening the understanding of factors influencing enterprise sustainability. While prior research analyzes the policy's environmental governance at the national and city levels [13], it overlooks its impact on sustainability at the micro-level. Hence, this paper investigates the impact of the NECDC policy on industrial enterprise sustainability, thereby expanding research on factors shaping enterprise sustainability. Lastly, this paper elucidates the mechanisms through which the NECDC policy affects industrial enterprise sustainability, enhancing understanding of the dual dividends obtained from its implementation. This paper demonstrates how the NECDC policy promotes industrial enterprise sustainability by fostering green innovation and easing financing constraints. Moreover, this paper highlights how government environmental constraints, enterprise characteristics, and sustainability foundations influence the relationship between the NECDC policy and industrial enterprise sustainability, offering valuable guidance for policymakers in formulating sustainable development policies.

The remainder of this paper is as follows: Section 2 reviews the literature on the NECDC policy and industrial enterprise sustainability, together with outlining the research hypotheses. Section 3 discusses the policy background and empirical approach. Section 4 presents the empirical findings, including baseline regression, robustness tests, channels, and alternative analyses. Finally, Section 5 summarizes the research findings and their implications.

2. Literature review and hypothesis development

2.1. Literature review

The existing literature relevant to this study can be categorized into three main types:

The first set of studies examines the impact of the NECDC policy, focusing on environmental pollution, carbon emissions, and green economic growth. For instance, Guo et al. [14] stated that the NECDC policy lowers environmental pollution and produces considerable negative spillover effects on neighboring cities [15]. However, due to the absence of long-term policy planning, sustaining pollution reduction effects is challenging [7]. Che et al. [16] observed a 15.34 % reduction in urban carbon emissions on account of the NECDC policy, primarily driven by scale and structural emission reduction effects [17]. Nevertheless, the NECDC policy has a negligible inhibitory effect on resource-based and small-to-medium-sized cities [18]. Additionally, the NECDC policy demonstrates substantial spatial spillover effects, fostering carbon emissions reduction in surrounding cities [12]. Regarding green development, the NECDC policy positively impacts urban energy efficiency, primarily via tax incentives [13] and the promotion of green innovation [19]. Furthermore, the influence of the NECDC policy on green total factor productivity varies across resource endowment and urban scale [9].

The second category of literature explores the determinants of corporate sustainability. Previous studies largely investigated the impact of internal factors on enterprise sustainability, including corporate governance structure, management characteristics, and operational strategies. Concerning governance structure, research highlights the role of board diversity [20], independence [21], and size [22] in guiding companies towards sustainability. Gardazi et al. [23] documented that a greater number of independent directors diminishes corporate sustainability, especially in polluting industries and highly marketable regions [24]. Regarding management characteristics, scholars point out that the personality and ethical leadership of the CEO impact corporate sustainability [25]. Moreover, CEO turnover stimulates corporate sustainability performance five years post-turnover [26]. In terms of operational strategies, several studies highlight the importance of technological peer pressure [27] and competitive strategies [28] on

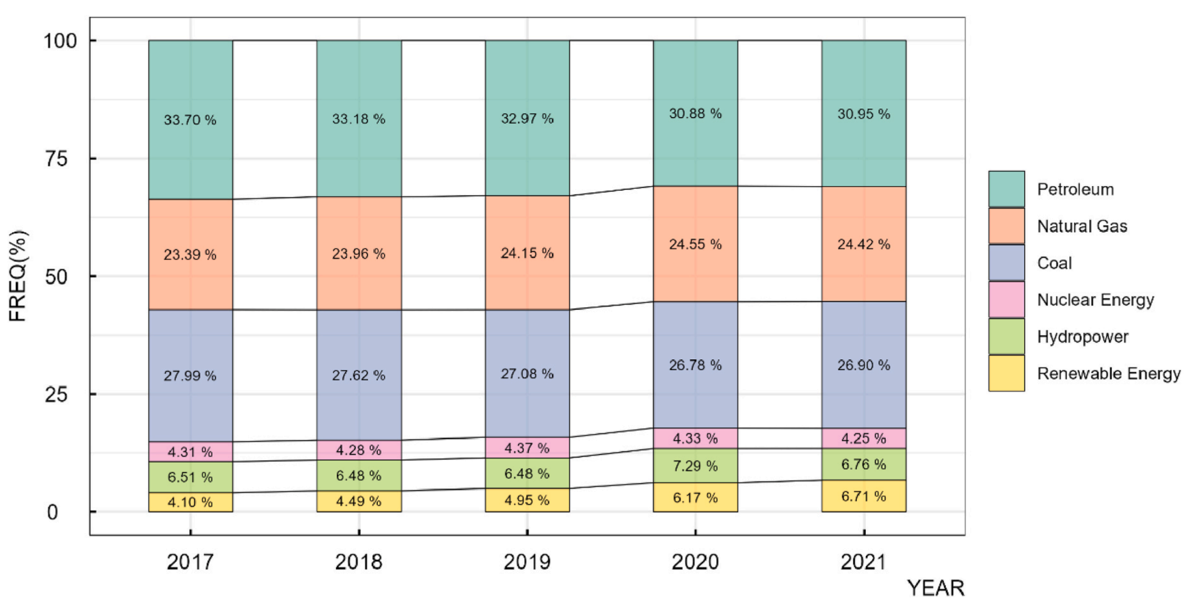

Fig. 1. Energy consumption structure.
Notes: Fig. 1 depicts the global energy consumption distribution by type. The composition of global primary energy consumption includes oil, natural gas, coal, nuclear energy, hydropower, and renewable energy sources such as solar, wind, and biomass, among others. The dataset is sourced from the BP Statistical Review of World Energy.

corporate sustainability performance. Furthermore, group-affiliated companies often exhibit higher sustainability due to institutional pressures [29]. Barón Dorado et al. [30] also revealed that implementing environmental management systems facilitates the sustainable development performance of manufacturing firms.

The third group of literature examines the effectiveness and mechanisms of targeted policies on enterprise sustainability. A substantial body of literature has validated the impact of policies such as low-carbon city initiatives [31], carbon emissions trading [32], and green finance [33] on enterprise sustainability. In developing countries, studies have documented that the level of enterprise sustainability is relatively low [34], requiring governments to adopt targeted policies [35]. Li et al. [36] highlighted the positive impact of China's low-carbon city pilot policy on enterprise sustainability, primarily through fostering eco-friendly technology [37]. Similarly, Sun et al. [38] examined the dilemma between environmental protection and economic growth, suggesting that carbon emissions trading policies spur corporate value-added rates, steering economic growth towards low-carbon pathways. However, some literature suggests that carbon emissions trading policies may diminish investment expenditure, particularly in industries like construction materials and steel [39]. Additionally, research discusses the effects of unique financial policies in developing countries on enterprise sustainability. For instance, Gao et al. [34], focusing on China's Green Financial Reform and Innovation Pilot policy, demonstrated its prominent promotion of ESG performance by alleviating financing constraints, encouraging green investment, and stimulating managers' environmental awareness.

In summary, while current research on the NECDC policy and industrial enterprise sustainability has made notable strides, several limitations persist. First, existing works predominantly focus on the pollution reduction effects of the NECDC policy, overlooking a comprehensive examination of its overall impact on sustainable development. Second, research primarily addresses the policy's implementation effects at the macro level, neglecting micro-level evidence on sustainability, thus obscuring the role of city-level policy-making in enterprise sustainability. Lastly, the mechanisms through which the NECDC policy affects industrial enterprise sustainability remain ambiguous, hampering efforts to elucidate the underlying rationale behind its impact on industrial enterprise sustainability.

2.2. Hypothesis development

2.2.1. Effects of green innovation

Green innovation serves as a catalyst for industrial enterprise sustainability [40]. However, industrial enterprises generally exhibit limited incentive for engagement in green innovation owing to its high complexity [41], risks [42], and public goods nature [43]. To foster participation in green innovation, external incentives are essential [44]. The NECDC policy mandates local governments to devise clear financial and tax support initiatives, such as cash rewards and tax breaks, for green innovation. These incentives significantly boost the green innovation efforts of industrial enterprises, thereby elevating their sustainable development.

The NECDC policy is able to spur the willingness of industrial enterprises to engage in green innovation. The NECDC policy focuses on innovating new energy technologies and improving pollution control in pilot areas [9], which can mitigate the risks and costs associated with green innovation for industrial enterprises [13]. To boost the innovation capabilities of high-energy-consuming enterprises, local governments may offer subsidies [45], tax exemptions [46], and other policy support for green innovation activities [41], thereby diminishing the economic costs and risks connected to such endeavors and increasing enterprises' enthusiasm [15]. Additionally, the NECDC policy sets mandatory targets for the proportion of new energy consumption in pilot areas, thereby raising the pollution opportunity costs for industrial enterprises. Consequently, industrial enterprises are compelled to reinforce green innovation for higher energy utilization efficiency.

The NECDC policy provides support for green innovation in industrial enterprises. The NECDC policy provides financial backing for the green innovation activities of industrial enterprises through subsidies, tax exemptions, and alternative measures, thus lowering associated costs [15]. Moreover, the incentivizing actions of local governments play a guiding role in channeling various stakeholders into the new energy sector via market mechanisms. This enriches the resource pool for green innovation, stimulates motivation for green innovation, and consequently improves its sustainability. Liu et al. [10] affirmed that the NECDC policy offers substantial tax incentives, easing financing constraints for enterprises engaged in green innovation. Yang et al. [13] validated that the NECDC policy provides considerable fiscal support, thereby fostering enhancements in green total factor productivity in resource-based cities.

2.2.2. Alleviation effect of financing constraints

The NECDC policy articulates a range of fiscal and financial measures to alleviate funding constraints on industrial environmental investments, securing essential resources for sustainable development. For example, it requires financial institutions to establish local financing platforms and prioritize credit for demonstration city projects. Specifically, the NECDC policy alleviates financing constraints on industrial enterprise sustainability via the following mechanisms:

Enhancing credit accessibility: The NECDC policy enhances credit access for industrial enterprises by improving the financial environment [10]. It is often accompanied by local government initiatives and favorable industry expectations [30], motivating financial institutions to extend more credit and promote industrial sustainability [47]. The policy also fosters the development of green financial products, such as green loans and special-purpose financing [46], which lower borrowing barriers [48]. Furthermore, enhanced information disclosure and improved credit data mitigate information asymmetry [49], allowing financial institutions to assess risks more accurately and improve credit allocation efficiency [48]. Increased credit access provides a stable funding source, enabling industrial enterprises to expand production, pursue upgrades, and strengthen their sustainability [11].

Boosting government subsidies: The subsidy measures within the NECDC policy, including fiscal subsidies, tax incentives, and dedicated funding, play a pivotal role in alleviating firms' financing constraints [50]. By providing initial capital for operations and environmental projects [33], these subsidies reduce reliance on external financing and strengthen firms' commitment to sustainable development [51]. Moreover, receipt of subsidies subjects firms to government oversight, where sustainability performance is evaluated, and penalties are imposed on underperformers [52]. This regulatory mechanism motivates firms to increase environmental investments to mitigate the risk of sanctions [53], thereby improving both economic and environmental outcomes [10]. Beyond relieving short-term financial pressures, these subsidies also offer critical support for firms' long-term green transformation [54]. In a nutshell, the preceding insights lead to the formulation of the following research hypotheses.

Hypothesis 1. The NECDC policy elevates the sustainable development of industrial enterprises.

Fig. 2 illustrates the theoretical framework of this article.

3. Policy background and empirical strategy

3.1. Policy background

The development and utilization of new energy sources are pivotal in addressing resource limitations, enhancing energy security, and ensuring environmental sustainability. Given the escalating tensions between China's energy demands, environmental degradation, and economic growth, Chinese authorities prioritize the advancement and

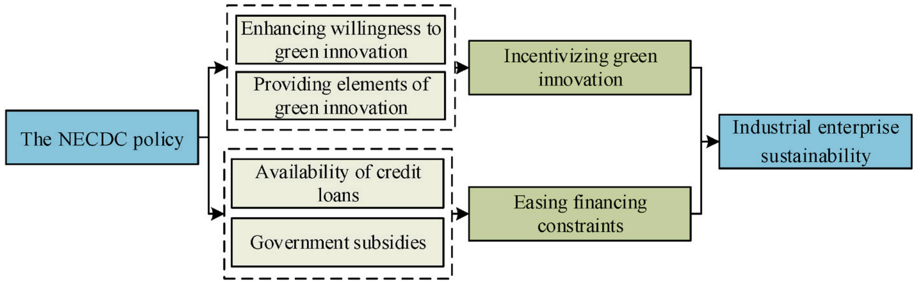

Fig. 2. Analytical framework.

adoption of new energy technologies. The national Twelfth Five-Year Plan underscores the imperative to elevate the share of new energy consumption, advocating for the diversified and eco-friendly evolution of the energy sector. This strategic emphasis extends to the cultivation of alternative energy sources such as solar, biomass, and geothermal energy.

To boost the adoption of new energy in urban settings, the National Energy Administration (NEA) initiated the establishment of new energy consumption demonstration cities in 2012. These cities must meet specific criteria, including regulations on pollution control and benchmarks for new energy utilization. Specifically, pollution control requirements entail compliance with standards for diminishing major pollutants and curbing energy consumption intensity. New energy utilization standards emphasize achieving a certain proportion of new energy consumption within cities or annually. For instance, the NECDC policy mandates that new energy consumption in pilot cities must surpass 6 %, with a minimum of two new energy technologies meeting prescribed standards.

The establishment of NECDC propels technological advancements in new energy utilization, facilitating its extensive integration into urban landscapes [14]. The NECDC policy upgrades urban energy frameworks by encouraging the decentralized adoption of diverse renewable energy sources, which fosters a clean and efficient energy utilization infrastructure [54]. In practice, plans submitted by various regions undergo scrutiny by the NEA, ensuring adherence to specified criteria. In 2014, the inaugural group of NECDC and industrial parks, comprising 81 cities and 8 industrial parks, was announced. Fig. 3 showcases the geographical dispersion of new energy pilot cities.

3.2. Model specification

In accordance with the literature available [14], this paper employs a DID approach to identify the response of industrial enterprise sustainability to the NECDC policy. The empirical specification is as follows:

$$SUSBILITY_{itc} = \alpha_0 + \alpha_1 CLEANEN_{tc} + \alpha_2 CITYX_{tc} + \alpha_3 FIRMX_{itc} + \varphi_i + \gamma_t + \delta_c + \varepsilon_{itc} \tag{1}$$

In equation (1), c, i, and t denote a city, enterprise, and year in sequence. *SUSBILITY* represents the sustainability level of industrial enterprises, measured by both environmental and economic performance. *CLEANEN* stands for the variable of the NECDC policy. α captures the effect of the NECDC policy on industrial enterprise sustainability, which is the core estimate of interest in this work. An impressively positive of α implies

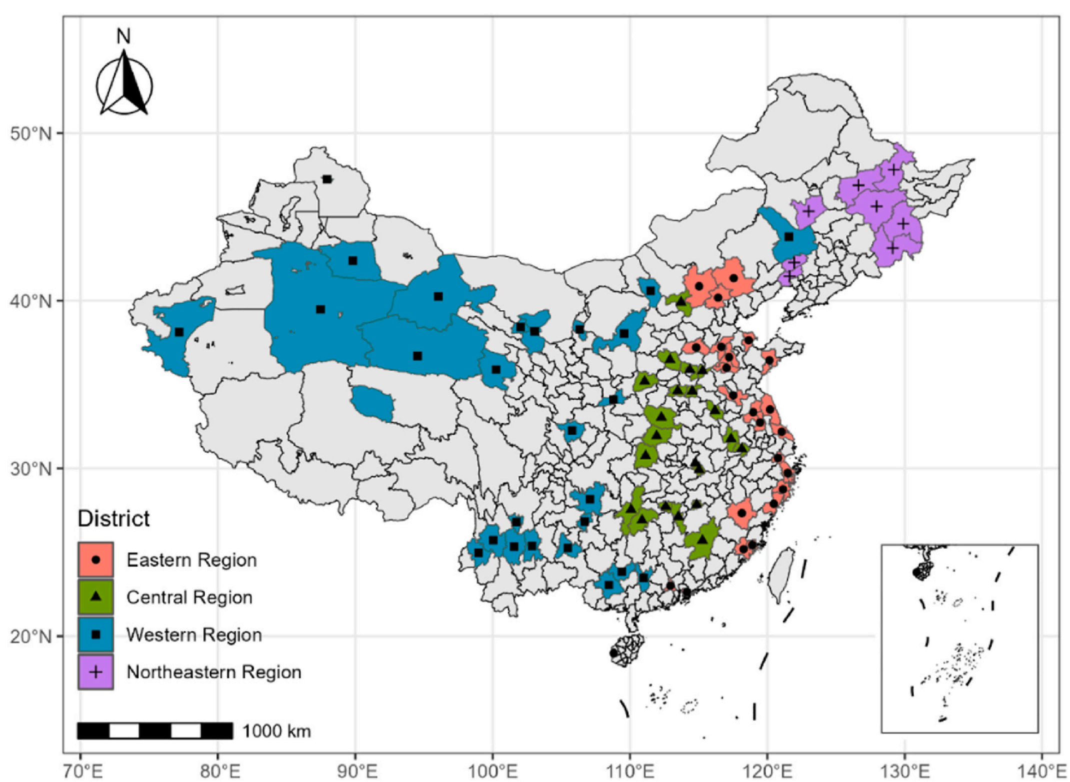

Fig. 3. The spatial distribution of NECDC.

that the NECDC policy can promote industrial enterprise sustainability, thus supporting the expectations of this study. *CITYX* symbolizes city-level control variables, while *FIRMX* represents enterprise-level control variables. Additionally, this study controls for city (φ), enterprise (γ), and year (δ) fixed effects. ε is the random disturbance term in the model.

3.3. Variable description

3.3.1. Industrial enterprise sustainability

Building on Baek and Lee [55] and Saunila et al. [56], we categorize industrial enterprise sustainability into two dimensions: environmental performance (*SUSDE*) and economic performance (*PROFIT*). Specifically, *SUSDE* is measured by the enterprise environmental responsibility rating score [57], which aggregates indicators such as resource consumption, pollutant emissions, and waste management. To reduce potential biases, we use the logarithm of this score in the empirical analysis, where a higher *SUSDE* reflects better environmental governance. Meanwhile, *PROFIT* is gauged by the return on total assets (ROA) of industrial enterprises [58]. Existing literature employs several indicators to assess the financial performance of industrial enterprises, including return on equity (*ROE*), Tobin's Q ratio (*TOBIN*), and ROA. Compared to *ROE* and *TOBIN*, ROA offers notable advantages. Specifically, it captures the ability to generate profits relative to total assets, providing a more comprehensive measure of operational efficiency and management's capacity to leverage assets for profitability. Moreover, ROA is not influenced by capital structure or market valuation, making it particularly well-suited for cross-industry comparisons, especially in the presence of significant industry heterogeneity. For these reasons, we adopt ROA as the primary measure of financial performance while conducting robustness checks with *ROE* and *TOBIN*.

3.3.2. New energy consumption demonstration cities

Following Hou et al. [59], we designate the cities engaged in the pilot initiative to build the NECDC, initiated by the Chinese government in 2014, as the experimental group. Conversely, we regard other prefecture-level cities as the control group, constructing the variable for the NECDC policy (*CLEANEN*). In particular, if a company is situated within the prefecture-level cities covered by the NECDC policy in 2014 or later, *CLEANEN* is denoted as 1; otherwise, it is labeled as 0.

3.3.3. Control variables

Similar to Yang et al. [13], this paper takes per capita GDP (*PGDP*), industrial structure (*STRUC*), and fiscal expenditure (*FINSUP*) as macro-level controls. At the corporate level, this study aligns with Shi and Huang [47] and Song et al. [54], incorporating key corporate characteristics as control variables. Specifically, it accounts for firm size (*ASSET*), leverage ratio (*LEV*), cash ratio (*CASH*), shareholding ratio of the largest shareholder (*FIRST*), proportion of independent directors (*INDEP*), and CEO duality (*DUAL*). Additionally, this study incorporates city, firm, and year fixed effects. Table 1A of the appendix details the calculation methods for each variable.

3.3.4. Data sources

This study utilizes a dataset of publicly traded companies in Chinese industries spanning from 2011 to 2021. In 2010, the Chinese government initiated a series of environmental policies to improve regional air quality through collaborative efforts and penalties for environmental violations. Taking the 2010 sample into the study could trigger confounding factors, potentially compromising the accuracy of estimates. Additionally, before 2010, substantial data gaps existed regarding corporate environmental responsibility. Therefore, we opt to conduct empirical tests using datasets from 2011 to 2021. The analysis focuses on listed industrial enterprises within sectors B, C, and D, encompassing the mining (B), manufacturing (C), and the production and distribution of electricity, heat, gas, and water (D).

To ensure the reliability of empirical estimates, we implemented the following procedures on the original sample of industrial enterprises: (1) Excluding industrial enterprises with PT, ST, or *ST statuses; (2) Omitting industrial enterprises that underwent IPO during the study period; (3) Removing industrial enterprises that went public via reverse mergers, as changes in their operational industries and entities may render the corporate information non-referential; (4) Eliminating samples with remarkable data gaps; (5) Employing winsorization on continuous variables at the 1st and 99th percentiles to address the potential impact of outliers.

The datasets in this paper are obtained from multiple sources, including the China Economic and Financial Research (CSMAR) database, the China National Research Data Sharing Platform (CNRDS), and the China City Statistical Yearbook. Specifically, the data about industrial enterprise environmental responsibility is extracted from the CSMAR database, while information regarding the return on total assets is sourced from the CNRDS. To ensure data consistency, we conducted cross-validation of the financial data retrieved from the CSMAR database. The corporate-level control variables are derived from the CSMAR database, while city-level data are acquired from the China City Statistical Yearbook. Notably, to address missing data at the city level, interpolation techniques were applied.

3.4. Descriptive statistics

Table 1 displays the descriptive statistics of key variables, including the number of observations, means, standard deviations, medians, and extremes. *SUSDE* exhibits a mean of 0.854 and a standard deviation of 0.454, indicating considerable variation in environmental responsibility among industrial enterprises across different cities. Similarly, *PROFIT* has a mean of 0.090 and a standard deviation of 0.074, suggesting remarkable differences in profitability among industrial enterprises. Notably, the mean value of *PROFIT* (0.090) exceeds the median value (0.076), suggesting that highly profitable industrial enterprises contribute to an elevated overall profitability level. This implies that most industrial enterprises have weak profitability, with only a few demonstrating strong profitability. The descriptive statistics of alternative control variables fall within reasonable ranges and are generally consistent with Liu et al. [10].

Next, we assess the overall disparities in industrial enterprise sustainability concerning the implementation of the NECDC policy. Intergroup difference tests are conducted employing the Wilcoxon method, with results depicted in Fig. 4. Clearly, the disparities are evident in both environmental and financial performance between pilot and non-pilot cities, with p-values <0.01. This initial finding substantiates the prominent impact of the NECDC policy on industrial enterprise sustainability, thereby corroborating our hypothesis. Nevertheless, the overall effect of the NECDC policy on industrial enterprise sustainability remains equivocal and warrants further investigation utilizing an econometric model.

Table 1
Descriptive statistics.

VarName	Obs	Mean	SD	Min	Median	Max
SUSDE	9510	0.854	0.454	0.000	1.099	1.792
PROFIT	9510	0.090	0.074	0.000	0.076	1.153
CLEANEN	9510	0.733	0.442	0.000	1.000	1.000
PGDP	9510	10.309	4.813	1.009	10.000	46.775
STRUC	9510	0.539	0.131	0.101	0.514	0.839
FINSUP	9510	0.155	0.062	0.022	0.143	1.879
ASSET	9510	22.206	1.360	18.784	21.977	28.636
LEV	9510	0.396	0.192	0.008	0.394	0.987
CASH	9510	0.161	0.123	−0.165	0.127	0.837
FIRST	9510	0.352	0.149	0.003	0.332	0.900
INDEP	9510	0.376	0.056	0.143	0.364	0.800
DUAL	9510	0.290	0.454	0.000	0.000	1.000

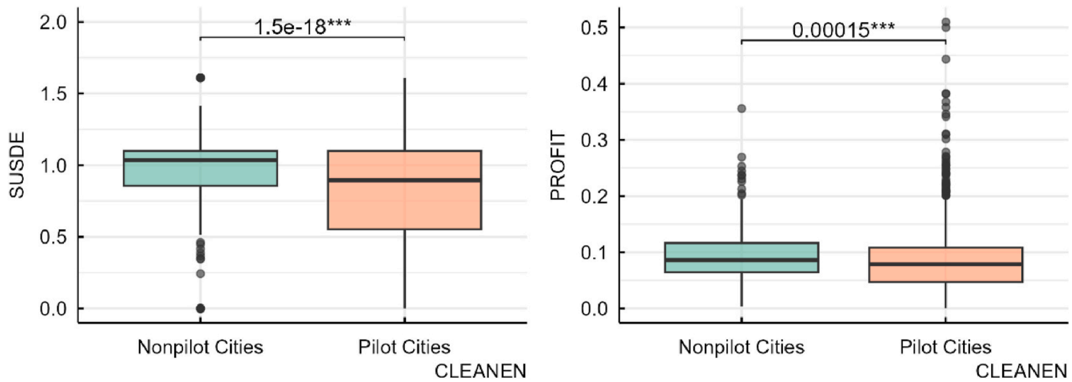

Fig. 4. Intergroup difference test of industrial enterprise sustainability.
Notes: Fig. 4 displays the coefficient differences of industrial enterprise sustainability between pilot and non-pilot cities for new energy. The values depicted in the figure denote p-values acquired from the Wilcoxon test. Additionally, ***, **, and * indicate significance at the 1 %, 5 %, and 10 % levels, accordingly.

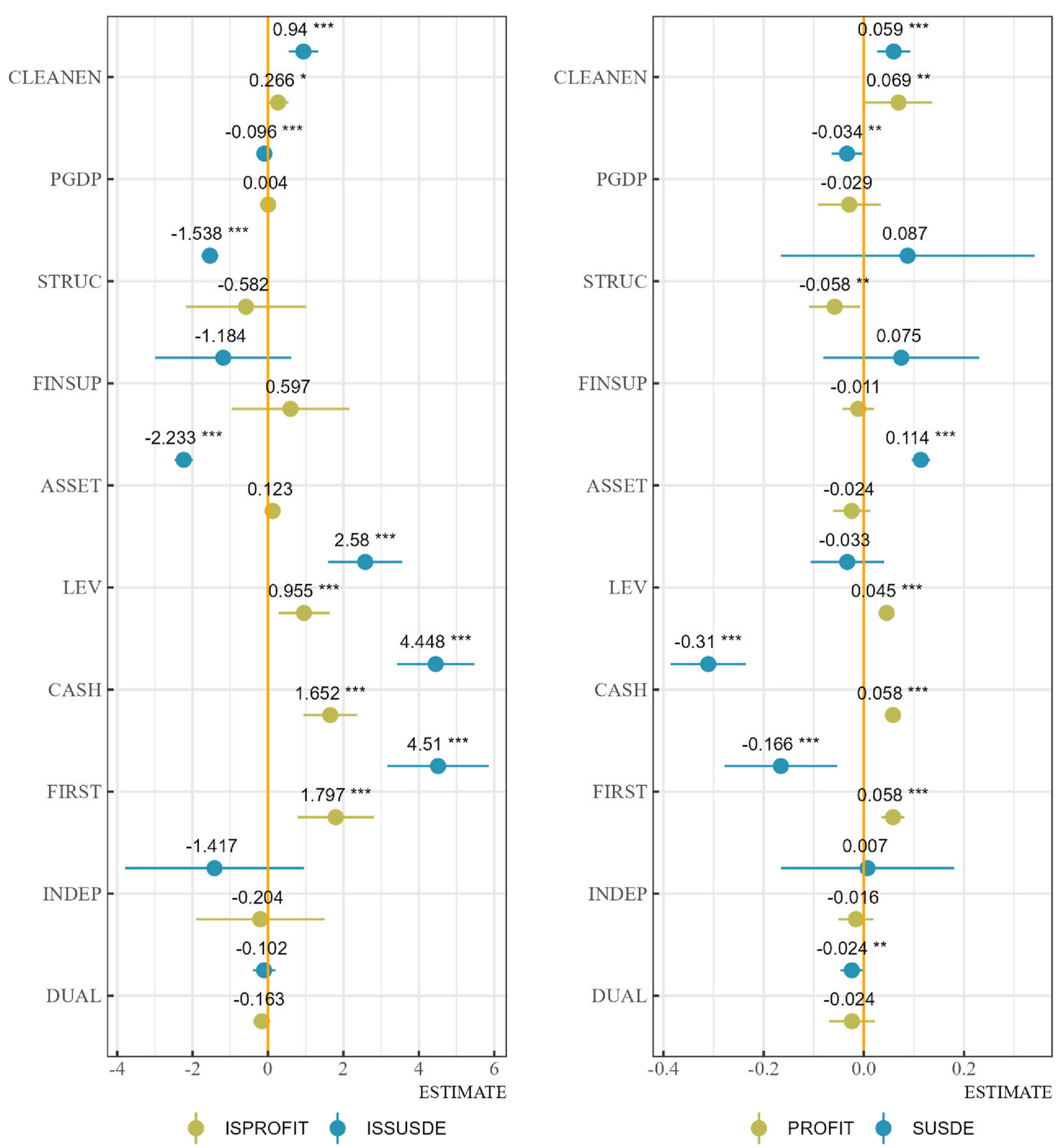

Fig. 5. Regression coefficients.
Notes: Fig. 5 illustrates the estimation of the NECDC policy on industrial enterprise sustainability. The numbers in the figure represent coefficients; ***, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

4. Empirical analysis

4.1. Baseline regression

Fig. 5 presents the outcomes regarding the impact of the NECDC policy on industrial enterprise sustainability. The economic benefits of the NECDC policy are analyzed in terms of sustainable development behavior and actual effectiveness. First, we construct dummy variables for the sustainable development behavior of industrial enterprises (*ISSUSDE*, *ISPROFIT*) and utilize a logit model to assess the likelihood of the NECDC policy affecting the sustainable development behavior of industrial enterprises, primarily investigating whether the NECDC policy impacts industrial enterprise sustainability. *ISSUSDE* is assigned 1 if the score of enterprise environmental responsibility is non-zero; otherwise, it is assigned 0. Similarly, *ISPROFIT* is set to 1 if the total asset return rate exceeds the industry-specific mean; otherwise, it is set to 0. Second, we employ a DID strategy to capture the net benefits of the NECDC policy on industrial enterprise sustainability. We gauge the level of industrial enterprise sustainability based on two dimensions: environmental performance (*SUSDE*) and financial performance (*PROFIT*). Environmental performance (*SUSDE*) is determined by the score of corporate environmental responsibility, while financial performance (*PROFIT*) is measured by the total asset return rate of industrial enterprises.

The left panel of Fig. 5 depicts the effects of the NECDC policy on the sustainable development behavior of industrial enterprises. The coefficient of *CLEANEN* on *ISSUSDE* is both significant and positive, with a p-value <0.01, indicating that the NECDC policy acts as a catalyst for industrial enterprises to engage in environmental governance behavior. Similarly, the response of *CLEANEN* to *ISPROFIT* is significantly positive, suggesting that the NECDC policy enhances the probability of industrial enterprises improving financial returns. These findings imply that the NECDC policy dramatically increases the likelihood of sustainable development for industrial enterprises.

In the subsequent analysis, we examine the overall welfare implications of the NECDC policy on industrial enterprise sustainability. The right panel of Fig. 5 presents the results from the DID estimation. The coefficient of *CLEANEN* on *SUSDE* is statistically significant and positive at the 1 % level, indicating that the NECDC policy leads to improvements in environmental performance among industrial enterprises. In economic terms, the implementation of the NECDC policy is associated with a 5.9 % increase in environmental upgrading. Furthermore, the coefficient of *CLEANEN* on *PROFIT* is 0.069, with a p-value <5 %, suggesting that the NECDC policy raises the economic performance of industrial enterprises. In practical terms, the enactment of the NECDC policy contributes to a 6.9 % advancement in the financial performance of industrial enterprises. By and large, the NECDC policy substantially augments industrial enterprise sustainability, yielding dual benefits in both economic and environmental domains. Thus, our first research hypothesis is supported.

Our study extends the research on NECDC policy and environmental governance. Prior works by Gao et al. [17] and Hou et al. [59] have demonstrated the capacity of the NECDC policy to augment the efficacy of urban environmental governance. In contrast, our study adopts a dual-pronged approach, examining both environmental and economic ramifications. Leveraging micro-level data, we analyze the effect of the NECDC policy on sustainable development, broadening and enriching the investigation into the economic implications of the NECDC policy.

4.2. Robustness check

4.2.1. Parallel trends and dynamic effects test

Effective estimation using the DID method hinges on the precondition that, before the implementation of the NECDC policy, industrial enterprises in both the treatment and control groups displayed similar trends in sustainability. Deviations from this assumption bring about estimation biases, as the estimated effects might partly arise from systematic disparities between the treatment and control groups. Moreover, the baseline regression solely captures the average alterations in industrial enterprise sustainability over the study duration, failing to depict the divergent implications across periods. Therefore, following Che et al. [16], we formulate an empirical specification (2) for parallel trends and dynamic effects tests.

$$SUSBILITY_{itc} = \alpha_0 + \sum_{t=-2}^{7} \beta_t CLECY_c \times PIOD_t + \alpha_2 CITYX_{tc} + \alpha_3 FIRMX_{itc} + \varphi_i + \gamma_t + \delta_c + \varepsilon_{itc} \tag{2}$$

where *CLECY* denotes whether the city falls under the purview of the NECDC policy. It is assigned a value of 1 if included and 0 otherwise. *PIOD* represents time-dummy variables. Given the limited data available for the third year of the sample and the extended duration of the post-policy period, the observations for the third year are consolidated into period -2. t stands for the number of periods relative to the base period. Here, β captures the effect of the NECDC policy on industrial enterprise sustainability in the t year. The setting of other variables remains consistent with specification (1). Additionally, to prevent perfect collinearity, we omit samples from period -1.

Fig. 6 presents the outcomes of the parallel trends and dynamic effects assessments. Notably, prior to the enforcement of the NECDC policy, the estimates of β are neither statistically significant nor distant from zero, indicating the absence of pre-existing trends. This implies an absence of remarkable divergence in industrial enterprise sustainability between the treatment and control groups pre-policy implementation, thus affirming adherence to the premise of parallel trends. Furthermore, in the first year of implementation, the NECDC policy demonstrates a positive but statistically insignificant effect on *SUSDE*, becoming significant only after the second phase. This pattern reflects a delayed impact on environmental performance, underscoring the policy's long-term governance benefits. By contrast, its positive effect on financial performance is evident across all phases. These findings position the policy as a catalyst for industrial enterprise sustainability, yielding lasting and meaningful outcomes.

One possible explanation for this result is that the impact of the NECDC policy on industrial enterprise sustainability is a long-term process, rendering its effects less pronounced within a single calendar year. Additionally, the cyclical progression of green innovation and equipment upgrades indicates that the policy's influence on sustainability may manifest with a time lag.

4.2.2. Placebo test

To ensure the accuracy of causal identification when employing the DID method, this study adopts a randomized experiment to mitigate potential biases arising from incomparable experimental and control groups. Specifically, we randomly select interaction term (*CLEANEN*) samples of equivalent sizes to the actual numbers for each year and conduct estimations using the DID strategy. This process is iterated 1000 times to minimize potential interference from other low-probability factors.

Fig. 7 displays the kernel density distribution of t-values for *CLEANEN* after random sampling. We utilize the t-statistics of *CLEANEN* from the baseline estimation as a reference point to evaluate the results of the placebo test. Clearly, only a small fraction of the t-values in the randomized experiment surpass the actual values, indicating a minimal influence of unobserved factors on the relationship between the NECDC policy and industrial enterprise sustainability. Overall, the non-random pattern of the effect underscores the reliability of the baseline estimation.

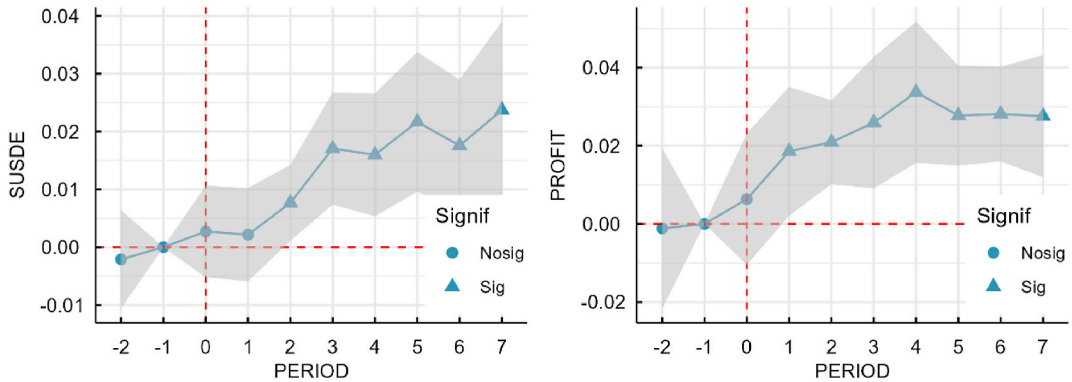

Fig. 6. Parallel trends test.

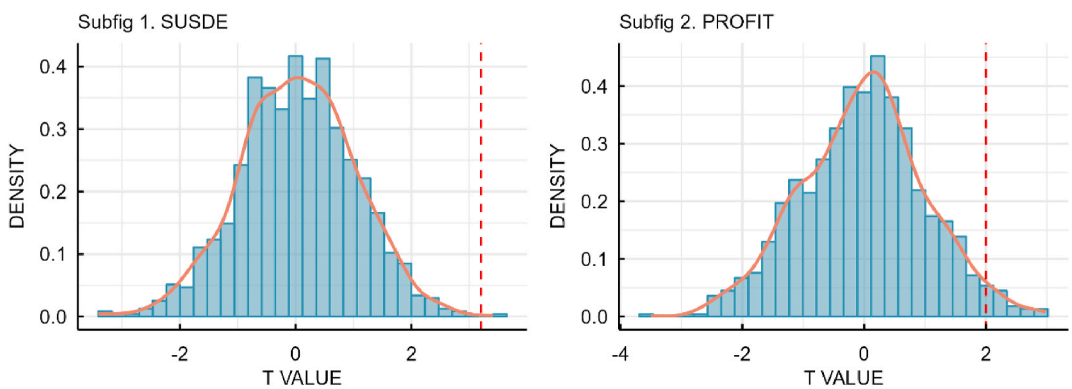

Fig. 7. Placebo test.
Notes: Fig. 7 depicts the placebo test results assessing the impact of the NECDC policy on industrial enterprise sustainability. The left panel presents *SUSDE* as the dependent variable, while the right panel features *PROFIT*.

4.2.3. 2SLS

To address endogeneity concerns in estimation, we employ the instrumental variable method to complement the mitigations from the DID approach. We select urban slope as the instrument variable. From a theoretical standpoint, flatter terrains indicated by gentler urban slopes are conducive to industrial clustering, triggering increased energy consumption. Cities with high energy consumption are more likely to be selected as new energy pilots, satisfying the relevance condition. Additionally, urban slope is naturally determined and does not directly influence industrial sustainability, fulfilling the exogeneity condition.

Columns (1)–(2) in Table 2 present the outcomes obtained through the instrumental variable method. Both the C-D Wald and K-P rk Wald statistics exhibit F-values surpassing 10, satisfying the relevance condition for the instruments. Obviously, the estimates of *CLEANEN* remain significantly positive at the 5 % level. This underscores the persistent positive impact of the NECDC policy on industrial enterprise sustainability.

4.2.4. PSM + DID

Given that the selection of the NECDC policy is voluntary, potential non-random selection may bring about sample selection bias for empirical findings. To mitigate this, we employ propensity score matching (PSM) to address such bias. PSM generates matching scores based on the characteristics of treatment and control groups, creating new groups for more reliable results. We utilize control variables from specification (1) for matching and compute the probability of a city being designated as a NECDC using a probit model. Kernel matching is employed for this purpose. Subsequently, we conduct empirical tests

Table 2
Endogeneity.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	SUSDE	*PROFIT*	*SUSDE*	*PROFIT*	*SUSDE*	*PROFIT*
CLEANEN	1.156**	0.283**	0.061***	0.006*	0.059***	0.009**
	(2.088)	(2.351)	(3.476)	(1.717)	(3.487)	(2.503)
IMR					−0.035	0.526***
					(-0.150)	(11.282)
Constant	–	–	−1.546***	0.113**	−1.620***	−0.323***
	–	–	(-6.762)	(2.426)	(-5.408)	(-5.340)
FIRM	YES	YES	YES	YES	YES	YES
YEAR	YES	YES	YES	YES	YES	YES
CITY	YES	YES	YES	YES	YES	YES
N	9510	9510	9358	9347	9510	9510
F	17.35	31.23	25.63	11.12	26.38	21.80

Notes: Robust standard errors are reported in parentheses. ***, **, * indicate statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

using matched samples, with regression results presented in columns (3)–(4) of Table 2. Notably, the coefficients of *CLEANEN* remain significantly positive, reinforcing our main findings.

4.2.5. Heckman strategy

The DID method is effective in evaluating the economic welfare impacts of the NECDC policy. However, it may encounter sample self-selection issues during application. The central government selects pilot cities based on various factors, such as regional economic development, industrial structure, energy-saving potential, and environmental capacity. This selection bias may bring about endogeneity problems and biased regression results. Following Shi and Huang [60], we employ the Heckman strategy to address sample self-selection. Specifically, we construct dummy variables indicating whether a city is designated as a NECDC and conduct probit estimation using all control variables from specification (1). The results of the probit estimation are used to compute the inverse Mills ratio (IMR), which is then reintroduced into model (1) for re-examination.

Columns (5)–(6) in Table 2 present the results of the Heckman model. In column (6), the coefficient of IMR is significantly negative at the 1 % level, indicating the presence of sample selection bias in the empirical sample, validating our concern regarding this issue. However, the estimate of *CLEANEN* remains significantly positive, suggesting that even after accounting for and mitigating sample selection bias, the conclusion that the NECDC policy affects industrial enterprise sustainability remains valid.

4.2.6. Other robustness checks

(1) *Alternative measures of industrial enterprises sustainability*

To address potential heteroscedasticity, the baseline regression uses the logarithm of the environmental performance score. However, this approach may introduce bias due to overfitting. To mitigate this issue, we also employ the raw environmental score (*DESCO*) in our analysis, with the results presented in column (1) of Table 3. Furthermore, in line with DasGupta and Roy [61] and Zhou et al. [62], we evaluate financial performance using return on equity (*ROE*) and market performance using Tobin's Q (*TOBIN*). The estimation results, with *ROE* and *TOBIN* as dependent variables, are reported in columns (2)–(3) of Table 3. In all specifications, the coefficients of *CLEANEN* are consistently positive and statistically significant, supporting the robustness of the baseline regression findings.

(2) *Tobit strategy*

We take advantage of the Tobit strategy to analyze the effect of the NECDC policy on industrial enterprise sustainability, accounting for the censored nature of both *SUSDE* and *PROFIT*, which are non-negative variables. The Tobit approach is widely acknowledged for its capacity to generate reliable estimates in the presence of censored data [63]. The results, shown in columns (4)–(5) of Table 3, reveal that the relationship between *CLEANEN* and both *SUSDE* and *PROFIT* is significantly positive, reinforcing our primary findings.

(3) *Excluding special city samples*

To ensure the robustness of our empirical findings, we omit samples from municipalities directly under the central government and provincial capitals from our analysis. These municipalities are more likely to receive preferential treatment in terms of politics and the economy compared to ordinary prefecture-level cities. By way of example, during the implementation of the NECDC policy, the central government often prioritizes these municipalities to serve as policy benchmarks, potentially triggering bias for empirical results. Thus, we conduct regression analyses excluding samples from these municipalities, with the results presented in columns (6)–(7) of Table 3. Significantly, the estimates of *CLEANEN* remain statistically significant, reaffirming the robustness of our primary conclusions.

(4) *Excluding policy interference*

The effects of the NECDC policy on industrial enterprise sustainability may be confounded by concurrent policy interventions, potentially leading to biased estimates. To obtain more precise conclusions, this study controls for the effects of the following policies: First, between 2010 and 2017, the Chinese government launched three rounds of low-carbon pilot city programs, requiring selected cities to establish industrial systems and consumption patterns aligned with low-carbon emissions. These initiatives could affect the sustainability performance of industrial enterprises. To address this, the baseline model includes a dummy variable for the low-carbon pilot city policy (*LOBON*). Columns (1)–(2) of Table 4 report the impact of the NECDC policy on industrial enterprise sustainability after accounting for the influence of the low-carbon pilot city policy.

Second, the implementation of the revised *Environmental Protection Law* in 2015 strengthened pollution controls and substantially raised the penalties for noncompliant polluting enterprises. This policy could also affect industrial sustainability outcomes. To account for this, the study introduces an interaction term between the dummy variable for the revised Environmental Protection Law and a variable indicating heavily polluting industries into the baseline model (*ELAW*). Columns (3)–(4) of Table 4 report the estimate of the NECDC policy after adjusting for the influence of the revised law. Additionally, columns (5)–(6) report the estimation results that account for the simultaneous effects of the low-carbon city pilot policy and the new *Environmental Protection Law*.

Overall, the findings confirm that even after controlling for the low-carbon pilot city initiatives and the revised *Environmental Protection Law*, the NECDC policy maintains a significantly positive impact on the sustainable development of industrial enterprises.

Table 3
Alternative robustness checks.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	DESCO	*ROE*	*MAVAL*	*SUSDE*	*PROFIT*	*SUSDE*	*PROFIT*
CLEANEN	0.124***	0.004**	0.074***	0.043***	0.301***	0.060***	0.007**
	(2.982)	(2.042)	(3.695)	(3.356)	(4.918)	(3.510)	(2.166)
Constant	−4.643***	0.053**	−1.895***	−2.363***	14.287***	−1.521***	−0.082*
	(-7.485)	(2.182)	(-6.364)	(-18.628)	(24.085)	(-6.744)	(-1.843)
FIRM	YES	YES	YES	YES	YES	YES	YES
YEAR	YES	YES	YES	YES	YES	YES	YES
CITY	YES	YES	YES	YES	YES	YES	YES
N	9510	9510	9510	9510	9510	9403	9403
F	19.19	54.02	21.83	–	–	27.45	57.30

Notes: Standard errors in parentheses. ***, **, * denote significance at the 1 %, 5 %, and 10 % levels, respectively.

Table 4
Policy exclusivity checks.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	SUSDE	*PROFIT*	*SUSDE*	*PROFIT*	*SUSDE*	*PROFIT*
CLEANEN	0.060***	0.007**	0.055***	0.006*	0.056***	0.007*
	(3.571)	(2.032)	(3.246)	(1.886)	(3.297)	(1.901)
LOBON	0.064	0.004			0.059	0.004
	(1.175)	(0.397)			(1.094)	(0.358)
ELAW			0.077***	0.007*	0.076***	0.007*
			(3.609)	(1.700)	(3.583)	(1.691)
Constant	−1.600***	0.134***	−1.681***	0.127***	−1.668***	0.128***
	(-7.267)	(3.001)	(-7.625)	(2.828)	(-7.554)	(2.844)
FIRM	YES	YES	YES	YES	YES	YES
YEAR	YES	YES	YES	YES	YES	YES
CITY	YES	YES	YES	YES	YES	YES
N	9510	9510	9510	9510	9510	9510
F	26.56	9.984	27.66	10.24	25.45	9.393

Notes: The variable *LOBON* equals 1 if the city of an industrial enterprise is a low-carbon pilot city and the policy is implemented in the specified year or any subsequent years; otherwise, it is 0. The variable *ELAW* equals 1 if the revised *Environmental Protection Law* is enacted in the specified year or later, and the enterprise is classified as heavily polluting; otherwise, it is 0. Heavily polluting industries are identified by the following codes: B06, B07, B08, B09, C17, C19, C22, C25, C26, C28, C29, C30, C31, C32, and D44. Robust standard errors are reported in parentheses, with ***, **, and * indicating significance at the 1 %, 5 %, and 10 % levels, respectively.

4.3. Channel tests

Section 2 delineated the mechanisms through which the NECDC policy fosters industrial enterprise sustainability, primarily by stimulating green innovation and mitigating financing constraints. In line with Che et al. [16], we formulate the economic specification (3) to explore these pathways.

$$MESUM_{itc} = \alpha_0 + \beta CLEANEN_{tc} + \alpha_2 CITYX_{tc} + \alpha_3 FIRMX_{itc} + \varphi_i + \gamma_t + \delta_c + \varepsilon_{itc} \tag{3}$$

In equation (3), *MESUM* denotes the intermediary variables, including green innovation and financing constraints. β captures the estimation of the NECDC policy, which is the core focus of our attention. All other variables are consistent with the specification (1).

Table 5 reports the empirical findings regarding the mechanisms for green innovation and financial limitations. Following Bai et al. [41], we measure green innovation by counting the number of green patent applications (*GREINNO*). In a similar vein, according to the literature available [60], financing constraints for industrial enterprises are quantified using the SA index (*FINTAIN*). In column (1), the positive estimate for *CLEANEN* indicates a significant impact of the NECDC policy on green innovation, highlighting its potential to enhance industrial enterprise sustainability via green innovation. Similarly, in column (2), the coefficient of *CLEANEN* is significantly negative (p-value $<$0.01), suggesting that the NECDC policy can notably mitigate financing constraints faced by industrial enterprises within pilot cities, thereby fostering their sustainable development.

The preceding empirical findings collectively affirm the underlying mechanisms through which the NECDC policy shapes industrial enterprise sustainability. In the subsequent sections, we explore green innovation and financing constraints in greater detail. Following extant literature [52], this study categorizes green innovation into substantive green innovation and strategic green innovation, gauged respectively by the count of green invention patent applications (*SUBINNO*) and the count of green utility patent applications (*STRINNO*). From a theoretical standpoint, the NECDC policy mitigates financing constraints via two primary mechanisms: enhancing credit accessibility and providing fiscal support. Similar to Graff Zivin et al. [64] and Wang and Zhao [65], we quantify credit access using the logarithm of the sum of short-term loans, long-term loans, and non-current liabilities maturing within one year (*CREAID*), while fiscal support is measured by the ratio of government subsidies to total assets at year-end, as disclosed in the financial statement notes (*MDRGU*).

Columns (3)–(6) in Table 5 summarize the empirical findings regarding various aspects of industrial enterprise green innovation and financing sources. In column (3), the coefficient of *CLEANEN* is statistically significant and positive, indicating a substantial promotion of substantive innovation within enterprises due to the NECDC policy. This finding underscores the effectiveness of the NECDC policy in fostering sustainable development by encouraging substantive innovation. However, in column (4), while the estimate of *CLEANEN* on *STRINNO* is positive, it fails to reach statistical significance. This suggests that the NECDC policy does not dramatically stimulate strategic innovation, indicating a limited impact on sustainable development via strategic

Table 5
Mechanisms.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	GREINNO	*FINCO*	*SUBINNO*	*STRINNO*	*CREAID*	*MDRGU*
CLEANE	0.108***	−0.030***	0.037***	0.038	0.024**	0.034***
	(3.511)	(-3.320)	(3.161)	(1.300)	(2.346)	(2.612)
Constant	−5.897***	0.587***	−0.032	1.391***	−0.914***	1.539***
	(-11.718)	(3.823)	(-0.234)	(3.694)	(-5.242)	(9.306)
FIRM	YES	YES	YES	YES	YES	YES
YEAR	YES	YES	YES	YES	YES	YES
CITY	YES	YES	YES	YES	YES	YES
N	9510	9510	9510	9510	9510	9510
F	18.31	5.288	2.024	2.030	5.697	2.778

Notes: Table 5 illustrates the mechanism test outcomes regarding the influence of the NECDC policy on industrial enterprise sustainability. To address the heteroscedasticity, we apply the natural logarithm to one plus the count of green patents per enterprise. Moreover, standard errors are presented in parentheses, with significance levels denoted as ***, **, and * for 1 %, 5 %, and 10 %, respectively.

innovation. In columns (5)–(6), the responses of *CLEANE* to both *CREAID* and *MDRGU* are statistically significant and positive, implying that the NECDC policy boosts credit accessibility and fiscal support for industrial enterprises. This highlights the policy's role in alleviating financing constraints by enhancing credit availability and fiscal backing, thereby promoting industrial enterprise sustainability. In conclusion, the NECDC policy primarily facilitates substantive innovation rather than strategic innovation within enterprises. Additionally, the NECDC policy boosts access to both credit and fiscal resources, thereby enhancing the sustainability of industrial enterprises.

This study extends prior research concerning the mechanisms underlying the impact of the NECDC policy. Liu et al. [10] previously highlighted how this policy diminishes pollutant emissions via the promotion of green innovation. Expanding upon their findings, our study reveals that the NECDC policy predominantly fosters substantive green innovation to enhance sustainability, thereby enriching the understanding of the mechanism driving the NECDC policy.

4.4. Additional consideration

The preceding findings suggest that the NECDC policy elevates industrial enterprise sustainability. In this section, we explore a pivotal question: What attributes of both cities and enterprises impact the economic welfare outcomes of the NECDC policy? To address this query, we examine diverse factors across four dimensions: urban environmental stress, enterprise scale, industry characteristics, and enterprise sustainability foundations. This analysis offers robust empirical evidence to inform the broader adoption of the NECDC policy.

4.4.1. Environmental pressure

Local governments serve as the primary implementers of the NECDC policy. Faced with considerable environmental governance pressures, these entities rigorously enforce policy objectives and boost environmental oversight, thus fostering industrial enterprise sustainability. For instance, they may impose stringent control measures on high-energy-consuming enterprises, such as real-time monitoring, operational halts, closures, and substantial fines [10]. To mitigate potential repercussions from environmental degradation, industrial enterprises expedite technological advancements to enhance energy utilization efficiency and fortify their capacities for sustainable development.

Columns (1)–(2) in Table 6 present the empirical findings regarding the influence of urban environmental pressure on the relationship between the NECDC policy and industrial enterprise sustainability. To assess the heterogeneous effects, we construct a dummy variable to gauge environmental pressure (*ENPRE*) based on cities' mean $PM_{2.5}$ levels. Specifically, if the annual concentration of $PM_{2.5}$ exceeds the city's mean value, *ENPRE* is assigned a value of 1; otherwise, it is assigned 0. The coefficients of *ENPRE* × *CLEANEN* are significantly positive in both columns (1) and (2), indicating that the NECDC policy contributes to the promotion of sustainable development among industrial enterprises located in cities with heightened environmental pressure.

4.4.2. Enterprise scale

The influence of the NECDC policy on industrial enterprise sustainability may vary across enterprise sizes. Large enterprises, compared to small and medium-sized ones, exhibit impressively higher total energy consumption. Consequently, they are strongly incentivized by policy regulations to upgrade production equipment. Additionally, large enterprises possess superior R&D infrastructure and offer better welfare benefits, enabling them to attract high-tech talent and establish economies of scale and scope, thereby fostering green innovation. More importantly, the robust financial strength and resistance to risk make large enterprises more capable of obtaining loans from financial institutions, alleviating financing constraints in green innovation.

This study employs a dummy variable (*LARGE*) based on the average asset scale of enterprises to examine the diverse impacts of enterprise size on the relationship between the NECDC policy and industrial enterprise sustainability. If the asset scale of an enterprise surpasses the average, LARGE is assigned a value of 1; otherwise, it is 0. Columns (3)–(4) in Table 6 show how the economic benefits of the NECDC policy vary with enterprise scale. In these columns, the estimates of *LARGE* × *CLEANEN* are both significantly positive, indicating that the effect of the NECDC policy on the sustainable development of large industrial enterprises is notably pronounced. This aligns with findings from Chen et al. [19].

4.4.3. Sectoral characteristics

Previous evidence documents that the NECDC policy fosters the sustainability of industrial enterprises by raising green innovation.

Table 6
Moderation analysis.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	SUSDE	*PROFIT*	*SUSDE*	*PROFIT*	*SUSDE*	*PROFIT*
CLEANEN	0.034*	0.004	0.044***	0.007**	0.007	0.004
	(1.863)	(0.996)	(2.654)	(2.210)	(0.384)	(1.067)
ENPRE	−0.029*	−0.001				
	(-1.753)	(-0.283)				
ENPRE × *CLEANEN*	0.057***	0.007**				
	(3.743)	(2.276)				
LARGE			0.440***	0.028***		
			(8.199)	(2.599)		
LARGE × *CLEANEN*			0.181***	−0.031***		
			(3.071)	(-2.603)		
HPIND					−0.013	−0.009*
					(-0.535)	(-1.845)
FINTAIN × *HPIND*					0.187***	0.010**
					(7.475)	(2.053)
Constant	−1.524***	−0.071	−1.517***	−0.076*	−1.399***	−0.076*
	(-6.718)	(-1.591)	(-6.861)	(-1.697)	(-6.186)	(-1.691)
FIRM	YES	YES	YES	YES	YES	YES
YEAR	YES	YES	YES	YES	YES	YES
CITY	YES	YES	YES	YES	YES	YES
N	9510	9510	9510	9510	9510	9510
F	23.78	48.52	57.25	48.49	30.71	48.26

Notes: The industry codes for heavily polluting industrial enterprises include B06, B07, B08, B09, C17, C19, C22, C25, C26, C28, C29, C30, C31, C32, and D44. Moreover, robust standard errors in parentheses. ***, **, and * indicate significance at the 1 %, 5 %, and 10 % levels, respectively.

However, its regulatory effects are particularly strong in heavily polluting industries, compelling these firms to accelerate green innovation and improve their sustainability. Theoretically, the NECDC policy operates via two primary channels: First, it drives industrial transformation by leveraging market-based incentives, encouraging the adoption of new energy technologies and the consumption of clean energy. This reduces dependence on traditional energy sources, lowers emissions, and enhances environmental outcomes. Second, the NECDC policy intensifies pressure on industrial enterprises via regulatory mechanisms, fostering increased investment in green technologies and environmentally friendly production practices, thus boosting their competitiveness in a low-carbon economy.

To examine the impact of the NECDC policy on economic welfare across industries, we categorize industrial enterprises into heavily polluting and non-heavily polluting sectors (HPIND). Specifically, HPIND is assigned a value of 1 for industries classified as heavily polluting and 0 otherwise. Columns (5)–(6) of Table 6 present the empirical results regarding the effect of the NECDC policy on the sustainability of heavily polluting industrial industries. In these columns, the estimates of FINTAIN $\times$ HPIND are both significantly positive, indicating that the NECDC policy exerts a more substantial positive influence on the sustainability of heavily polluting industrial enterprises.

4.4.4. Foundations of industrial sustainability

The economic implications of the NECDC policy may hinge on the foundation of industrial sustainability. Enterprises with strong sustainability capabilities face fewer constraints under the NECDC policy. These entities typically have advanced technology and profitability, allowing them to fully utilize green technologies for energy efficiency. This helps alleviate the environmental pressures associated with the policy. Additionally, industries with strong sustainability profiles attract attention from the governmental and public sectors. This encourages them to increase the use of new energy sources and accelerate the transition to cleaner energy. Even without the constraints of the NECDC policy, those incumbents proactively integrate new energy sources into their production processes to maintain a positive corporate image and mitigate the potential adverse effects of public policies.

To examine the diverse impacts of the NECDC policy on enterprises with different sustainability foundations, we employ a quantile regression approach, focusing on the 10th, 25th, 50th, 75th, and 90th percentiles for analysis, as shown in Fig. 8. In the left panel, it is evident that the policy significantly improves environmental responsibility performance across the 10th to 75th percentiles. However, at the 90th percentile, this effect of environmental improvement is less pronounced, indicating that the NECDC policy mainly benefits industrial enterprise sustainability with relatively poorer environmental performance. In the right panel, at the 10th and 25th percentiles, the impact of the NECDC policy on the financial performance of industrial enterprises is not significant, but beyond the 25th percentile, it becomes highly significant. This suggests that the NECDC policy does not notably impact industrial enterprise sustainability with weak financial performance but promotes the sustainable development of those with robust profitability. This divergence could be attributed to enterprises with strong profitability being able to allocate substantial funds for green innovation, thereby strengthening overall sustainability via high energy efficiency.

5. Conclusion and policy implications

Promoting sustainability is crucial for curbing natural resource depletion, mitigating environmental degradation, and preserving ecological integrity. Energy, as a cornerstone of global economic and social activities, plays a pivotal role in transitioning from traditional fossil fuel usage to new energy consumption, thereby fostering sustainability. Despite extensive macro-level investigations into the ramifications of optimizing energy consumption patterns for sustainability, there remains a lack of micro-level analyses examining its impacts and underlying mechanisms. Unraveling the complexities of optimizing energy consumption structures and corporate sustainability is essential, as it has the potential to enhance environmental governance effectiveness and raise global sustainability standards.

This study utilizes the NECDC policy in China as a quasi-natural experiment and employs a DID approach to assess its impact on industrial enterprise sustainability. Leveraging data from Chinese publicly traded companies spanning 2011–2021, the key findings are as follows: (1) The NECDC policy significantly improves industrial enterprise sustainability, yielding dividends in both environmental governance and income growth. This conclusion remains robust even after addressing endogeneity concerns and conducting alternative tests. (2) The NECDC policy fosters industrial enterprise sustainability primarily through substantial green innovation, as opposed to strategic innovation. By improving credit access and increasing fiscal support, the NECDC policy also alleviates financing constraints, thereby incentivizing industrial enterprises to enhance their sustainability performance. (3) Further analysis indicates that the NECDC policy significantly boosts sustainability in cities with high environmental pressure, with particularly pronounced effects on large enterprises, high-pollution industries, and firms with strong developmental foundations.

5.1. Theoretical implications

The theoretical implications of this study are primarily manifested in three key areas. First, it integrates the NECDC policy and sustainable development into an analytical framework, broadening the policy's research scope. Previous literature has primarily focused on the policy's

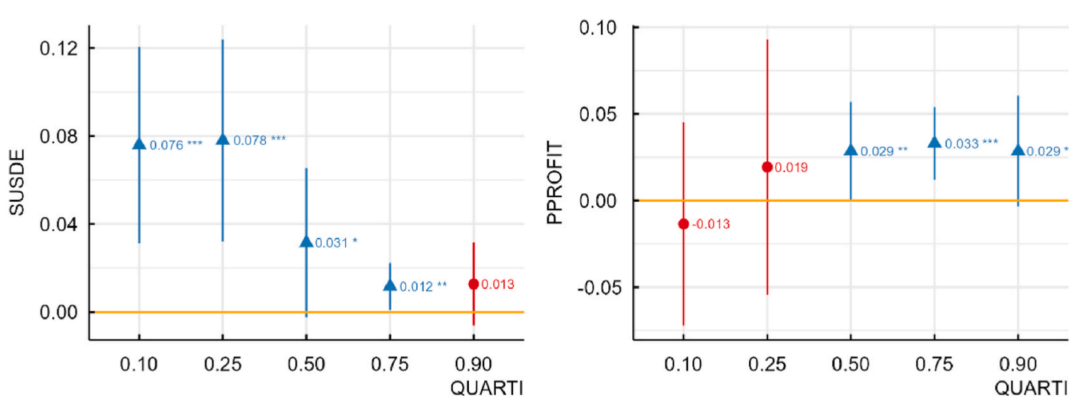

Fig. 8. Quantile regression.

Notes: Fig. 8 displays the quantile regression outcomes regarding the impact of the NECDC policy on industrial enterprise sustainability. The figures denote regression coefficients, adjusted for the variables considered in this study. ***, **, and * signify statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

effects on pollutant emissions, such as carbon and SO_2 emissions. However, there has been limited exploration into the influence of the NECDC policy on sustainable development. In contrast, this paper evaluates sustainable development performance from both environmental and economic perspectives, providing a comprehensive assessment of the policy's impact on sustainable development. Thus, it expands research on the economic implications of the NECDC policy.

Second, we evaluate the impact of the NECDC policy on the micro-level sustainable development of enterprises, deepening the study of factors influencing enterprise sustainable development. Existing literature mainly examines the environmental governance role of the NECDC policy at the national and city levels, without exploring its micro-level impact on sustainable development or clarifying its effect on enterprise environmental governance. To bridge this gap, this paper explores the impact of the NECDC policy on industrial enterprise sustainability. This not only enriches the literature on evaluating the NECDC policy but also advances the understanding of factors driving enterprise green transformation.

Lastly, we clarify the internal mechanisms by which the NECDC policy affects industrial enterprise sustainability, thereby deepening our understanding of its contribution to pollution abatement. While prior studies have mainly explored the pollution mitigation aspect of the NECDC policy through the lenses of industrial structure upgrading, agglomeration, and government backing, they have overlooked the micro-level pathways through which it influences pollution management. In contrast, this paper explicates how the NECDC policy enhances industrial enterprise sustainability by stimulating eco-friendly innovation and reinforcing environmental regulations, thereby providing deeper insights into its role in pollution control. Moreover, we analyze various factors shaping the connection between the NECDC policy and industrial enterprise sustainability, such as urban environmental limitations, enterprise traits, and foundations for sustainable development. This examination carries substantial practical implications for advancing the sustainable growth of industrial enterprises.

5.2. Practical implications

The practical implications of this study can be examined from the perspectives of policymakers, financial institutions, and industrial enterprises. First, the findings underscore the role of new energy consumption demonstration cities in fostering the sustainable development of industrial enterprises. Consequently, policymakers should draw on the successful experiences of these cities, gradually scaling up pilot projects to promote the shift from traditional to renewable energy sources. Additionally, policymakers should align resource allocation with regional advantages to support the growth of renewable energy sectors and enhance supply. For instance, solar energy could be emphasized in the west, wind energy in the north, and marine energy along the coast. Simultaneously, it is essential for policymakers to increase fiscal support, such as VAT reductions for renewable energy and greater investment in green development funds, to mitigate the financial challenges faced by industrial enterprises undergoing green transformation.

Second, for financial institutions, the study demonstrates that the establishment of NECDC can alleviate financing constraints for industrial enterprises by enhancing access to credit, thereby fostering their sustainable development. To support this, financial institutions should develop a broad array of green financial products, including green bonds, credit ratings, and insurance, to meet the diverse financing needs of firms undergoing green transitions. For small and medium-sized enterprises (SMEs), mechanisms such as credit guarantees, green funds, and syndicated loans could help lower financing barriers. Furthermore, financial institutions should improve post-investment oversight of green projects by implementing performance evaluation systems, ensuring that funds are effectively directed toward enhancing the sustainability of enterprises.

Third, for industrial enterprises, the study reveals that the NECDC policy has a significant impact on the sustainable development of large industrial enterprises. As a result, these enterprises should seize this policy as an opportunity for green transformation, adjusting their production models and innovation strategies accordingly. Large enterprises can strengthen their leadership by establishing green technology research centers and optimizing production processes. Meanwhile, SMEs should capitalize on policy support to collaborate with research institutions and larger enterprises in developing green technologies. Enterprises under higher environmental pressure should prioritize upgrading pollution control infrastructure and explore green financial tools to accelerate the development of green production capacities, balancing economic and environmental benefits.

5.3. Limitations and future research

This study acknowledges certain limitations. First, we concentrate solely on the direct effects of the NECDC policy on industrial enterprise sustainability, neglecting its potential impacts on surrounding regions. Previous research indicates that the NECDC policy might influence the environmental governance dynamics in neighboring areas, suggesting the presence of spatial spillover effects. Hence, future investigations could explore the impact of the NECDC policy on enterprise sustainability within adjacent cities, thus enriching the findings of this study. Second, our empirical analysis of the economic welfare implications of the NECDC policy relies on data from publicly traded companies, potentially limiting its applicability to all enterprises. Subsequent research endeavors could leverage field survey data to validate the influence of the NECDC policy on enterprise sustainable development, thereby broadening the scope of the conclusions derived in this study.

CRediT authorship contribution statement

Peihao Shi: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Jianhui Liu:** Validation, Supervision, Project administration.

Declaration of competing interest

We declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence this work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the position presented in, or the review of, the manuscript entitled.

Acknowledgments

The authors acknowledge financial support from the National Social Science Fund of China (Grant No. 22BJY037).

Appendix

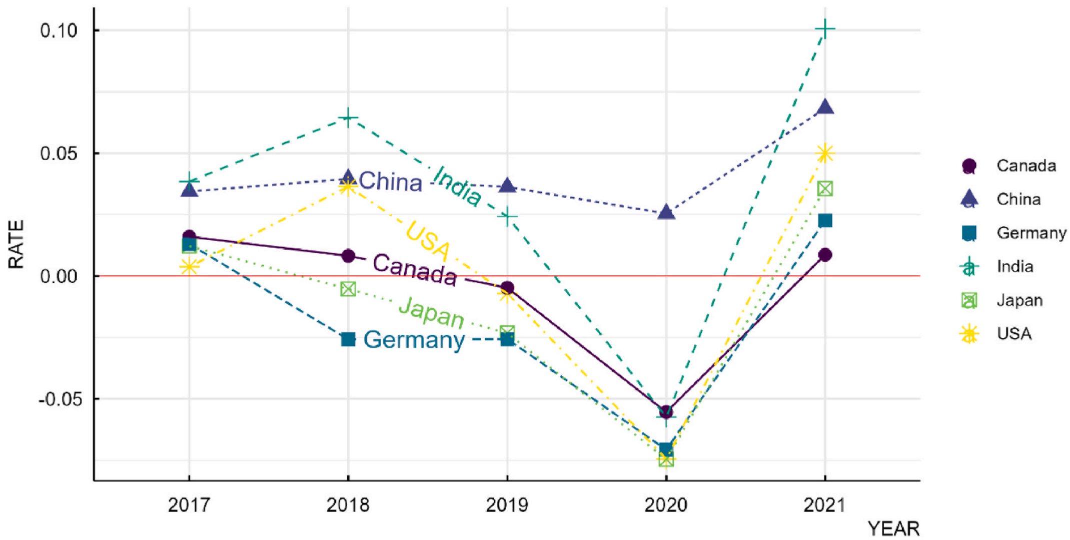

Fig. 1A. Energy consumption growth across major countries globally.

Notes: Fig. 1A displays the energy consumption growth rates in major countries worldwide. China, in particular, demonstrated a consistent upward trajectory in energy consumption from 2017 to 2021. Remarkably, despite the adverse effects of the COVID-19 pandemic, China's energy consumption remained resilient, highlighting the importance of accelerating the structural shift in its energy consumption patterns to support global sustainability endeavors. Notably, the data utilized in this analysis is sourced from the BP Statistical Review of World Energy.

Table 1A
Variable definitions.

Variables	Variable description
SUSDE	Natural logarithm of one plus the corporate environmental responsibility rating score.
PROFIT	Ratio of net profit at the end of the year to total assets of the enterprise.
CLEANEN	For cities designated as new energy consumption demonstration cities under the pilot policy after 2014, *CLEANEN* is set to 1; otherwise, it is set to 0.
PGDP	Ratio of regional gross domestic product to permanent resident population.
STRUC	Ratio of urban tertiary industry to regional gross domestic product.
FINSUP	Ratio of urban public fiscal expenditure to regional gross domestic product.
ASSET	Natural logarithm of one plus the sum of year-end total assets of enterprises.
LEV	Ratio of total liabilities to total assets of the enterprise.
CASH	Ratio of net cash flows from operating activities to total assets of the enterprise.
FIRST	Proportion of shares held by the largest shareholder to total equity.
INDEP	Ratio of the number of independent directors to total board directors.
DUAL	If the role of chairman and general manager is held by the same individual, DUAL equals 1; otherwise, it equals 0.

References

[1] J.S. Shapiro, R. Walker, Why is pollution from US manufacturing declining? The roles of environmental regulation, productivity, and trade, Am. Econ. Rev. 108 (12) (2018) 3814–3854, https://doi.org/10.1257/aer.20151272.

[2] A. Jha, G. Leslie, Start-up costs and market power: lessons from the renewable energy transition, Am. Econ. Rev. 115 (2) (2025) 690–724, https://doi.org/10.1257/aer.20211145.

[3] F. Costa, F. Gerard, Hysteresis and the welfare effect of corrective policies: theory and evidence from an energy-saving program, J. Polit. Econ. 129 (6) (2021) 1705–1743, https://doi.org/10.1086/713729.

[4] P. Shi, Q. Huang, Green mergers and acquisitions and corporate environmental responsibility: substantial transformation or strategic arbitrage? Econ. Anal. Pol. 83 (2024) 1023–1040, https://doi.org/10.1016/j.eap.2024.08.013.

[5] Z. Cheng, X. Yu, Y. Zhang, Is the construction of new energy demonstration cities conducive to improvements in energy efficiency? Energy 263 (2023) https://doi.org/10.1016/j.energy.2022.125517.

[6] H. Zhang, C. Di Maria, B. Ghezelayagh, Y. Shan, Climate policy in emerging economies: evidence from China's low-carbon city pilot, J. Environ. Econ. Manag. 124 (2024) 102943, https://doi.org/10.1016/j.jeem.2024.102943.

[7] Y. Feng, C. Nie, Re-examining the effect of China's new-energy demonstration cities construction policy on environmental pollution: a perspective of pollutant emission intensity control, J. Environ. Plann. Manag. 65 (12) (2022) 2333–2361, https://doi.org/10.1080/09640568.2022.2050685.

[8] J. Chai, L. Tian, R. Jia, New energy demonstration city, spatial spillover and carbon emission efficiency: evidence from China's quasi-natural experiment, Energy Policy 173 (2023), https://doi.org/10.1016/j.enpol.2022.113389.

[9] B. Guo, Y. Feng, X. Wang, J. Lin, New Energy Demonstration City Construction and High-Quality Economic Development, Singap Econ Rev, 2023, https://doi.org/10.1142/S0217590823470069.

[10] X. Liu, C. Wang, H. Wu, C. Yang, K. Albitar, The impact of the new energy demonstration city construction on energy consumption intensity: exploring the sustainable potential of China's firms, Energy 283 (2023), https://doi.org/10.1016/j.energy.2023.128716.

[11] J. Yang, J. Wang, W. Wang, H. Wu, Exploring the path to promote energy revolution: assessing the impact of new energy demonstration city construction on urban energy transition in China, Renew. Energy 236 (2024) 121437, https://doi.org/10.1016/j.renene.2024.121437.

[12] X. Wang, R. Long, Q. Sun, H. Chen, S. Jiang, Y. Wang, et al., Spatial spillover effects and driving mechanisms of carbon emission reduction in new energy demonstration cities, Appl. Energy 357 (2024), https://doi.org/10.1016/j.apenergy.2023.122457.

[13] X. Yang, W. Wang, H. Wu, J. Wang, Q. Ran, S. Ren, The impact of the new energy demonstration city policy on the green total factor productivity of resource-based cities: empirical evidence from a quasi-natural experiment in China, J. Environ. Plann. Manag. 66 (2) (2022) 293–326, https://doi.org/10.1080/09640568.2021.1988529.

[14] B. Guo, Y. Feng, J. Lin, X. Wang, New energy demonstration city and urban pollutant emissions: an analysis based on a spatial difference-in-differences model,

Int. Rev. Econ. Finance 91 (2024) 287–298, https://doi.org/10.1016/j.iref.2024.01.048.
[15] S. Wang, L. Ma, Does new energy demonstration city policy curb air pollution? Evidence from Chinese cities, Sci. Total Environ. 918 (2024), https://doi.org/10.1016/j.scitotenv.2024.170595.
[16] S. Che, J. Wang, H. Chen, Can China's decentralized energy governance reduce carbon emissions? Evidence from new energy demonstration cities, Energy 284 (2023), https://doi.org/10.1016/j.energy.2023.128665.
[17] X. Gao, G. Zhang, Z. Zhang, Y. Wei, D. Liu, Y. Chen, How does new energy demonstration city pilot policy affect carbon dioxide emissions? Evidence from a quasi-natural experiment in China, Environ. Res. 244 (2024), https://doi.org/10.1016/j.envres.2023.117912.
[18] L. Liu, Y. Meng, A. Razzaq, X. Yang, W. Ge, Y. Xu, et al., Correction to: can new energy demonstration city policy reduce carbon emissions? A quasi-natural experiment from China, Environ. Sci. Pollut. Res. 30 (18) (2023) 51875, https://doi.org/10.1007/s11356-023-26253-5.
[19] M. Chen, Y. Su, Z. Piao, J. Zhu, X. Yue, The green innovation effect of urban energy saving construction: a quasi-natural experiment from new energy demonstration city policy, J. Clean. Prod. 428 (2023), https://doi.org/10.1016/j.jclepro.2023.139392.
[20] P. Arayakarnkul, P. Chatjuthamard, S. Treepongkaruna, Board gender diversity, corporate social commitment and sustainability, Corp. Soc. Responsib. Environ. Manag. 29 (5) (2022) 1706–1721, https://doi.org/10.1002/csr.2320.
[21] Y. Zhao, J. Lee, How does board interlock network matter for sustainability? A social learning approach to corporate environmental performance, Bus. Strat. Environ. 32 (8) (2023) 5889–5908, https://doi.org/10.1002/bse.3454.
[22] J.L. Walls, P. Berrone, P.H. Phan, Corporate governance and environmental performance: is there really a link? Strateg. Manag. J. 33 (8) (2012) 885–913, https://doi.org/10.1002/smj.1952.
[23] S.S.N. Gardazi, A.F.S. Hassan, S.F. Saidin, J.B. Johari, Dynamic relationship between board of directors and corporate sustainability performance: evidence from energy sector, Int J Econ Manage 17 (1) (2023) 19–35, https://doi.org/10.47836/ijeam.17.1.02.
[24] K. Luo, Y. Huang, Y. Lv, Non-state shareholder governance and corporate sustainability: evidence from environmental, social and governance ratings, Sustain. Dev. 32 (1) (2024) 211–226, https://doi.org/10.1002/sd.2650.
[25] K. Mahran, A.A. Elamer, Chief Executive Officer (CEO) and corporate environmental sustainability: a systematic literature review and avenues for future research, Bus. Strat. Environ. 33 (3) (2024) 1977–2003, https://doi.org/10.1002/bse.3577.
[26] Y. Bernard, L. Godard, M. Zouaoui, The effect of CEOs' turnover on the corporate sustainability performance of French firms, J. Bus. Ethics 150 (4) (2018) 1049–1069, https://doi.org/10.1007/s10551-016-3178-7.
[27] S. Wang, C. Yan, Y. Zhao, Technological peer pressure and corporate sustainability, Energy Econ. 130 (2024), https://doi.org/10.1016/j.eneco.2023.107257.
[28] V. Osei, C. Bai, D. Asante-Darko, A. Kwarteng, Competitive strategy and circular economy practice implementation toward corporate sustainability performance, Bus. Strat. Environ. (2024), https://doi.org/10.1002/bse.3749.
[29] K.H. Lee, D. Shin, M. Lee, Business group affiliation and corporate sustainability performance in emerging economies: evidence from South Korea, Bus. Strat. Environ. 32 (7) (2023) 4503–4518, https://doi.org/10.1002/bse.3378.
[30] Dorado A. Barón, G. Giménez Leal, Vila R. de Castro, Environmental policy and corporate sustainability: the mediating role of environmental management systems in circular economy adoption, Corp. Soc. Responsib. Environ. Manag. 29 (4) (2022) 830–842, https://doi.org/10.1002/csr.2238.
[31] S. Yang, A. Jahanger, M.R. Hossain, How effective has the low-carbon city pilot policy been as an environmental intervention in curbing pollution? Evidence from Chinese industrial enterprises, Energy Econ. 118 (2023), https://doi.org/10.1016/j.eneco.2023.106523.
[32] T. Li, X. Meng, L. Wang, Y. Gong, Will China's carbon emission trading regulation really decrease the green investment of firms? A microperspective on corporate governance, Bus. Strat. Environ. 34 (2) (2025) 2222–2238, https://doi.org/10.1002/bse.4103.
[33] H. Huang, W. Mbanyele, F. Wang, C. Zhang, X. Zhao, Nudging corporate environmental responsibility through green finance? Quasi-natural experimental evidence from China, J. Bus. Res. 167 (2023) 114147, https://doi.org/10.1016/j.jbusres.2023.114147.
[34] D. Gao, X. Zhou, J. Wan, Unlocking sustainability potential: the impact of green finance reform on corporate ESG performance, Corp. Soc. Responsib. Environ. Manag. (2024), https://doi.org/10.1002/csr.2801.
[35] L. Han, Y. Shi, J. Zheng, Can green credit policies improve corporate ESG performance? Sustain. Dev. 32 (3) (2024) 2678–2699, https://doi.org/10.1002/sd.2803.
[36] S. Li, X. Zheng, J. Liao, J. Niu, Low-carbon city pilot policy and corporate environmental performance: evidence from a quasi-natural experiment, Int. Rev. Econ. Finance 89 (2024) 1248–1266, https://doi.org/10.1016/j.iref.2023.08.007.
[37] Y. Wang, S. Wei, X. He, H. Gu, Environmental regulation and entrepreneurial activity: evidence from the low-carbon city pilot policy in China, Sustain. Cities Soc. 98 (2023), https://doi.org/10.1016/j.scs.2023.104829.
[38] C. Sun, Y. Tie, L. Yu, How to achieve both environmental protection and firm performance improvement: based on China's carbon emissions trading (CET) policy, Energy Econ. 130 (2024) 107282, https://doi.org/10.1016/j.eneco.2023.107282.
[39] Y.-J. Zhang, W. Wang, How does China's carbon emissions trading (CET) policy affect the investment of CET-covered enterprises? Energy Econ. 98 (2021) 105224 https://doi.org/10.1016/j.eneco.2021.105224.
[40] J. Liao, X. Liu, X. Zhou, N.R. Tursunova, Analyzing the role of renewable energy transition and industrialization on ecological sustainability: can green innovation matter in OECD countries, Renew. Energy 204 (2023) 141–151, https://doi.org/10.1016/j.renene.2022.12.089.
[41] D. Bai, L. Du, Y. Xu, S. Abbas, Climate policy uncertainty and corporate green innovation: evidence from Chinese A-share listed industrial corporations, Energy Econ. 127 (2023) 107020, https://doi.org/10.1016/j.eneco.2023.107020.
[42] Y. Hu, S. Jin, J. Ni, K. Peng, L. Zhang, Strategic or substantive green innovation: how do non-green firms respond to green credit policy? Econ. Modell. 126 (2023) https://doi.org/10.1016/j.econmod.2023.106451.
[43] K. Mehmood, P. Kautish, S.K. Mangla, A. Ali, Y. Kazancoglu, Navigating a net-zero economy future: antecedents and consequences of net-zero economy-based green innovation, Bus. Strat. Environ. 33 (5) (2024) 4175–4197, https://doi.org/10.1002/bse.3685.
[44] P. Shi, H. Wang, Information acquisition or just going through the motions? Institutional investors' site visits and green innovation, Corp. Soc. Responsib. Environ. Manag. 31 (6) (2024) 5189–5207, https://doi.org/10.1002/csr.2859.
[45] S. Zhao, W. Abbassi, A.I. Hunjra, H. Zhang, How do government R&D subsidies affect corporate green innovation choices? Perspectives from strategic and substantive innovation, Int. Rev. Econ. Finance 93 (2024) 1378–1396, https://doi.org/10.1016/j.iref.2024.04.014.
[46] E. Campiglio, A. Spiganti, A. Wiskich, Clean innovation, heterogeneous financing costs, and the optimal climate policy mix, J. Environ. Econ. Manag. 128 (2024), https://doi.org/10.1016/j.jeem.2024.103071.
[47] P. Shi, Q. Huang, The impact of financial investment on corporate environmental sustainability: reservoir effect or crowding-out effect? Bus. Strat. Environ. 33 (6) (2024) 6084–6105, https://doi.org/10.1002/bse.3798.
[48] K. Yang, Q. Zhang, Q. Liu, J. Liu, J. Jiao, Effect mechanism and efficiency evaluation of financial support on technological innovation in the new energy vehicles' industrial chain, Energy 293 (2024), https://doi.org/10.1016/j.energy.2024.130761.
[49] Z. Hui, H. Li, A.A. Elamer, Financing sustainability: how environmental disclosures shape bank lending decisions in emerging markets, Corp. Soc. Responsib. Environ. Manag. 31 (5) (2024) 3940–3967, https://doi.org/10.1002/csr.2789.
[50] J. Lee, J. Hwang, H. Kim, Different government support effects on emerging and mature ICT sectors, Technol. Forecast. Soc. Change 174 (2022), https://doi.org/10.1016/j.techfore.2021.121253.
[51] W. Wang, J. Wang, H. Wu, Assessing the potential of energy transition policy in driving renewable energy technology innovation: evidence from new energy demonstration city pilots in China, Econ. Change Restruct. 57 (5) (2024), https://doi.org/10.1007/s10644-024-09748-0.
[52] X. Li, F. Guo, Q. Xu, S. Wang, H. Huang, Strategic or substantive innovation? The effect of government environmental punishment on enterprise green technology innovation, Sustain. Dev. 31 (5) (2023) 3365–3386, https://doi.org/10.1002/sd.2590.
[53] Y. Ma, Y. Sha, Z. Wang, W. Zhang, The effect of the policy mix of green credit and government subsidy on environmental innovation, Energy Econ. 118 (2023) 106512, https://doi.org/10.1016/j.eneco.2023.106512.
[54] Y. Song, X. Pang, Z. Zhang, J.-M. Sahut, Can the new energy demonstration city policy promote corporate green innovation capability? Energy Econ. 136 (2024) 107714 https://doi.org/10.1016/j.eneco.2024.107714.
[55] S. Baek, D.H. Lee, Can R&D investment be a key driver for sustainable development? Evidence from Korean industry, Corp. Soc. Responsib. Environ. Manag. 31 (2) (2024) 838–853, https://doi.org/10.1002/csr.2607.
[56] M. Saunila, J. Ukko, J. Kinnunen, Sustainability partnership as a moderator in the relationship between business sustainability and firm competitiveness, Bus. Strat. Environ. 33 (2) (2024) 123–133, https://doi.org/10.1002/bse.3493.
[57] J. Tan, K.C. Chan, R. Niu, Do anticipated government environmental audits promote corporate social responsibility? Evidence from China, Corp. Soc. Responsib. Environ. Manag. (2024), https://doi.org/10.1002/csr.2780.
[58] G. Lu, G. Shang, Impact of supply base structural complexity on financial performance: roles of visible and not-so-visible characteristics, J. Oper. Manag. 53–56 (2017) 23–44, https://doi.org/10.1016/j.jom.2017.10.001.
[59] Y. Hou, M. Yang, Y. Ma, H. Zhang, Study on city's energy transition: evidence from the establishment of the new energy demonstration cities in China, Energy 292 (2024), https://doi.org/10.1016/j.energy.2024.130549.
[60] P. Shi, Q. Huang, Alignment of words and actions? Government environmental attention and enterprise digital transformation, Technol. Forecast. Soc. Change 210 (2025) 123888, https://doi.org/10.1016/j.techfore.2024.123888.
[61] R. DasGupta, A. Roy, Firm environmental, social, governance and financial performance relationship contradictions: insights from institutional environment mediation, Technol. Forecast. Soc. Change 189 (2023) 122341, https://doi.org/10.1016/j.techfore.2023.122341.
[62] G. Zhou, L. Liu, S. Luo, Sustainable development, ESG performance and company market value: mediating effect of financial performance, Bus. Strat. Environ. 31 (7) (2022) 3371–3387, https://doi.org/10.1002/bse.3089.
[63] V. Czellar, D.T. Frazier, E. Renault, Approximate maximum likelihood for complex structural models, J. Econom. 231 (2) (2022) 432–456, https://doi.org/10.1016/j.jeconom.2021.05.009.
[64] J. Graff Zivin, M. Neidell, N.J. Sanders, G. Singer, When externalities collide: influenza and pollution, Am. Econ. J. Appl. Econ. 15 (2) (2023) 320–351, https://doi.org/10.1257/app.20210500.
[65] B. Wang, W. Zhao, Interplay of renewable energy investment efficiency, shareholder control and green financial development in China, Renew. Energy 199 (2022) 192–203, https://doi.org/10.1016/j.renene.2022.08.122.

Mr. Peihao Shi is a Ph.D. candidate in China. He majors in ecological economics at School of Management and Economics, Wuhan University. He has published over 20 academic papers in journals, including *Business Strategy and the Environment*, *Corporate Social Responsibility and Environmental Management*, and *Technological Forecasting and Social Change*. His E-mail is: peihaoshi@whu.edu.cn.

Ms. Jianhui Liu is a professor of the School of Economics and Management of Southwest University, China. Her research interests include environmental policy, ecological economics, and energy economics. He has published over 50 research papers in prestigious peer-reviewed journals. His E-mail is: Ljh06@swu.edu.cn.