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EDITED BY
Liang Li,
Nanjing University of Information Science and Technology, China

REVIEWED BY
Yanchao Feng,
Zhengzhou University, China
Xiaodan Guo,
Northeastern University, China
Yufeng Chen,
Zhejiang Normal University, China

*CORRESPONDENCE
Zhuoran Lin,
lzr@mail.sdufe.edu.cn

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Can the resource-exhausted city promotion program reduce enterprise carbon emission intensity? Evidence from China

Zhuoran Lin* and Jingyi Gao

Longshan Honors School, Shandong University of Finance and Economics, Jinan, China

The Resource-Exhausted City Promotion (RECP) program is a significant initiative by the Chinese government aimed at fostering transformation. The RECP program constitutes a vital avenue for advancing low-carbon transformation, though its influence on microenterprises' carbon emissions and underlying mechanisms remains unexplored. We use China's industrial enterprise database from 2003 to 2014 and organize data concerning resource-exhausted cities in China. Employing the staggered Difference-in-Differences (staggered DID) method, the research investigates the impact of the RECP program on enterprise carbon emission intensity. Results show that the impact of the RECP program on enterprise carbon emission intensity is significantly negative. This effect is more significant for enterprises in areas with lower environmental protection pressure, those situated in mining cities, larger enterprises, and those exhibiting higher carbon emission intensity. Furthermore, we identify the influencing channels from the above effect as the screening effect and the tourism development level. The screening effect resulting from the exit of enterprises in highly polluting industries can exacerbate the negative impact of the RECP program on the enterprise carbon emission intensity. Meanwhile, enhancing the level of tourism in the region is a key strategy for the RECP program to further reduce the enterprise carbon emission intensity. This effect emerges as a crucial approach for reducing enterprise carbon emission intensity within the RECP program framework. The results of this study contribute to driving the implementation of such program for government and enterprises.

KEYWORDS

resource-exhausted city promotion program, enterprise carbon emission intensity, transformation and upgrading, sustainable development, staggered difference-in-differences

1 Introduction

Towards the close of the 19th century and the onset of the 20th century, China confronted a dual crisis encompassing external resource blockades and internal technological limitations. In response to this national quandary, China turned its attention to harnessing domestic resources for development (Tao, 2017). During the early years of the People's Republic of China, there was a distinct emphasis on fostering heavy industry and actively advancing the First Five-Year Plan. This initiative led to the rapid growth of numerous resource-based cities, primarily dependent on extracting and processing regional minerals, forests, and other natural resources (He and Song, 2023). Over the past few decades, resource-based cities have effectively leveraged their role in resource and energy supply, significantly contributing to China's economic growth and regional equilibrium. However, intensified resource extraction and diminishing resource availability have pushed these cities into a phase of depletion, posing a formidable threat to their prospects for high-quality development (Zhao et al., 2022).

This research studies a large-scale place-based policy, the so-called Resource-Exhausted City Transition (RECT hereafter) program. Presently, a resource-exhausted city is characterized as one possessing fewer than 5 years of viable extractable resources or where the cumulative resource extraction surpasses 70% of the city's original reserves. To foster the evolution and advancement of such cities, the State Council of China issued the "Opinions on Promoting Sustainable Development of Resource-based Cities" on 24 December 2007. This document provides comprehensive directives across eight domains. These include establishing and enhancing enduring mechanisms for the sustainable growth of resource-exhausted cities, reinforcing programs, and augmenting environmental management and preservation efforts. Subsequently, in 2008, 2009, and 2012, China successively incorporated 69 resource-exhausted cities (comprising districts and counties) in three phases into the roster of supported resource-exhausted cities. This strategic move was intended to bolster support for the sustainable advancement of these cities.

In 2013, the State Council of China enacted the Sustainable Development Plan of National Resource-based Cities, 2013–2020 (SDP), underscoring the imperative of advancing the sustainable growth of resource-based cities. Subsequently, the report of the 19th National Congress of the Communist Party of China in 2017 underscored the necessity of supporting resource-based cities in their pursuit of transformation and upgraded developmental approaches. In 2019, President Jinping Xi, during the fifth meeting of the Central Finance Commission, explicitly highlighted the importance of engaging in the battle for an advanced industrial base and modernizing industrial chains, accelerating the transformation and development of resource-exhausted cities. In 2021, the Chinese government issued the "Promote the high-quality development of resource-based areas" in the 14th Five-Year Plan. This plan explicitly emphasizes that the advancement of high-quality transformation in resource-based cities constitutes a vital component in enhancing the institutional mechanisms for coordinated regional development. Moreover, it serves as a significant strategy for expediting developmental improvements. In 2022, the report of the 20th National Congress of the Communist Party of China underscored the imperative of prioritizing environmentally sustainable transformations and expediting the exploration of novel pathways to foster the high-quality development of resource-based cities. Hence, there is an immediate need to identify more sustainable and higher-quality development trajectories for resource-exhausted cities. This endeavor holds immense importance in ensuring energy and resource security, propelling economic transformation, and fortifying social stability (Yang et al., 2021).

Since 1990, when the Intergovernmental Panel on Climate Change (IPCC) released its First Assessment Report, the link between greenhouse gases and climate change has gradually gained recognition. The reduction of carbon dioxide emissions and the pursuit of low-carbon development have emerged as primary global concerns (Gao et al., 2017). In recent years, as environmental pollution has increased worldwide, unregulated carbon emissions have resulted in steady warming of the global temperature, a rise in the number of hot weather days, and ecosystem devastation. Against this backdrop, addressing the tension between economic development and environmental protection, and tackling significant environmental challenges, are critical issues for China, which is currently industrializing and developing (Zhang et al., 2024). In September 2020, Chinese government conveyed to the world at the United Nations General Assembly China's commitment to achieving a carbon peak by 2030 and carbon neutrality by 2060. Chinese government also underscores the necessity of refining the regulation of overall energy consumption and intensity, with a specific emphasis on curbing fossil fuel usage. A gradual transition toward the dual control of total carbon emissions and intensity is advocated.

In the process of achieving regional transformation and advancement, enterprises play a pivotal role as the principal drivers of economic growth—a role that is too significant to overlook (Gao and Yuan, 2021). The operational endeavors of these enterprises typically entail substantial utilization of natural resources, accompanied by a corresponding surge in carbon emissions. According to data provided by China in 2019, almost 90% of the nation's carbon emissions in 2018 emanated from enterprise production activities. In resource-exhausted areas with high energy consumption and emissions, unchecked resource exploitation and reckless carbon dioxide discharge by enterprises can cause irreversible damage to air quality and the ecological environment. This action may foster the emergence of "path dependence" and "resource curse" (Wang D. et al., 2023). Breaking free from resource depletion constraints and managing natural resources proficiently is crucial for a green revolution, driving enterprises and the nation toward sustainable development (Feng et al., 2024a).

The RECP program is mainly aimed at exploring transformation paths and promoting urban renewal to achieve coordinated regional development and sustainable development in China (Zhu et al., 2023). Transformation and upgrading are recognized as effective strategies to curb the escalating trajectory of carbon emissions. These strategies are crucial for liberating resource-exhausted cities from the grip of the "resource curse" and realizing low-carbon progress (Li and Wang, 2022). This change is poised to impact the green evolution of local enterprises and elevate carbon emission efficiency. Hence, within the context of constructing an ecological civilization, it is essential to explore how the RECP program influences enterprise carbon emission intensity. This is important for the continued advancement of these cities and the exploration of energy conservation and emission reduction strategies by enterprises.

Building upon this foundation, the objective of this study is to explore the correlation between the RECP program and pollution emissions from corporations. By undertaking a thorough review of pertinent literature, we leverage a quasi-natural experiment that encompasses the RECP program in China from 2003 to 2014. This study uses the staggered Difference-in-Differences (staggered DID) method and data from micro-manufacturing enterprises to uncover the intricate impacts and underlying mechanisms of the RECP program on enterprise carbon emission intensity.

This paper offers several potential marginal contributions: Firstly, it provides empirical substantiation at the micro-enterprise level within the scope of this field, thereby partially bridging a research gap. Secondly, this study delves into the variations in regional environmental protection pressure, diverse regional resource types, and differing enterprise sizes influenced by the RECP program and their impact on enterprise carbon emission intensity. It undertakes a quantile regression analysis to examine the heterogeneous enterprise carbon emission intensity. This approach aims to dissect the underlying mechanisms and connections ranging from the regional level to the enterprise level. Ultimately, these findings lay the groundwork for subsequent research and analysis of the impact mechanisms. Third, the paper identifies the screening effect to highlight the positive contribution of the exit of enterprises in highly polluting industries and analyzes the positive impact of tourism development based on its development level. Lastly, this study offers guidance for developing countries addressing the issue of resource-exhausted cities, aiding them in finding a suitable way forward.

The remainder of this paper is organized as follows: Section 2 presents a review of the related literature; Section 3 conducts a theoretical analysis and introduces the corresponding research hypothesis; Section 4 delineates the data, variables, and methodology; Section 5 encompasses empirical testing and result analysis; and finally; Section 6 summarizes the main findings of the study, analyzes the marginal contributions and limitations, and provides further policy recommendations.

2 Literature review

The references in this paper predominantly encompass two categories of literature. The first category pertains to studies concerning the factors influencing enterprise carbon emission intensity. The second category involves research on the evaluation of the impacts of the RECP program.

Currently, a wealth of relevant research exists in the field of enterprise carbon emission intensity. On the one hand, studies delve into internal factors impacting enterprise carbon emission intensity, including board characteristics (Ben-Amar et al., 2017), technological advancement, firm size, the potential for carbon emission reduction (Chen et al., 2017), managerial perceptions, ownership structure (Yang et al., 2019), CEO responses to climate change (Garel and Petit-Romec, 2022), corporate social responsibility (Zhang et al., 2022), liability structure (Chen and Zhu, 2022), and political affiliation (Wang ZR. et al., 2023). On the other hand, other scholars have explored the impact of external factors on enterprise carbon emission intensity. These factors include regional disparities (Cole et al., 2013), degree of internationalization (Sadler, 2016), business environment, socio-cultural influences (Liu et al., 2018), environmental regulations (Chen et al., 2018; Ren et al., 2022), as well as various policies such as carbon emissions trading (Yu et al., 2022), green credit (Sun and Zeng, 2023), and smart city pilot initiatives (Xu et al., 2023).

For an extended duration, the promotion of high-quality transformations in resource-exhausted cities has emerged as a pivotal endeavor toward achieving harmonized regional development. The present academic research focusing on evaluating the impacts of the RECP program predominantly centers on assessing the efficacy of these policies, evaluation of transformational performance, and the evolutionary mechanisms of such cities. Examinations of program implementation effects and transformation performance predominantly revolve around dimensions such as regional innovation (Lu et al., 2022), reductions in carbon emissions (Wu et al., 2023), the process of industrial upgrading (Shen et al., 2023), and urbanization and urban development (Li and Zhuang, 2023). Meanwhile, investigations into the evolution and transformation mechanisms of resource-exhausted cities pivot around demographic attributes (Bradbury, 1984), the lifecycle of mining areas (Bradbury and St-Martin, 1983), economic structural shifts (Kuai et al., 2015), novel models for resource-exhausted towns (Houghton, 1993), economic resilience (Wang and Long, 2023) and ecosystem quality (Dou et al., 2023) perspectives.

Within this context, scholars have offered varied perspectives on the nexus between the transformational development of resource-exhausted cities and regional carbon emissions. Some scholars assert that the RECP program can notably curtail carbon emissions in these cities (Du and Li, 2020). Conversely, others posit an inverted U-shaped relationship between the two (Zhang et al., 2021). Still, others contend that the RECP program may increase environmental pollutant emissions and worsen urban pollution (Wu et al., 2023). The prevailing literature predominantly dissects the transmission pathways of the RECP program impacting enterprise carbon emissions from the standpoints of economics, technology, industry, ecology, and spatial spillovers. Wu et al. (2023) assert that transformational policies primarily drive carbon emission reductions by fostering advancements in green technology. Zheng and Ge (2022) identify that, as the RECP program takes effect, spatial spillover effects are more likely to yield diminished carbon emissions. Zhao et al. (2023) underscore carbon emission reduction through tactics like decreasing resource dependence, elevating citizens' quality of life, and constraining the pace of industrial expansion.

Since the RECP program aims for a win-win situation for environmental protection and economic development, it is necessary to investigate whether it can effectively reduce enterprise carbon emission intensity. Most existing studies focus on the provincial and prefectural levels, examining the macro-level correlation between the evolution of resource-exhausted cities and regional carbon emissions. However, there is a relative lack of research on the association between the RECP program and the low-carbon development of micro-level enterprises. Therefore, this study seeks to connect the RECP program with enterprise-level carbon emission intensity and use empirical methods to investigate its influence.

3 Theoretical analysis and research hypothesis

Following the identification of resource-exhausted cities in batches, support systems such as centralized financial transfers and local sustainable development reserves have been gradually established. These measures are aimed at natural resource management, fostering alternative industries, promoting green development, enhancing basic public services, the closure of enterprises and related aftermath work (Wu et al., 2023).

In the face of the challenges posed by heavy reliance on single resource-based industries and the significant ecological and environmental costs, the RECP program exhibits the screening effect. This effect works by constraining the growth of conventional resource-dependent sectors through the imposition of industrial limitations and more stringent environmental restrictions. This approach results in a favorable reduction of carbon emissions. The RECP program is geared towards bolstering enterprises operating in pivotal industries. This support provides these enterprises with increased resources and production factors when compared to those in non-key sectors. Consequently, it guides sustainable production practices within these key industries, thereby fostering a virtuous cycle of industrial development (Sun and Liao, 2021). As resource scarcity and the decline of ancillary industries shape the landscape, the competitiveness of waning industries in resource-exhausted cities diminishes. This trend signifies a gradual withdrawal from the existing industrial structure layout (Chang et al., 2023). Accelerating the phase-out of high-energy-consuming and high-emission industries, notably resource extraction and primary processing sectors might prompt traditional industrial entities to exit the market. Simultaneously, this action could facilitate the emergence of new eco-friendly and sustainable businesses engaged in production activities. In a positive external environment, enterprises within resource-exhausted cities collectively catalyze the low-carbon transformation of the industrial structure, enhancing carbon emission efficiency.

The RECP program fosters the development of new and substitute industries, encourages the expansion and diversification of industrial chains, and bolsters economies of scale for industrial enterprises. These efforts aim to lessen excessive reliance on original resource-based industries (Shen et al., 2023). This approach effectively reduces carbon emissions. Numerous resource-based cities in China are categorized as "mine first, city later" with their industrial setups predominantly centered around resource-based sectors. However, the depletion of these resources leads to the decline of other industries as well (Sachs, 1999). The lack of alternative industries serves as a significant barrier for these cities to overcome their challenges. Consequently, the vigorous development of new deep-processing industries or the active expansion of the service sector will constitute the essential route for industrial transformation in these cities. This becomes both the pivotal path and the focal point of industrial transformation (Liu et al., 2024). The proposed strategy, as outlined in the "Opinions on Promoting Sustainable Development of Resource-based Cities", emphasizes cultivating and nurturing successive alternative industries and expediting the progress of the tertiary sector. In practice, developing tourism is a popular path for transformation in China (Zhao et al., 2022). With the support of the RECP program, resource-exhausted cities utilize industrial relics and sites to develop tourism. This includes establishing mining museums, protecting and restoring mining railroads, renovating urban buildings, and organizing mining tours (Ballesteros and Ramírez, 2007). These initiatives promote alternative industries, advance the low-carbon transformation of enterprises, and mitigate high enterprise carbon emission intensity.

In summary, the RECP program aims to drive regional transformation and upgrade via the exit of traditional industrial enterprises, the rise of new industries, the development of replacement industries, and the improvement of environmental awareness, thereby lowering the enterprise carbon emission intensity. Building on this premise, we propose Hypothesis 1 (H1).

Hypothesis 1: The RECP program can reduce corporate carbon intensity.

Screening effects resulting from local policies lead to the exit of a large number of efficient or inefficient firms. Albrizio et al. (2017) noted that, at the industry level, the impact of regional policies on productivity depends on the reallocation of resources among firms, with highly polluting firms more likely to exit the market. Simultaneously, enterprise behavior plays a pivotal role in transitioning production modes, thereby exerting a profound impact on environmental governance outcomes (Wu et al., 2024a). Therefore, we argue that the exit of highly polluting enterprises is a prerequisite and basic guarantee for the effective implementation of the RECP program. This exit also serves as an important manifestation of the screening effect of the RECP program, which is both complementary and mutually reinforcing. Together, the RECP program and the screening effect promote the sustainable development of enterprises.

Initially, the departure of enterprises in highly polluting industries can facilitate the redistribution of resources among businesses, guiding them towards low-carbon development, bolstered by the RECP program. The RECP program incentivizes enterprises to curtail resource consumption and transition to less polluting industries through financial subsidies and tax incentives. Additionally, governmental measures about resource acquisition and environmental preservation serve to constrain the expansion of enterprises in highly polluting sectors. Consequently, faced with the dilemma of limited resources versus environmental goals, heavily polluting enterprises heavily reliant on resources are more prone to being phased out of the market. This will optimize resource allocation among enterprises, fostering the expedited growth of enterprises with lower pollution levels (Wu et al., 2024a). The growth of low-pollution businesses propels green, low-carbon economies, creating positive externalities that enhance corporate carbon emission efficiency.

Secondly, during the implementation phase of the RECP program, stringent environmental regulations and transformation pressures emerge as crucial drivers behind the exodus of enterprises from heavily polluting industries. This, in turn, enhances the efficacy of emission reduction efforts. The intensity of environmental regulations, particularly heavily polluting regulations, is a crucial factor in the location decisions of industrial enterprises, and it is also a key condition for screening (Feng et al., 2024b). Faced with an array of program pressures, enterprises within resource-exhausted cities, characterized by high energy consumption and emissions, undergo green and low-carbon transformations. Those unable to adapt to this transition are compelled to curtail production or even exit the market (Dou et al., 2023). Considering the perspective of the value chain, enterprises operating in distinct segments of the value chain exhibit varied responses when confronted with resource scarcity arising from depletion. In general, the impact of resource fluctuations is more pronounced in manufacturing industries situated lower in the value chain. Enterprises in highly polluting industries at the low end of the value chain, due to their limited ability to transform, will either be eliminated by the market or relocate to peripheral cities in response to increasing pressure to transform, resulting in a screening effect (Katz and Pietrobelli, 2018). The departure of enterprises from heavily polluting industries not only diminishes impediments to the execution of the RECP program but also offers prospects for these cities to transition into low-carbon industries. This further propels ecologically friendly production practices among enterprises and reduces carbon emission intensity.

In summary, the departure of enterprises from high-pollution industries is shaped by program adjustments and the mechanism of enterprise exit. This phenomenon amplifies the impact of the RECP program, directing enterprises towards diminishing carbon emissions intensity through resource recalibration and market withdrawal. Consequently, we propose Hypothesis 2 (H2).

Hypothesis 2: The screening effect of highly polluting industry departures positively moderates the reduction of enterprise carbon emission intensity, facilitated by the RECP program.

With the concept of revitalizing tourism resources in resource-exhausted cities, the utilization of distinctive city attributes such as its historical heritage, industrial cultural deposits, and industrial relics landscape has emerged as a viable avenue for cultivating successor industries in resource-based cities (Koster et al., 2019). The RECP program's evolution fosters tourism and establishes a symbiotic industrial loop between ecological protection and tourism. This not only mitigates the negative effects of resource contraction while reaping economic gains, but also enhances the ecological environment, and accelerates energy conservation and emission reduction efforts.

Given the current scenario of resource depletion, leveraging tourism development emerges as a promising avenue for extricating and reinvigorating regions. In truth, the pursuit of transformation and growth via tourism in resource-exhausted cities spans nearly 5 decades worldwide, with large-scale heritage tourism initiatives taking root in the early 1980s. It was in 1988 when the British government embarked on proactive tourism management, advocating for national industrial tourism development. This catalyzed the metamorphosis of numerous resource-exhausted cities. The early 1990s saw the German government implemented the "Industrial Heritage Tourism Road" and ecological revitalization strategies, yielding successful transformations for cities typified by the Ruhr industrial zone. Similarly, confronting the challenges of resource scarcity, locales like Potosi in Bolivia, Dawson City in Canada, and Ballarat in Australia have pioneered distinctive tourism models, harnessed by their industrial heritage. In recent years, China too has been dynamic in exploring its tourism assets and harnessing industrial heritage for tourism growth. Fuxin, as an early entrant among resource-based cities, commenced comprehensive management and utilization of mining landscapes, culminating in the establishment of a national mine park upon the closure of the Haizhou open-pit mine. Concurrently, the Wansheng Economic Development Zone has capitalized on its multifaceted tourism resources to zealously foster tourism as a critical breakthrough for transformation and advancement (Pretes, 2002).

From the aforementioned case study, several key insights emerge. Firstly, the thrust of the RECP program revolves around rejuvenating economic resurgence. Notably, tourism, serving as the prime catalyst for expansive growth, can ignite economic progress and establish a self-sustaining economic cycle (Ballesteros and Ramírez, 2007). Secondly, the RECP program places significant emphasis on enhancing the regional environment and expanding the scope of development. In this context, the promotion of tourism is particularly critical for resource-exhausted cities, as it has the potential to enhance both the natural and cultural landscapes, thereby contributing to an overall improvement in the ecological environment (Zhao et al., 2022). Additionally, throughout the transition and upgrading phase, tourism development showcases attributes of cost-effectiveness, elevated earnings, and heightened adaptability, rendering it an ideal candidate for robust promotion during this transitional epoch (Dwyer et al., 2009). Consequently, the execution of the RECP program yields evident impacts on tourism advancement. Furthermore, due to the long-term rough exploitation of mineral resources, outdated production and waste treatment technologies, and low environmental awareness, the public has a negative impression of tourism development in resource-exhausted cities (Yuan et al., 2019). To reshape the tourism image of these cities, enterprises focus more on protecting the ecological environment and take measures to reduce their environmental impact. Promoting the adjustment and optimization of the tourism industry structure can create new forms of tourism, new scenarios, and new demands, fully utilizing advantageous resources such as industrial heritage. This development can influence the industrial layout, factor structure, and organization of industrial enterprises (Chao et al., 2023). Resource-based traditional industries play a crucial role in diversifying the scope of the tourism sector. Simultaneously, the demands of tourism industry development on corporate image and responsibility typically drive enterprises to adopt green and sustainable technologies, creating novel production methods and low-carbon business models. These endeavors are geared towards enhancing corporate carbon emission efficiency and mitigating the intensity of corporate carbon emissions.

In conclusion, the RECP program leverages regional advantages, develops tourism, raises environmental awareness among enterprises, and guides them to reduce carbon emission intensity. Thus, we propose Hypothesis 3 (H3).

Hypothesis 3: The RECP program lowers enterprise carbon emission intensity by fostering the growth of the tourism sector.

4 Data, variables, and methodology

4.1 Data source

The information regarding resource-exhausted cities is sourced from the list of such cities published by the National Development and Reform Commission (NDRC) in multiple releases. According to the "Opinions on Promoting Sustainable Development of Resource-based Cities", a total of 69 resource-exhausted cities have been identified by China government. This includes 24 cities at the prefecture level and 45 at the district (county) and other administrative levels. Due to the distinct economic and political advantages possessed by municipalities, provincial capitals, and sub-provincial cities, this group of cities exhibits particular characteristics. To ensure the research's integrity and to eliminate potential external influences, we deliberately exclude samples from the aforementioned categories of municipalities, capital cities, and sub-provincial cities. Recognizing that changes in administrative coding might occur due to policies like transitioning counties and cities to districts after being designated as resource-exhausted, we identified these cities and made changes to their administrative codes. The China Administrative Zoning Network provided information about such changes from 2003 to 2014 across various prefectures. By manually compiling administrative codes before and after these changes, we focused on the amalgamation of city administrative codes and industrial enterprise data before and after the transformation. This comprehensive approach allows for accurate analysis and comparison.

The enterprise data employed originates from the China Industry Business Performance Data spanning from 2003 to 2014. This database is compiled by China's National Bureau of Statistics through the consolidation of annual reports from enterprises surpassing a certain scale. It encompasses a comprehensive collection of over 130 indicators. To assure the credibility of the outcomes, the following measures were undertaken for the data:

Firstly, outliers were eliminated from the dataset using the following steps:

(1) We excluded instances with non-compliant accounting standards. For instance, cases with paid-in capital equal to or below 0, fixed assets' original value below 0, total industrial output value below 0, total assets below current assets, and accumulated depreciation less than the current year's depreciation were removed.
(2) Samples with fewer than eight employees at year-end and less than five million in main business income were discarded.
(3) Entries with missing values for opening business time, administrative code, industry code, and other essential variables were also removed.

Secondly, a standardization process was implemented:

(1) The administrative codes, initially consisting of 12 digits, were harmonized to incorporate only the initial six digits.
(2) Standardization was applied to enterprise codes. The legal person code was utilized to generate a new identification code for each enterprise.

Thirdly, adjustments were made to the industry codes. The timeframe spans from 2003 to 2014, encompassing two distinct sets of national economic industry classification standards. To ensure consistency, a manual alignment was performed. By referencing the standard table of national economic industry classification and evaluating enterprises' primary business activities both before and after, a unified two-digit industry code classification was established.

Fourth, we addressed missing values in our dataset. To maximize the number of observations, we employed a method inspired by Lakshminarayan et al. (1999) for key indicators. Specifically, we supplemented missing values as follows:

(1) To complete missing values for value-added, we calculated industrial value-added as the difference between gross industrial output and industrial intermediate inputs, plus value-added tax.
(2) For the missing gross industrial output value indicator in 2004, we computed industrial value added as sales revenue minus opening inventory plus closing inventory, minus industrial intermediate inputs, plus VAT.
(3) To estimate intermediate inputs, we calculated them as gross output multiplied by the ratio of business costs to business income, minus total wages paid, depreciation for the year, and finance charges.

Fifth, we conducted deflation of nominal prices: Nominal prices were adjusted using 2003 as the base year. The value added of the industry was deflated utilizing the respective provincial price index for fixed asset investment. Concurrently, the capital stock was deflated by applying the ex-factory price index of industrial producers. Both these crucial price indices were sourced from the China Statistical Yearbook.

Additional data originates from the China Stock Market & Accounting Research Database (CSMAR).

4.2 Variables description

4.2.1 Dependent variable

The dependent variable is enterprise carbon emission intensity (CE). The prevailing method for measuring carbon emissions is primarily founded on the United Nations Intergovernmental Panel on Climate Change (IPCC) guidelines and the 2006 "IPCC Guidelines for National Greenhouse Gas Inventories." The calculation equation for carbon emissions is shown in Eq. 1:

$$\mathbf{CO_2} = \sum_{i=1}^{n} \mathbf{E_i} \times \mathbf{NCV_i} \times \mathbf{CEF_i} \times \mathbf{COF_i} \times \frac{\mathbf{44}}{\mathbf{12}} \qquad (1)$$

where i represents different energy categories. CO_2 represents the total carbon dioxide emissions. E_i signifies the final consumption of the energy source i. NCV_i denotes the net calorific value of the energy source i (referred to as the average low-level calorific value in China's national standard GB/T2589-2008). CEF_i represents the carbon content per unit of calorific value of the energy source i. COF_i indicates the carbon oxidation rate of the energy source i (because 99% and 100% carbon present in fossil fuels undergoes oxidation, the default value for COF_i is established as 1 according to the guidelines provided by the IPCC). "44" and "12" represent the molecular weights of carbon dioxide and carbon, respectively. $\frac{44}{12}$ represents the molecular weight ratio of carbon dioxide to carbon.

Building upon the measurement approach outlined by Zhang et al. (2020), we employ the carbon dioxide emissions calculated from industrial enterprises. The enterprise carbon emission intensity is gauged by utilizing the ratio between the carbon emissions of enterprises and the total industrial output value. The formula for this calculation is as follows:

$$\mathbf{CE} = \mathbf{CO_2} / \mathbf{Total\ industrial\ output} \qquad (2)$$

Eq. 2 represents the total carbon emissions of enterprises per 10,000 yuan of gross industrial output value.

4.2.2 Independent variable

The independent variable in our study is resource-exhausted city promotion program (Policy), which is represented as a binary variable. This variable takes a value of 1 for a county or city c in year t if it is designated as a resource-exhausted city during that year and in the subsequent years. Before such designation, it holds a value of 0. Furthermore, the variable consistently retains a value of 0 if the county or city c has never been designated as a resource-exhausted city.

4.2.3 Control variables

(1) Total factor productivity of enterprises (TFP). The total factor productivity (TFP) of an enterprise reflects its innovation capacity; thus, a higher TFP correlates with lower carbon emission intensity (Chen et al., 2021). TFP is computed using the ACF method, with the enterprise's industrial value-added representing production capacity, the year-end number of employees indicating labor input, year-end net fixed assets serving as the measure of capital stock, and intermediate inputs acting as proxy variables, following the methodology of Ackerberg et al. (2015). Utilizing these data and methods, enterprise TFP is estimated through Stata 14.0 software. Complying with the accounting standard: net fixed assets are determined by subtracting accumulated depreciation from the original value of fixed assets, and each of the mentioned indicators is log-transformed for analysis.

(2) Corporate financial leverage (Lev). Enterprises can significantly enhance their carbon efficiency by increasing financial leverage to phase out outdated capacity and adopt cleaner technologies and more efficient production processes (Wu et al., 2024b). To account for this influence, the model incorporates a financial leverage variable. The ratio of liabilities to assets is employed as a metric for corporate financial leverage (Liu et al., 2021), with data sourced from the China Industrial Enterprises Database.

(3) Opening to the outside world (FDI). In the academic community, there is a perspective on the relationship between opening to the outside world and carbon emissions known as the pollution haven effect. According to this view, developed countries, facing stricter environmental regulations and increased production costs, relocate pollution-intensive industries to developing countries with lower production costs. Meanwhile, developing countries, driven by the necessity for economic growth, often maintain lower environmental standards, leading to a "race to the bottom" phenomenon. This behavior ultimately contributes to higher carbon emission intensity among enterprises (Candau and Dienesch, 2017). To account for this influence, the model integrates a variable signifying the level of opening to the outside world. Drawing inspiration from Gao (2004), the ratio of actual utilized foreign capital to GDP serves as a metric for opening to the outside world. The required data are sourced from the China Stock Market & Accounting Research Database (CSMAR).

(4) Enterprise size (Size). Typically, larger businesses exhibit faster growth rates, consume more energy, and produce higher levels of carbon emissions (Song et al., 2024). Therefore, enterprise size notably and positively impacts enterprise carbon emission intensity, with emission intensity rising alongside the expansion of enterprise size (Secinaro et al., 2020). To control the impact of enterprise size within the sample on carbon emission intensity, the model includes a logarithmic variable representing enterprise size. Drawing from Liu et al. (2021), the natural logarithm of total assets of the sample firms is employed as the measure of enterprise size. The data for this variable are sourced from the China Industrial Enterprises Database.

(5) Industry concentration (HHI). Lower industry concentration often signifies intense market competition, compelling companies within these industries to prioritize enhancing financial performance and profitability. Consequently, their focus on environmental considerations such as carbon emission control may diminish, leading to an increase in carbon emission intensity (Zou et al., 2015). To manage the influence of industry concentration on enterprise carbon emission intensity, the model integrates an industry concentration variable. Measured using the Herfindahl index, this variable captures the ratio of the square of an enterprise's sales revenue to the industry's total sales. Higher values indicate greater industry concentration. The data for this variable are obtained from China's industrial enterprise database.

(6) Firm's rate of return on assets (ROA). Firm's rate of return on assets indicates an enterprise's profitability. Enterprises with strong profitability have greater financial support and discretionary funds. This enables them to invest in environmental protection, new technology development, and sustainable practices, thus reducing their carbon emission intensity (Zheng and Jin, 2023). Firm's rate of return on assets is an important factor affecting enterprise carbon emission intensity. We introduce firm's rate of return on assets variable in the model to control for its impact on carbon emission intensity. Drawing from the study by Liu et al. (2021), the ratio of net profit to total assets is adopted as a measure of firm's rate of return on assets. The data for this variable are obtained from the China Industrial Enterprises Database.

(7) Firm's fixed assets investments (Fix). Firm's fixed assets investments include new construction and the upgrading of existing assets. Increased levels of fixed assets facilitate the renovation and upgrading of equipment, which significantly improves energy utilization efficiency and helps reduce carbon emissions (Greenstone, 2002). To manage the effect of firm's fixed assets investments on carbon emission intensity, the model includes a fixed asset proportion variable. Drawing from Matemilola and Ahmad's approach (Matemilola and Ahmad, 2015) to measure capital investment intensity, the ratio of fixed assets to total assets is adopted as a gauge of firm's fixed assets investments. The data for this variable are sourced from the China Industrial Enterprises Database.

4.3 Descriptive statistics

Table 1 presents the descriptive statistics of the primary variables under study. The means and medians of these variables closely align,

TABLE 1 Descriptive statistics.

Variable type	Variables	Variable meaning	Observations	Mean	Standard deviation	Min	Median	Max
Dependent variable	CE	Enterprise carbon emission intensity	1189624	0.008	0.068	0.000	0.000	6.252
Independent variable	Policy	Resource-exhausted city promotion program	1189624	0.023	0.151	0.000	0.000	1.000
Control variable	TFP	Total factor productivity of enterprises	1189624	1.246	0.806	0.000	1.127	8.703
	Lev	Corporate financial leverage	1189624	0.537	0.493	−371.133	0.535	120.585
	FDI	Opening to the outside world	1189624	0.005	0.011	0.000	0.003	0.381
	Size	Enterprise size	1189624	10.130	1.506	0.000	9.988	19.437
	HHI	Industry concentration	1189624	0.290	0.277	0.000	0.188	1.000
	ROA	Firm's rate of return on assets	1189624	0.197	1.249	−65.157	0.076	1335.067
	Fix	Firm's fixed assets investments	1189624	0.363	0.354	0.000	0.317	62.684

indicating no discernible bias tendencies. Specifically, the dependent variable of enterprise carbon emission intensity demonstrates a mean value of 0.008. This signifies that enterprises generally exhibit low carbon emission intensity and elevated efficiency. The mean value of the dummy variable for resource-exhausted cities is 0.023, indicating that less than half of the industrial enterprises in the sample are situated in resource-exhausted cities. Moreover, the data concerning financial leverage, rate of return on assets, and fixed asset investment for the sample enterprises exhibit large extreme variance, underscoring a notable level of diversity in financial aspects within the sample.

4.4 Econometric mode

Following the theoretical analysis and research design detailed above, we employ the Difference-in-Differences (DID) method to assess the impact of the RECP program on enterprise carbon emission intensity. Considering the unique circumstances surrounding the establishment of resource-exhausted cities, which preclude the establishment of uniform time dummy variables, we adopt the staggered Difference-in-Differences (staggered DID) model. Drawing inspiration from the approach of Zheng and Ge (2022), we formulate the subsequent comprehensive econometric model for resource-exhausted cities' total effect estimation. The empirical model is designed as the Eq. 3:

$$\mathbf{CE_{i,t} = \beta_0 + \beta_1 Policy_{i,t} + \sum \beta_j Control + \gamma_t + \mu_i + \varepsilon_{i,t}} \quad (3)$$

Where, i represents the industrial enterprise i, and t represents the year i; $CE_{i,t}$ stands for the dependent variable denoting the enterprise carbon emission intensity; $Policy_{i,t}$ is the pivotal independent variable indicating the presence of the RECP program; Control encompasses a set of county- and city-level control variables, which encompass total factor productivity of enterprises (TFP), corporate financial leverage (Lev); opening to the outside world (FDI); enterprise size (Size); industry concentration (HHI); firm's rate of return on assets (ROA); firm's fixed assets investments (Fix); γ_t represents year fixed effect, controlling for time-invariant factors; μ_i is enterprise fixed effect, controlling for enterprise-specific time-invariant factors; $\varepsilon_{i,t}$ signifies the residual term; β_0 is the constant term in the model; β_1 is the core estimation coefficient, representing the net effect of the RECP program on the enterprise carbon emission intensity. If β_1 is positive, it indicates that the RECP program enhances the improvement of enterprise carbon emission intensity. Conversely, a negative value suggests an inhibiting effect.

5 Results and discussion

5.1 Baseline regression

Following the econometric model (3) established in the fourth section of this paper, we estimate a panel data model that incorporates enterprise fixed effect and year fixed effect. The purpose is to assess the effects of the RECP program on the enterprise carbon emission intensity. Regressions use region-level clustering robust standard errors. Additionally, control variables are progressively introduced from columns (1) to (8). Notably, the independent and dependent variables of the model remain consistent throughout these regressions. The estimation outcomes of the baseline model are presented in Table 2.

The results from the model estimation in Table 2 reveal the following patterns: under the circumstances of controlling for enterprise and year effects, the estimated coefficient related to the RECP program concerning enterprise carbon emission intensity, without adding any control variables, is −0.005, signifying a negative association at a 10% significance level. This suggests that the RECP program contributes to a reduction in enterprise carbon emission intensity. Subsequent to the incorporation of all control variables, it remains apparent in column (8) of Table 2 that the estimated coefficient for the RECP program on enterprise carbon emission intensity is −0.004, significant at the 5% significance level. This effect corroborates Hypothesis H1.

TABLE 2 Regression results of resource-exhausted city promotion program on enterprise carbon emission intensity.

Variables	CE							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Policy	−0.005*	−0.005*	−0.005*	−0.005**	−0.005**	−0.005**	−0.005**	−0.005**
	(−1.71)	(−1.85)	(−1.86)	(−2.15)	(−2.16)	(−2.17)	(−2.16)	(−2.15)
TFP		−0.000	−0.000	−0.000*	−0.000**	−0.000**	−0.000	−0.000**
		(−1.39)	(−1.64)	(−1.86)	(−2.16)	(−2.16)	(−1.64)	(−2.05)
Lev			−0.001**	−0.001**	−0.001**	−0.001**	−0.001**	−0.001
			(−2.08)	(−2.16)	(−2.07)	(−2.06)	(−2.11)	(−1.30)
FDI				0.071*	0.071	0.071	0.071	0.071*
				(1.66)	(1.64)	(1.64)	(1.64)	(1.66)
Size					0.001**	0.001**	0.001***	0.001**
					(2.33)	(2.31)	(2.68)	(2.56)
HHI						−0.001	−0.001	−0.001
						(−0.74)	(−0.67)	(−0.66)
ROA							−0.000**	−0.000**
							(−2.40)	(−2.07)
Fix								−0.001***
								(−3.45)
Enterprise fixed effect	yes	yes	yes	yes	yes	yes	yes	Yes
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	Yes
Observations	1189624	1189624	1189624	1189624	1189624	1189624	1189624	1189624
Adj. R-squared	0.350	0.352	0.352	0.358	0.358	0.358	0.361	0.361
F Statistics	2.910	2.541	4.953	4.807	5.629	5.058	6.780	6.553

Note: T-values are reported in parentheses. The estimated coefficients are reported above the parentheses. The robust standard errors are clustered at the region level. *, ** and *** represent significance at the levels of 10%, 5% and 1%, respectively.

5.2 Robustness tests

5.2.1 Parallel trend test

The fundamental assumption underpinning the Difference-in-Differences method is the Parallel Trend Test, indicating the absence of significant divergence in trends between the control group and the experimental group before program implementation. Referring to the research method of Beck et al. (2010), we adopt the event study method to conduct the parallel trend test. As shown in Figure 1, the horizontal axis represents the years before and after the policy implementation, the dotted line marks the policy implementation time, and the vertical axis represents the percentage change in the difference in carbon intensity between the experimental group and the control group. As seen in Figure 1, there is no significant difference between the control and experimental groups before the implementation of the RECP program. However, after the implementation of the RECP program, there is a significant negative difference between the control group and the experimental group. This indicates that the parallel trend test is passed.

5.2.2 Placebo test: randomly generated treatment group

To further establish that the reduction in enterprise carbon emission intensity predominantly results from the RECP program rather than incidental or stochastic factors, we employ a Placebo Test approach, drawing inspiration from the methodologies of La Ferrara et al. (2012). In this test, resource-exhausted cities are artificially designated, and "pseudo-policy variables" are introduced in a randomized manner. The selection of these variables aligns with the approach in column (8) of Table 2, encompassing independent variables, control variables, and fixed effects. Through 300 iterations of the model (3) regression estimations, using randomized resource-exhausted cities and artificially generated establishment times, we amass a set of 300 estimations for the "pseudo-policy variables." These estimated coefficients for the "pseudo-policy variables" are then subjected to kernel density estimation, yielding the distribution depicted in Figure 2, resembling a normal distribution curve.

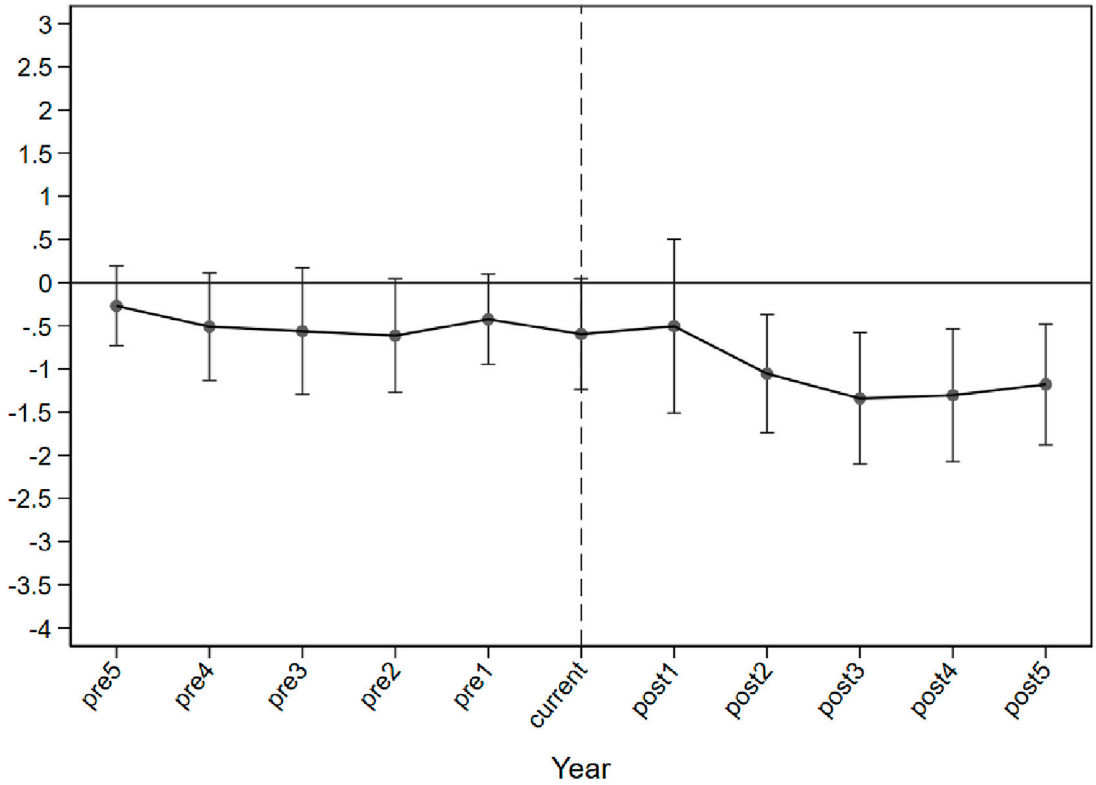

FIGURE 1
Result of the parallel trend test.

Figure 2 depicts the distribution of estimated coefficients for the 300" pseudo-policy variables." The horizontal axis represents the estimated coefficients, while the vertical axis signifies the density of distribution. A vertical dotted line denotes the true regression coefficient of −0.0047316. The figure unmistakably demonstrates that the actual regression coefficient markedly varies from the "pseudo-regression" coefficient. The kernel density distribution of the "pseudo-regression" coefficient assumes a normal distribution shape, largely concentrated around the zero point. This empirical evidence corroborates the assertion that the substantial reduction in enterprise carbon intensity, as a result of the RECP program, is not influenced by concealed or unobservable factors. Consequently, the outcomes presented in Table 2 remain robust.

5.2.3 Multi-dimension fixed effects

Drawing on the idea of Feng et al. (2024c), to rigorously mitigate any spurious linkages arising from omitted variables, we employ a Multi-dimension Fixed Effects model for a comprehensive robustness test. In this model, beyond the pre-existing enterprise fixed effect and the year fixed effect, province and interaction terms encompassing province and year are additionally incorporated. This extended model is utilized to estimate the influence of the RECP program on enterprise carbon emission intensity. The outcomes of this regression analysis are presented in columns (1) and (2) in Table 3. The regression results exhibit remarkable similarity to the benchmark regression findings. Specifically, the RECP program continues to exhibit a negative and statistically significant impact on enterprise carbon emission intensity, with a significance level of 5% and an estimated coefficient of −0.004.

5.2.4 Dependent variable winsorized

To mitigate the potential impact of extreme values on the estimation results of the baseline regression, this study adopts a methodology akin to the one employed by Li et al. (2021). Specifically, we applied 1% winsorization to the enterprise carbon emission intensity, as an effort to counteract the influence of extreme values. The outcomes of this modified regression are presented in columns (3) and (4) in Table 3. Notably, even after implementing this winsorized approach, the influence of the RECP program on enterprise carbon emission intensity remains statistically significant. This reaffirms the robustness of the benchmark regression results, further confirming that the presence of extreme values does not exert a discernible impact on the analysis.

5.2.5 Measurements to alter the timing of policy enactment

Acknowledging the variations in the months of policy implementation due to the publication of three batches of resource-exhausted city lists, this study seeks to neutralize the potential influence of these differences on the regression findings. We adopt the approach outlined by Lu et al. (2017) to recalibrate the dummy variable $Policy_{i,t}$ for each batch of resource-exhausted cities during their respective setup years. This recalibration is carried out based on the proportion of months remaining in the year following

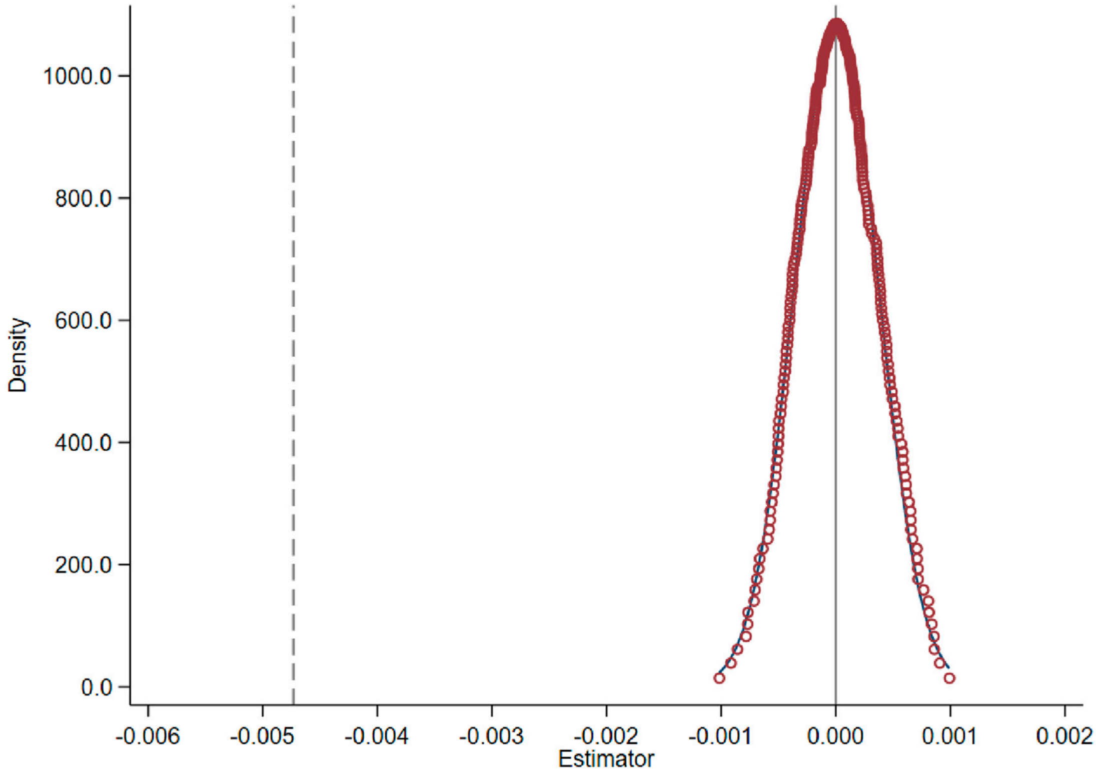

FIGURE 2
Result of the placebo test.

the publication of the list, relative to a total of 12 months (when the publication date falls after the 15th day of the month, 1 month is added to the count of published months). Conversely, if the publication date falls before the 15th day of the month, the count of published months remains unchanged and is not subjected to any adjustment). The specific methods are as follows:

(1) For the first batch with a publication date of 17 March 2008, the dummy variable $Policy'_{i,t}$ is set at 0 before 2008, and 3/4 for 2008.
(2) For the second batch with a publication date of 5 March 2009, the dummy variable $Policy'_{i,t}$ is set at 0 before 2009, and 5/6 for 2009.
(3) For the third batch with a publication date of 15 November 2011, the dummy variable $Policy'_{i,t}$is set at 0 before 2011, and 1/12 for 2011.

Following this adjustment and retaining the same control variables and fixed effects as in the baseline regression, we once again conduct regression analysis to assess the impact of the RECP program on enterprise carbon emission intensity. The results of this re-estimation are presented in columns (5) and (6) in Table 3.

The estimation results reveal no statistically significant distinction from the coefficient estimated in the baseline regression outcomes. Notably, even with the inclusion of all control variables, the estimated coefficient is −0.005 and remains notably negative at a significance level of 5%. This outcome underscores the robustness of the estimation findings presented in Table 2.

5.2.6 Mitigation of potential impacts from other relevant policies

In addition to the 69 resource-exhausted cities initially selected by the State in batches, on 16 December 2010, Chinese government issued the "Planning for Ecological Protection and Economic Transformation of Daxing'anling and Xiaoxing'anling Forestry Areas (2010–2020)." This plan identified nine county-level units within the Daxing'anling and Xiaoxing'anling Forestry Areas eligible for financial transfer policies aimed at addressing resource depletion. To address the potential interference of this policy with our baseline regression results, following the idea of Liu et al. (2024), we introduce a cross-multiplier term. This term consists of a dummy variable indicating whether a city or county is one of these nine forest areas and another dummy variable indicating whether it is after 2010. We added this control variable to our initial model (3) and re-ran the regression estimation. The results of this regression are presented in columns (7) and (8) in Table 3, with the resultant econometric model shown by Eq. 4.

$$\mathbf{CE_{i,t}} = \boldsymbol{\varpi_0} + \boldsymbol{\varpi_1}\mathbf{Policy_{i,t}} + \boldsymbol{\varpi_2}\mathbf{Forest^{*}year_{i,t}} + \sum \boldsymbol{\varpi_j}\mathbf{Control} + \gamma_t + \boldsymbol{\mu_i} + \boldsymbol{\varepsilon_{i,t}} \tag{4}$$

TABLE 3 Regression results of the robustness test.

Variables	Multi-dimension fixed effects		Dependent variable winsorized		Measurements to alter the timing of policy enactment		Mitigation of potential impacts from other relevant policies	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CE	CE	CE	CE	CE	CE	CE	CE
Policy	−0.004**	−0.003**	−0.002**	−0.002**	−0.004**	−0.005**	−0.005*	−0.005**
	(−2.30)	(−2.11)	(−2.07)	(−2.46)	(−2.08)	(−2.28)	(−1.70)	(−2.15)
Forest*year							−0.014***	−0.008**
							(−4.99)	(−2.05)
Control	no	yes	no	yes	no	yes	no	yes
Enterprise fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Province fixed effect	yes	yes	no	no	no	no	no	no
Year*province fixed effect	yes	yes	no	no	no	no	no	no
Observations	1189624	1189624	1189624	1189624	1189624	1189624	1189624	1189624
Adj. R-squared	0.356	0.367	0.530	0.535	0.350	0.361	0.350	0.361
F Statistics	5.273	24.335	4.277	11.854	4.314	6.707	15.037	6.441

Note: T-values are reported in parentheses. The estimated coefficients are reported above the parentheses. The robust standard errors are clustered at the region level. *, ** and *** represent significance at the levels of 10%, 5% and 1%, respectively.

Among these, $Forest^*year_{i,t}$ serves as the control variable, representing the cross-multiplied term between a dummy variable indicating whether a city or county is one of these nine forest areas and another dummy variable indicating whether it is after 2010. The pivotal coefficient in the model is ϖ_1, signifying the extent of influence exerted by enterprise exit on carbon emission intensity. The remaining variables are detailed as outlined in model (3).

The regression outcomes underscore that even with the incorporation of controls for potentially influencing policies, the impact of the RECP program on enterprise carbon emission intensity remains negative and the coefficient of the interaction term is −0.012. Importantly, the estimated coefficients exhibit no significant divergence from the coefficients observed in the baseline regression findings. This further substantiates the robustness of the estimation results.

5.3 Heterogeneity analysis

5.3.1 Regional environmental protection pressure

To bolster ecological conservation, China has enacted precise environmental protection policies and systems while optimizing the construction of a nationwide network for automatic ambient air quality monitoring. Existing studies have primarily measured regional environmental pressure using regional PM2.5 levels and sewage charges paid by enterprises. However, regional PM2.5 content does not fully reflect energy consumption or long-term environmental pressure. Additionally, sewage charge measurements only involve enterprises that pay these charges and the actual amounts paid can be reduced through various means, influenced by changing policies. Therefore, we adopt the method proposed by Yu and Ma (2022), measuring regional environmental pressure based on whether centralized heating is provided. Centrally heated areas burn large amounts of fossil fuels in winter to meet heating needs, significantly increasing air pollution and greenhouse gas emissions. This creates substantial pressure on the local environment. Consequently, given the prominent environmental protection issues and Chinese government's long-term emphasis on environmental protection, areas with centralized heating face greater environmental protection pressures than those without it. Considering potential variations in carbon emission intensity among enterprises in regions with varying environmental protection pressures, we categorize samples based on whether enterprises are located in areas with centralized heating or not. This categorization aligns with China's recent announcement of the heating demarcation line standard. Subsequently, regression estimations are conducted separately for these two groups. The econometric model remains consistent with the baseline model, and the estimation results are presented in columns (1) and (2) of Table 4. Within this table, column (1) represents the sub-sample estimation results for regions with high environmental protection pressure, while column (2) signifies the sub-sample estimation results for regions with low environmental protection pressure.

The impact of the RECP program on the enterprise carbon emission intensity varies depending on the environmental protection pressure in the regions, as shown in Table 4. In regions with low environmental protection pressure, the RECP program has a significantly negative effect at the 1% significance level with an estimated coefficient of −0.005, indicating its

TABLE 4 Regression results of the heterogeneity analysis.

Variables	CE					
	(1)	(2)	(3)	(4)	(5)	(6)
	High-stress areas	Low-stress areas	Forest industry cities	Mining cities	Small-scale enterprises	Large-scale enterprises
Policy	−0.003	−0.005***	−0.001	−0.005*	−0.002	−0.008**
	(−1.04)	(−3.51)	(−1.16)	(−1.93)	(−1.27)	(−2.23)
Control	yes	yes	Yes	yes	yes	Yes
Enterprise fixed effect	yes	yes	Yes	yes	yes	Yes
Year fixed effect	yes	yes	Yes	yes	yes	Yes
Observations	398034	780265	50976	1120960	560105	614896
Adj. R-squared	0.360	0.370	0.136	0.371	0.444	0.335
F Statistics	3.455	5.251	5.277	5.952	4.959	5.700

Note: T-values are reported in parentheses. The estimated coefficients are reported above the parentheses. The robust standard errors are clustered at the region level. *, ** and *** represent significance at the levels of 10%, 5% and 1%, respectively.

effectiveness in reducing enterprise carbon emission intensity. However, in regions with high environmental protection pressure, the results are not statistically significant. Analyzing the reasons behind this phenomenon, on one hand, regions with low environmental pressure initially imposed fewer constraints on enterprises by local governments. As the RECP program gradually unfolded, local administrations encouraged industrial transformation and upgrading to mitigate resource dependency. This fostered significant shifts in industrial practices toward improved carbon emission efficiency. On the other hand, enterprises in these regions, devoid of the social responsibility of heating, have greater market flexibility for transformation or market exit, effectively reducing carbon emission intensity. However, regions facing high environmental pressures commenced industrial transformation earlier to enhance carbon efficiency. However, the pace of transformation slowed under the burden of the RECP program. Moreover, district heating, which demands substantial energy, is predominantly supplied by highly polluting industrial enterprises, directly or indirectly. Faced with the rigid demand for winter heating, some heating enterprises are unable to exit the market or undergo large-scale transformation. Local governments are reluctant to let them exit due to their significant contributions to employment and tax revenue. Under these constraints, the screening effect of the exit of enterprises in high-pollution industries is weak, and the carbon intensity of these enterprises cannot be significantly reduced.

5.3.2 Area resource type

To assess whether the RECP program has a uniform impact on the enterprise carbon emission intensity in different resource cities, we adopt a classification approach inspired by Wu and Bai (2022). Following the criteria outlined in the "National Resource Cities Sustainable Development Plan (2013–2020)," China's resource cities are categorized into two groups: forest industry cities and mining cities, based on the dominant types of cities. Forest resource cities are classified as forest industry cities, while all other cities are designated as mining cities. Subsequently, the analysis is conducted separately for these two categories, employing an econometric model aligned with the baseline model. The estimation results are presented in columns (3) and (4) of Table 4, where column (3) represents the estimation outcome for forest industry cities, and column (4) represents the estimation outcome for mining cities.

The regression analysis reveals that the RECP program in mining cities exerts a significantly negative impact on the enterprise carbon emission intensity with an estimated coefficient of −0.005, whereas the effect remains insignificant for forest industry cities. The possible reason is that mining cities usually rely on the extraction and processing of mineral resources, leading to greater resource depletion and higher carbon emissions from enterprises. Therefore, government support for these cities is more effective in mitigating existing problems and reducing carbon emission intensity. In contrast, forest industry cities focus more on the sustainable use of forest resources and ecological protection, making enterprises relatively environmentally friendly in their development process. Thus, the RECP program has less impact on the carbon intensity of enterprises in these cities. Secondly, industrial enterprises in mining cities depend more on resources for production. The strict requirements of the RECP program for technological transformation force enterprises to incur significant capital and time costs. This leads to the exit of enterprises that cannot adapt to the market or their relocation to other regions, ultimately reducing the overall carbon emission intensity in the region. However, most forest industry cities are located in remote areas with a weak economic base, resulting in slow progress in technological transformation and equipment upgrading. These enterprises often lack sufficient capital investment in environmental protection and the development of new industries, failing to utilize the policy benefits for low-carbon production transformation effectively. Moreover, mining cities have more industrial heritage, making it easier for enterprises to use existing resources to develop niche tourism and promote decarbonization. Most forest industry cities have weak tourism infrastructure and poor transportation conditions, leading to unstable tourism sources and difficulty in achieving large-scale tourism. Consequently, enterprises find it challenging to develop tourism and reduce carbon emission intensity under the RECP program.

5.3.3 Enterprise size

Different enterprise sizes can yield varying environmental benefits, consequently impacting corporate carbon emission efficiency (Lee and Min, 2015). Given that the RECP program may exhibit variations in carbon emission intensity behavior based on enterprise size, we adopt the research methodology proposed by Patten and Society (Patten, 2002). Enterprises in the sample are categorized based on their size relative to the industry median: those exceeding the industry median are considered large-scale enterprises, while those falling below are considered small-scale enterprises. Separate sub-sample estimations are conducted for these two distinct size categories, utilizing an econometric model consistent with the baseline model. The estimation results are presented in columns (5) and (6) of Table 4, with column (5) displaying the results for the sub-sample of small-sized enterprises, and column (6) displaying the results for the sub-sample of large-sized enterprises.

Regression results reveal that the RECP program has a significant impact on reducing carbon emission intensity in large-scale enterprises at the 1% significance level with an estimated coefficient of −0.008. However, this effect was not significant in the case of small-scale enterprises. This suggests that the implementation of the RECP program has a more pronounced negative impact on carbon emission intensity in large-scale enterprises.

The possible reasons for analyzing this result are as follows. First, from the perspective of government support, resource-exhausted cities mainly rely on large enterprises, which play a guiding role in regional development through their progress. With the introduction of the RECP program, the government usually focuses on the transformation and innovation of large enterprises. They provide more resources and support to promote environmentally friendly and energy-saving production methods. Small enterprises, due to financial and technological limitations, find it difficult to carry out large-scale technological upgrades and innovation. The government tends to support small enterprises by providing technical guidance, training, and market access support. Therefore, the impact of the RECP program on small enterprises is less significant, and improvements in their carbon intensity will take longer to manifest. Secondly, from the perspective of the enterprises' capabilities, large enterprises are more likely to leverage their advantages to introduce efficient production processes and low-carbon technologies under the guidance of the RECP program. They can also combine their rich pre-industrial resources to develop tourism, reducing their reliance on resources and improving their carbon emission efficiency. In contrast, small enterprises, due to their smaller scale and limited capacity for transformation, find it difficult to develop tourism and face challenges in industrial transformation, resulting in smaller changes in emission reduction.

5.3.4 Quantile regression

The Ordinary Least Squares (OLS) regression model can only assess the average impact and cannot analyze the magnitude of the impact of the RECP program under varying enterprise carbon emission intensities. To better understand the extent of the impact of the RECP program, we draw inspiration from Das et al. (2019). We employ a quantile regression model, defining the 10th percentile, 50th percentile, and 90th percentile of the dependent variable, enterprise carbon emission intensity, to represent low, medium, and high carbon emission intensities, respectively. We conduct quantile regression to explore the influence of core independent variables on different distributions of these dependent variables. The regression results are presented in Table 5.

According to Table 5, it becomes evident that at the 90th quantile, the RECP program exhibits a significant negative impact on enterprise carbon emission intensity. However, at the 10th and 50th quantiles, this impact is not statistically significant. This suggests that the RECP program notably contributes to enhancing the carbon emission efficiency of enterprises with high carbon emission intensity. To explain this phenomenon, several factors may be at play. Firstly, enterprises with high carbon emission intensity are often found in resource-intensive industries. The depletion of local resources necessitates these enterprises to undergo transformation, upgrade, or expand their industrial chains to promote sustainable development. Secondly, the government may have prioritized enterprises with high carbon emission intensity as key beneficiaries of the RECP program. This emphasis on high-intensity carbon emitters likely led to a more substantial reduction in their carbon emissions. In contrast, enterprises with low and medium carbon emission intensities may already be involved in more advanced industries, making them less susceptible to the local resource situation, resulting in a weaker effect from the RECP program.

5.4 Influencing mechanisms

5.4.1 Screening effect: exit of enterprises in highly polluting industries

"Survival of the fittest" is not only a principle governing biological evolution but also a cornerstone of enterprise development and a fundamental competitive mechanism. This dynamic reflects a norm within a market economy (Zingales, 1998). As urban resources continue to deplete, competition among enterprises for these resources becomes increasingly intense. Enterprises situated along distinct value chains may make disparate decisions in response to the progressively scarce local resources. Additionally, the differential implementation of preferential government policies for various enterprises could introduce variations in strength. Consequently, the actual business environment is likely to exhibit a selection effect on enterprises. Drawing from this perspective, we employ the approach detailed by Ma et al. (2021) to identify enterprises that have exited. Specifically, an enterprise is deemed to have exited if its information is no longer present in China's industrial enterprise database. To elaborate, if an enterprise does not feature in the industrial enterprise database in the years following 2014, the

TABLE 5 Results of quantile regression.

Variables	Model		
	10 loci	50 loci	90 loci
Policy	−0.605	−38.061	−0.000**
	(−0.13)	(−0.48)	(−2.21)
Control	yes	Yes	yes
Enterprise fixed effect	yes	Yes	yes
Year fixed effect	yes	Yes	yes
Observations	1189624	1189624	1189624

Note: T-values are reported in parentheses. The estimated coefficients are reported above the parentheses. The robust standard errors are clustered at the region level. ** represent significance at the levels of 5%, respectively.

final year of its appearance in the database is identified as its exit year. This process assigns a dummy variable $Exist_{i,t}$ a value of 1 in cases of enterprise exit and 0 otherwise. In light of variable design, this paper utilizes the enterprise exit dummy variable as a moderator variable. This variable is then cross-multiplied with the dummy variable $Policy_{i,t} \times Exist_{i,t}$ for resource-exhausted cities to gauge whether enterprise exit contributes to a reduction in carbon emission intensity. The resultant econometric model is represented by Eq. 5, with the estimated regression outcomes showcased in columns (1) and (2) of Table 6.

$$\mathbf{CE_{i,t}} = \boldsymbol{\alpha_0} + \boldsymbol{\alpha_1 Policy_{i,t}} \times \mathbf{Exist_{i,t}} + \alpha_2 \mathbf{Policy_{i,t}} + \alpha_3 \mathbf{Exist_{i,t}} + \sum \alpha_j \mathbf{Control} + \boldsymbol{\gamma_t} + \boldsymbol{\mu_i} + \boldsymbol{\varepsilon_{i,t}} \quad (5)$$

Among these, $Exist_{i,t}$ serves as the moderator variable, denoting the presence of enterprise exit. Meanwhile, $Policy_{i,t} \times Exist_{i,t}$ represents the cross-multiplied term between the dummy variable for resource-exhausted cities and the enterprise exit dummy variable. The pivotal coefficient in the model is α_1, signifying the extent of influence exerted by enterprise exit on carbon emission intensity. The remaining variables are detailed as outlined in model (3).

Incorporating the enterprise fixed effect, year fixed effect and control variables, and employing prefecture-level city clustering, the analysis focuses on the effects of interaction terms between the resource-exhausted city and enterprise exit variables. However, the insignificance of this interaction term suggests that the RECP program does not have a pronounced impact on reducing enterprise carbon emission intensity after enterprise exit.

Given that the screening effect may exert varying impacts on enterprises contingent on their degree of resource dependency and pollution intensity, we draw inspiration from Wang and Hao (2012) for classification purposes. The approach divides the 36 two-digit industry codes into two categories: heavily polluted and lightly polluted industries. Consequently, the sample enterprises are categorized into heavy pollution industry enterprises and light pollution industry enterprises based on their respective industry types. Leveraging this classification, we perform group regression on the sample data following the established model (3). The estimation results are displayed in columns (3) to (6) of Table 6. Columns (3) and (4) correspond to regression results for lightly polluted industries, while columns (5) and (6) represent regression results for heavily polluted industries.

Upon adding the control variables, the findings demonstrate that the coefficient of the interaction term between the RECP program and enterprise exit in heavily polluted industries variables is 0.002—significant at the 10% level. This outcome suggests a positive moderating influence of the screening effect on the RECP program in shaping enterprise carbon emission intensity. In contrast, this moderating effect is not statistically significant among enterprises in lightly polluted industries, thus confirming the validity of Hypothesis H2.

TABLE 6 Regression results for the screening effect mechanism.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	CE	CE	CE	CE	CE	CE
Policy	−0.004	−0.003	−0.001	−0.001	−0.005	−0.004
	(−1.53)	(−1.37)	(−1.22)	(−0.94)	(−1.36)	(−1.21)
Exist	−0.001**	−0.001**	−0.001***	−0.001***	−0.002*	−0.001
	(−2.32)	(−2.21)	(−3.15)	(−3.30)	(−1.75)	(−1.59)
Policy*Exist	−0.002	−0.002	0.001	0.001	−0.002*	−0.002*
	(−1.51)	(−1.53)	(0.87)	(0.84)	(−1.68)	(−1.70)
Control	no	yes	no	yes	no	Yes
Enterprise fixed effect	yes	yes	yes	yes	yes	Yes
Year fixed effect	yes	yes	yes	yes	yes	Yes
Observations	1303194	1300394	464113	463089	833687	831969
Adj. R-squared	0.350	0.353	0.173	0.178	0.371	0.374
F Statistics	2.784	5.502	3.793	4.135	2.208	6.445

Note: T-values are reported in parentheses. The estimated coefficients are reported above the parentheses. The robust standard errors are clustered at the region level. * and *** represent significance at the levels of 10% and 1%, respectively.

5.4.2 Tourism development level

Resource-exhausted cities are grappling with the predicament of diminishing resource production and extraction annually. To break free from the cycle of "prosperity in resource-rich cities, decline in resource-exhausted cities," embarking on economic transformation and sustainable development is the path to pursue. Chinese government highlighted the paramount importance of ecological civilization construction, emphasizing the pivotal role of the tourism industry as a resource-efficient and environmentally friendly sector in the industrial transformation strategy (Yuan and Jang, 2023). Leveraging tourism's distinct advantages, this industry emerges as a key driver for urban industrial transformation and environmental enhancement. Prior research has primarily employed tourism output as the central gauge of tourism development. Building upon the work of Liu et al. (2019), and aiming for more robust conclusions, this study adopts a novel approach. It combines standardized domestic and international tourism earnings by gross regional product ($Tour\_income_{i,t}$) and the logarithm of cumulative domestic and international tourist arrivals ($Tour\_people_{i,t}$), forming a composite index for assessing the level of tourism development. Subsequently, econometric models are designed as the Eqs 6–9 and the regression outcomes are presented in Table 7.

$$\mathbf{Tour\_income_{i,t} = \kappa_0 + \kappa_1 Policy_{i,t} + \sum \kappa_j Control + \gamma_t + \mu_i + \varepsilon_{i,t}} \tag{6}$$

$$\mathbf{CE_{i,t} = \eta_0 + \eta_1 Policy_{i,t} + \eta_2 Tour\_income_{i,t} + \sum \eta_j Control + \gamma_t + \mu_i + \varepsilon_{i,t}} \tag{7}$$

$$\mathbf{Tour\_people_{i,t} = \iota_0 + \iota_1 Policy_{i,t} + \sum \iota_j Control + \gamma_t + \mu_i + \varepsilon_{i,t}} \tag{8}$$

$$\mathbf{CE_{i,t} = \vartheta_0 + \vartheta_1 Policy_{i,t} + \vartheta_2 Tour\_people_{i,t} + \sum \eta_j Control + \gamma_t + \mu_i + \varepsilon_{i,t}} \tag{9}$$

Where $Tour\_income_{i,t}$ represents the aggregated domestic and international tourism income standardized against the Gross Regional Product, and $Tour\_people_{i,t}$ denotes the logarithm of the combined domestic and foreign tourism trips. The central coefficients of significance within this model encompass κ_1, η_1, ι_1 and ϑ_1 while the remaining variables are elucidated in model (3).

The regression results reveal a finding: the RECP program exerts a substantially positive impact on both the per-unit total domestic and foreign tourism income and the cumulative domestic and foreign tourism trips, with statistical significance at the 1% level. This observation underscores the substantial positive influence of the RECP program on regional tourism industry growth. In other words, the promotional effects of the RECP program contribute to the advancement of the local tourism sector. This contributes to the mitigation of enterprise carbon emissions intensity and enhances enterprise carbon emission efficiency, thereby validating Hypothesis H3.

6 Conclusion and policy implications

6.1 Research conclusion

We primarily examine the influence of the RECP program on enterprise carbon emission intensity during the period from 2003 to 2014. It delves into the mechanisms underlying how the RECP program drives carbon emission reduction in enterprises. Ultimately, we seek novel avenues for enhancing the RECP program by exploring diverse policy measures. Drawing on both domestic and international literature, we scrutinize the impact of the RECP program on enterprise carbon emission intensity. Leveraging panel data from China's industrial enterprise database from 2003 to 2014, the asymptotic double-difference method is applied for analysis. The findings reveal:

(1) The RECP program negatively impacts enterprise carbon emission intensity, a result consistently verified through various robustness tests.
(2) There is substantial geographic and enterprise heterogeneity in the impact of the RECP program on enterprise carbon emission intensity. Regarding geographic heterogeneity, the RECP program negatively affects enterprises in regions with lower environmental protection pressure and those in mining cities but has no significant impact on enterprises in regions with higher environmental protection pressure or those in forest industry cities. Concerning enterprise heterogeneity, the RECP program significantly reduces carbon emissions for large-scale and high-carbon-intensity enterprises, but it has no significant effect on small-scale or medium- and low-carbon-intensity enterprises.
(3) The mechanism analysis revealed the following insights: the screening effect, characterized by the withdrawal of enterprises in highly polluting industries, plays a positive role in moderating the increase in carbon emission intensity among enterprises that are restrained by the RECP program. Simultaneously, the RECP program has improved tourism development and reduced the carbon intensity of enterprises.

6.2 Marginal contributions and limitations

The study can contribute marginally to existing research in the following ways:

(1) In terms of research perspectives, we investigate the influence of the RECP program on corporate environmental behavior through an examination of their implementation in China. The RECP program introduces an innovative model of sustainable development, with a focus on transformation and upgrading. Environmental sustainability is crucial for human wellbeing, and the RECP program represents a significant avenue toward realizing this objective. Therefore, this study offers valuable insights that can serve as references for the effective implementation of the RECP program and for promoting sustainable development.
(2) In terms of research samples, we place particular emphasis on evaluating the influence of the RECP program on microenterprises. Through a comprehensive examination and analysis of the impact of the RECP program on the enterprise carbon emission intensity, we gain a more

TABLE 7 Regression results for the tourism development level mechanism.

Variables	(1)	(2)	(3)	(4)
	Tour_income	CE	Tour_people	CE
Policy	0.170***	−0.004*	0.164***	−0.004*
	(3.38)	(−1.80)	(3.16)	(−1.94)
Tour_income		−0.004***		
		(−2.72)		
Tour_people				−0.002
				(−1.57)
Control	yes	Yes	yes	Yes
Enterprise fixed effect	yes	Yes	yes	Yes
Year fixed effect	yes	Yes	yes	Yes
Observations	1120951	1120813	1130458	1130320
Adj. R-squared	0.925	0.348	0.972	0.352
F Statistics	2.712	5.239	5.513	5.835

Note: T-values are reported in parentheses. The estimated coefficients are reported above the parentheses. The robust standard errors are clustered at the region level. * and *** represent significance at the levels of 10% and 1%, respectively.

precise understanding of how local policies affect microenterprises during their implementation phase.

(3) In terms of our research strategy, we have delved into the primary mechanisms influencing the enterprise carbon emission intensity, focusing on the screening effect and level of tourism development. By doing so, we have furnished local governments with targeted and practical policy recommendations to bolster environmental enhancement and the sustainable development of enterprises. These recommendations aim to fortify collaboration between local governments and enterprises, augment environmental consciousness, and facilitate the achievement of sustainable development goals. This includes curtailing carbon emissions, enhancing environmental quality, and contributing to human wellbeing.

However, this study has certain limitations that warrant attention in future research. First, the study's timeframe spans from 2003 to 2014, which may not capture recent trends due to data coverage limitations. Second, this paper uses carbon emissions directly generated by fossil energy consumption in industrial enterprises to measure carbon emissions and employs a simplified calculation method for carbon intensity, potentially overlooking some relevant factors. Third, the indirect measurement of carbon emissions based on enterprise energy consumption may yield results differing from actual emissions due to regional variations in energy quality and combustion efficiency. Fourth, the study may not have fully considered the impact of the RECP program on other forms of pollution, necessitating further exploration. Fifth, the criteria for enterprise exit are defined as the disappearance of enterprise information from China's industrial enterprise database, but there may be special cases not accounted for in this analysis. Consequently, this study can benefit from enhancements and deeper exploration addressing these limitations.

6.3 Suggestions

In light of the aforementioned findings, we believe that enacting the RECP program holds immense policy significance. The RECP program is crucial for facilitating the transition and advancement of emerging industries within local enterprises, mitigating the enterprise carbon emission intensity, enhancing carbon emission efficiency, and aligning with the evolving norms of societal development. As a result, we formulate the subsequent policy recommendations:

Firstly, we should maintain the course and innovate, guiding the rational and efficient development of enterprises by improving the RECP program. The RECP program, an important and innovative environmental measure adopted by the Chinese government, has been shown to effectively reduce the enterprise carbon emission intensity through resource reorganization, industrial transformation, and upgrading. At the macro level, it addresses resource allocation issues, enhances China's environmental management system, and contributes to improvements in both the regional economy and the ecological environment. Therefore, local governments should vigorously promote the implementation of the RECP program and formulate auxiliary policies for collaborative governance to ensure its effective execution. Meanwhile, scientific methods should be employed to achieve efficient and effective governance. Besides, to balance economic development with environmental protection, the government should establish environmental impact assessment and monitoring mechanisms, regularly inspecting enterprise resource utilization and pollution levels to ensure compliance with relevant policies. Furthermore, local governments should use support policies and subsidies to encourage enterprises to invest in environmental protection, including the establishment of mineral resource recycling systems and cleaner production systems. By raising environmental awareness, promoting a circular economy, and fostering low-carbon production, these measures can control the environmental impact of mineral extraction and improve carbon emission efficiency.

Second, leverage the comparative advantages of each region and promote the common development of enterprises in resource-exhausted regions through differentiated policies. The results of this paper show that the effect of the RECP program varies among regions. Sole reliance on financial transfers is insufficient to reduce enterprise carbon emission intensity in regions with high environmental protection pressure, mining cities, small-scale enterprises, and those with medium- and low-carbon emission intensity. Therefore, development should be tailored to local conditions, integrating local advantages, regional development conditions, natural resources, environmental capacity, industrial foundation, and the characteristics of local enterprises. This involves identifying functional positioning, offering special policies, and improving carbon emission efficiency through precise policy application. In implementing the RECP program, in addition to financial support, relevant policies can guide enterprise development further. Enterprises in areas with greater environmental pressure can be guided to develop environmentally friendly industries by utilizing existing local resources. Enterprises in forest industry cities can leverage their natural resource advantages to extend the industrial chain, engage in deep processing, and develop environmentally friendly industries. Small-scale enterprises can be encouraged to take advantage of their flexibility and versatility in the collection, sorting, and processing of discarded resources, forming a direct link between consumers and large-scale enterprises to create a better recycling network. Medium- and low-polluting enterprises can be encouraged to maintain green development while collaborating with the government to promote carbon reduction tasks for high-polluting enterprises. Ultimately, this will promote a new path of high-quality development oriented toward ecological priority and green development, leading to a significant reduction in the enterprise carbon emission intensity.

Thirdly, the urban development goals of enterprises exiting highly polluting industries should be targeted, and the important role of the screening effect in reducing carbon emissions should be rationally promoted. The exit of enterprises in highly polluting industries will enhance the effectiveness of the RECP program in managing corporate carbon emissions, with an obvious screening effect. This effect will improve carbon emission efficiency and create a hierarchical division of labor within the city's manufacturing industry, promoting the flow of factors and the division of labor in the value chain. Therefore, the Chinese government should further guide and strengthen the functional division of labor in urban agglomerations to leverage the externalities of this division. Combine development with the RECP program to continue promoting sustainable development. Enterprises in resource-exhausted cities should vigorously develop light industries or productive services through rational allocation of resources. Enterprises in non-resource-exhausted cities should actively undertake the transfer of manufacturing industries while protecting the environment. This will form a production pattern of complementary factors and reasonable division of labor among regional enterprises, further achieving the goal of carbon reduction. Local governments should adhere to constructing a fair and efficient institutional system across a larger region, utilizing relevant supporting policies and funds to establish mechanisms for assisting declining industries in resource-exhausted cities. Additionally, they should build a dynamic mechanism where enterprises in high-pollution industries can freely enter and exit the market, allowing the market economy to play a dominant role in resource allocation and removing institutional and systemic obstacles.

Fourthly, a new spectrum of tourism resources is being identified, and tourism development is being used as a breakthrough to promote the new development of enterprises. Research shows that the RECP program effectively reduces the enterprise carbon emission intensity by improving the level of regional tourism development, changing the direction of enterprise development, and focusing on environmental protection. The government should actively guide the development of tourism in resource-exhausted cities during the implementation of the support policies. They should improve local transportation and construct supporting tourism infrastructure to develop a certain scale of tourism using existing resources. Enterprises should focus on rebranding, industrial transformation, and environmental improvement. They should conduct scientific market research and planning on local tourism resources to formulate a development strategy that highlights local tourism characteristics and aligns with industry trends. Additionally, enterprises should support innovative tourism products. They should collaboratively develop the cultural connotations of different tourism resources and create new cultural connotations through mixing, matching, grafting, and fusion. This approach will help innovate tourism products, promote the integrated development of tourism and other industries, and realize a balanced tourism development path through strong industrial connections. This strategy will encourage enterprises to adopt clean energy, improve energy utilization efficiency, prioritize ecological protection, and further achieve sustainable development.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: http://ssd.ccerdata.cn/login?key=8RkP6%2fcsNbb2jvkAMEQQaQ%3d%3d: Industrial Enterprise Database; https://www.ndrc.gov.cn/: more information about Resource-Exhausted City Promotion program; https://data.csmar.com/: the China Stock Market & Accounting Research Database (CSMAR); https://www.ndrc.gov.cn/xxgk/zcfb/ghwb/201012/t20101223_962111.html: the relevant information about "Planning for Ecological Protection and Economic Transformation of Daxing'anling and Xiaoxing'anling Forestry Areas (2010-2020)".

Author contributions

ZL: Conceptualization, Data curation, Formal Analysis, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing–original draft, Writing–review and editing. JG: Conceptualization, Formal Analysis, Investigation, Supervision, Visualization, Writing–review and editing.

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