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Exploring energy and tourism economy growth nexus with DEA-based index systems: The case of sustainable development of tourism destinations

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ABSTRACT

The promotion of sustainable tourism to advance the United Nations Sustainable Development Goals has garnered considerable attention. This paper aims to present a comprehensive analytical framework with data envelopment analysis (DEA) based index systems for examining the interaction between energy and the economic growth of tourism, with a specific focus on tourism destinations within the Yangtze River Delta region of China. The significance of energy in enhancing tourism economy efficiency is established by treating energy input as separable and disposable, while non-energy inputs are considered quasi-fixed. Subsequently, a quasi-fixed energy input directional distance function within the DEA framework has been developed to assess tourism economy efficiency. Furthermore, this paper explores the relationships among environmental pollution, tourism carbon emissions, and tourism economy growth using coupling coordination and decoupling models, respectively. The results indicate that, although improving, there remains a gap for tourism destinations to achieve integrated development between environmental and economic systems. The decoupling type of tourism destinations transitions from expansive negative decoupling to strong decoupling, and the relationship between tourism economic development and tourism carbon emissions tends to be coordinated. This paper provides an empirical study on the measurement of tourism economy efficiency and the relationship between carbon emissions, environmental pollution, and tourism performance. It advances understanding towards implementing sustainable and integrated regional development strategies.

1. Introduction

The widely investigated hypothesis of tourism-led economic growth suggests that tourism can serve as a driving force for economic development (Paramati et al., 2017). Existing evidence indicates that tourism contributes positively to socio-economic advancement by serving as a mechanism for poverty reduction, mitigating disparities, and enhancing the quality of life for local residents (Alcalá-Ordóñez and Segarra, 2023). However, it is crucial to acknowledge that the rapid growth of the tourism sector has exerted significant strain on the energy and environment (Ahmad and Ma, 2022; Tang et al., 2022). As is widely known, energy is a fundamental basis for economic growth and influences the efficiency of regional economic development (Du et al., 2023; Ren et al., 2024). The tourism sector relies heavily on the energy, resulting in the entire industry being implicated for carbon emissions and environmental pollution (Tian et al., 2021; Sun, 2016). Excessive energy consumption has led to adverse effects on regional economic growth (Danish & Wang, 2018). Given the United Nations Sustainable Development Goals (SDGs), exploring sustainable development for tourism destinations is imperative (Wu et al., 2023b).

The Yangtze River Delta (YRD) region is the most dynamic economic area in China and a key tourism destination in the government's "14th

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Five-Year Plan" for tourism (Wu et al., 2023b). As the strategy of integrated development in the YRD region deepens (Wang et al., 2023), the strategic importance of tourism in regional development is gradually becoming more prominent. This is because tourism is one of the primary means for consumers to enjoy spiritual pleasure, an essential component of leisure consumption, and a pillar industry of the socio-economy (Li and Wu, 2024). Assessing the economic efficiency of tourist destinations in accordance with the principles of the United Nations SDGs is crucial for further exploring their relationship with energy and environmental systems, as well as for formulating accurate policy recommendations (Wu et al., 2024). Given this context, it is imperative to develop a comprehensive framework to evaluate the performance of the tourism economy and investigate the relationship between carbon emissions, environmental pollution, and tourism performance.

The frontier analysis approach is widely applied in performance evaluation (Assaf and Josiassen, 2016), with Data Envelopment Analysis (DEA) being a typical representative. DEA is a non-parametric linear programming technique that was initially introduced by Charnes et al. (1978) and has been widely used as a benchmark technique to analyze the relative efficiency of decision-making units (DMUs) with multiple input and output indicators (Wang et al., 2022). DEA techniques have been adopted in various research fields (Emrouznejad and Yang, 2018; Soltanifar et al., 2023), including energy and tourism efficiency evaluation, to analyze efficiency evolution and productivity change (Hu and Chang, 2016). The traditional DEA model assumes that all inputs can be freely and instantly adjusted to achieve best practices based on the given radial and slack improvements (Wu et al., 2023a). However, this assumption might overestimate a DMU's capacity to adjust due to adjustment costs, regulations, and indivisibilities (Ouellette and Vierstraete, 2004). Unfortunately, existing tourism economy-related literature has overlooked this key point and overestimated the non-energy inputs' capacity for rapid adjustments in the short term.

At the heart of tourism development is the reestablishment of the relationship between the region and its environment, which entails nurturing the tourism industry while relying on both social and ecological systems (Fei et al., 2021). In the context of SDGs (Lozano-Ramírez et al., 2023), scholars are concerned with the connection between economic growth in tourism and the preservation of the ecological environment (Shaheen et al., 2019). Current research primarily focuses on investigating the ecological footprint of tourism (Dwyer et al., 2010; Hunter and Shaw, 2007), exploring the relationship between tourism economic development and ecological preservation (Shaheen et al., 2019; Zhang and Chen, 2021), and assessing tourism sustainability and competitiveness (Asmelash and Kumar, 2019; Streimikiene et al., 2021). However, the coupling coordination and decoupling status among environmental pollution, tourism carbon emissions, and tourism economic growth in the YRD region remain unclear. There is still a lack of comprehensive evidence on the coupling coordination and decoupling relationship among environmental pollution, tourism carbon emissions, and tourism economy growth at the regional level.

In response to the United Nations SDGs, this paper focuses primarily on "Target 7.3 Double the improvement in energy efficiency" and "Target 11.6 Reduce the environmental impacts of cities", which are closely aligned with the principles of sustainable tourism (Boluk et al., 2019). Drawing on the work of Hu and Chang (2016) and Wu et al. (2023b), this paper presents a comprehensive analytical framework for examining the interplay among energy, carbon emissions, and tourism economic growth. Our comprehensive evaluation approach includes index measurement, coupling coordination, and decoupling analysis. First, we introduce a novel data envelopment analysis approach with quasi-fixed factors to measure tourism economy efficiency. Additionally, we investigate the relationships among environmental pollution, tourism carbon emissions, and tourism economy growth using the coupling coordination and decoupling models, respectively. Finally, we apply the proposed framework to analyze cities in the YRD region as tourism destinations and provide practical insights for future sustainable development.

This paper aims to construct a comprehensive analytical framework for energy and tourism economic growth and provide practical implications for sustainable tourism development in the YRD region. It contributes to the existing literature in the following ways: First, we propose a quasi-fixed input Directional Distance Function (DDF) model with the range directional model setting, which contributes to the emerging development of DEA methodology. Second, we provide a suitable measurement approach for assessing tourism carbon emissions at the prefecture-city level, thereby advancing the SDGs and sustainable tourism literature. Third, we analyze the coupling coordination between the environment and tourism economy systems, promoting the application of coupling coordination models in tourism fields. Fourth, we reveal the decoupling status between tourism carbon emissions and tourism economic growth, thereby expanding the knowledge about the relationship between environmental sustainability and economic prosperity in the tourism industry.

The paper is structured as follows. Section 2 offers a literature review. Section 3 describes the research design and methodology. Section 4 covers indicator selection and data description. Section 5 presents the analysis of empirical results. Section 6 discusses the main findings and provides implications, limitations, and research recommendations.

2. Literature review

2.1. The United Nations SDGs and sustainable tourism

The United Nations SDGs represent a universal call to action to end poverty, protect the planet, and ensure prosperity for all (Boluk et al., 2019). Consisting of 17 interconnected goals, the SDGs address key issues such as poverty, education, gender equality, clean water and sanitation, affordable and clean energy, climate action, and sustainable cities and communities (Rasoolimanesh et al., 2023). They provide a roadmap for global cooperation and collective action to achieve a better and more sustainable future by 2030 (Hall, 2019). Sustainable tourism represents a pivotal endeavor within the tourism sector aligning with the United Nations SDGs (Wu et al., 2023b). It entails strategies aimed at mitigating adverse environmental impacts, conserving cultural heritage, and fostering economic opportunities for local communities (Streimikiene et al., 2021). By embedding sustainability principles into tourism practices, sustainable tourism endeavors to ensure the enduring vitality of destinations while delivering rewarding experiences for travelers.

2.2. Performance evaluation of tourism destinations

DEA and its variants are extensively utilized in tourism performance evaluation due to their capability to model the negative impacts of the environment through undesirable outputs (Assaf and Tsionas, 2019). The Super-efficiency slacks-based measurement model, incorporating undesirable outputs, has been utilized to assess tourism eco-efficiency of regions in China (Wu and Liang, 2023). Meanwhile, Lozano-Ramírez et al. (2023) introduced a non-oriented, slacks-based inefficiency model to gauge the sustainability efficiency of tourism across European Union countries. DDF models have also garnered attention among tourism scholars. For instance, Wu et al. (2023b) developed a meta-frontier non-radial DDF approach to evaluate the tourism sustainability index of cities in the YRD region. Furthermore, Wu et al. (2024) proposed a weighted additive DEA model incorporating directional settings to measure the sustainable performance of tourism destinations, considering economic, social, and environmental dimensions. Additionally, the measurement of tourism productivity based on DEA models is also a primary focus of research. For example, Zha et al. (2019) utilized a combination of the non-convex meta-frontier DEA-based model and structural decomposition analysis to assess and decompose the eco-productivity of the tourism industry.

2.3. Tourism economic and environmental systems

Given the ongoing regional integration of the YRD region, it is of great importance to examine the coupling and coordination between the environmental and tourism economic systems. The coupling coordination degree model is widely used to explore the level of coordinated development between these two systems (Liu et al., 2021). For instance, Tang (2015) investigated the intricate interplay of environmental effects induced by tourism using the information entropy weight and coupling coordination degree model. It has also been employed to investigate the correlation between tourism urbanization and rural revitalization, utilizing Zhangjiajie city, China as a case study (Ma et al., 2022). Similarly, the spatial-temporal coupling coordination among the ecological environment, regional economy, and island tourism has been analyzed (Fei et al., 2021). The environmental subsystem is identified as an obstacle factor for coordinated development.

Moreover, several studies have focused on spatial analysis and driving factors for green and sustainable development in Chinese cities or provinces. The geographical detector model was utilized to examine the driving factors, revealing that terrain and transportation significantly impact eco-economy coupling coordination (Li et al., 2022b). Furthermore, scenario analyses and case studies have been conducted to promote sustainability in the context of new urbanization patterns (Li et al., 2022a). For example, Song et al. (2018) examined the alignment between low-carbon development and urbanization, delving into strategies for achieving low-carbon development amidst rapid urbanization. Furthermore, technological innovation has been identified as a means to redefine the future landscape of sustainable development (Ahmad et al., 2023a, 2023b). Previous study has also recognized a correlation between innovation, higher economic prosperity, and reduced environmental pollution (Ahmad et al., 2022).

2.4. Tourism carbon emission and tourism development

The tourism industry's greenhouse gas emissions have been increasing annually. Among these, carbon emissions resulting from energy consumption are a significant contributing factor to exacerbating global climate change (Sun, 2016). Scholarly attention has been given to carbon emissions resulting from tourism-related activities such as tourist accommodation, transportation, and leisure activities (Wu et al., 2023b). The accurate measurement of tourism carbon emissions is critical, and several studies have explored this topic. Using case studies of cities in Hubei province, China, Zha et al. (2019) developed an assessment framework for quantifying both direct and indirect carbon emissions from the tourism industry, utilizing input-output tables. Wu et al. (2023b) systematically measured tourism carbon emissions in tourism destinations using the "bottom-up" method. This paper focuses on carbon emissions resulting from tourism transportation and measures tourism carbon emissions in cities located in the YRD region.

Additionally, the relationship between tourism carbon emissions and tourism economic growth has garnered considerable attention from scholars (Li and Liu, 2022; Liu et al., 2022). The Tapio decoupling index (Tapio, 2005) has been introduced on the basis of the decoupling elasticity theory. Dogan and Aslan (2017) explored the connection between energy consumption, carbon emissions, and tourism development on a national level. Existing literature has investigated the decoupling relationships between carbon emissions from the tourism industry (Tang et al., 2014) and economic growth at the provincial level (Wang et al., 2017). Scholars have also developed a hybrid method based on the Tapio decoupling model. For example, Wu et al. (2019) performed a decoupling analysis using a logarithmic mean Divisa index model from the perspectives of carbon intensity and emissions. Zha et al. (2021) employed an innovative accounting approach to disentangle tourism economy growth from tourism carbon emissions. They further explored the factors influencing the decoupling status between tourism growth and carbon emissions.

2.5. Summary of related literature and research gaps

Several studies have examined the causal relationship between energy consumption, carbon emissions, and tourism economy growth at the provincial level in China (Zhang and Zhang, 2021), as well as at the country level worldwide (Shi et al., 2020). However, there is a dearth of research investigating performance evaluation, coupling and coordination, and decoupling analysis at the prefecture-city level, particularly within urban agglomerations such as the YRD region. To fill those gaps, we propose a quasi-fixed input DDF model with the range directional model setting to measure tourism economy efficiency. This paper further explores the coupling and coordination relationship between the environmental and tourism economic systems. We also try to examine the decoupling effect of tourism carbon emissions by calculating the reduction or increase of energy consumption and carbon emissions resulting from tourism activities. This exploration is significant for promoting the United Nations SDGs and sustainable tourism development.

3. Research design and methodology

We frame the issue within the context of Design Science Research Methodology (DSRM) (Peffers et al., 2007), through which we create a straightforward artifact (i.e., a quasi-fixed input DEA model) to enhance goal attainment. Viewing DEA through the lens of DSRM represents a novel approach, as demonstrated by Charles et al. (2019) and Tsolas et al. (2020), who utilized this framework to tackle specific challenges within the DEA domain. In accordance with DSRM guidelines, we developed activity steps pertinent to this paper, outlined in Table 1. It illustrates the five activities constituting DSRM in a nominal sequence, along with detailed descriptions of each activity and the requisite knowledge bases for different activities.

Relevance and novelty are two essential characteristics of design science artifacts (Zhang et al., 2024; Zhu et al., 2022). In terms of relevance, this paper addresses the potential issue of "adjusted freely trap" in DEA by assuming that non-energy inputs in tourism destinations are not freely adjustable in the short term. In terms of novelty, this paper explores the range of potential improvement of the directional vector based on a quasi-fixed input DDF model. The design problem in this paper can be formulated as follows: Address the possible "adjusted freely trap" in DEA by designing an approach (i.e., a quasi-fixed input DEA model) that is able to define that only energy inputs can be changed,

Table 1
Design Science Research Methodology (DSRM) applied to this paper.

DSRM activities	Activity description	Knowledge base
Problem identification and motivation	The traditional DEA model assumes that all inputs can be freely and instantly adjusted to achieve best practices based on the given radial and slack improvements.	Literature review. Understanding of weaknesses of traditional DEA models. Real world problem.
Define the objectives of a solution	Define a mechanism that only energy inputs can be changed, while other non-energy inputs would be fixed in the short run.	Literature review. Knowledge of existing tools.
Design and development	Design an approach that combines the quasi-fixed input DDF model and the range of potential improvement of the directional vector.	Quasi-fixed input DDF model. Range directional model.
Demonstration	Case study demonstration. The proposed approach is applied to evaluate tourism economy efficiency of tourism destinations in the YRD region.	Applying the proposed approach to a real-world case.
Evaluation	Comparative analysis.	Understanding of current solution and its advantages.

while other non-energy inputs would be fixed in the short run in order to optimize the decision-making process to achieve efficiency improvement of tourism destinations. Finally, we provide a comprehensive method framework, including the improved quasi-fixed input DDF model, coupling coordination model, and the Tapio decoupling model.

3.1. Quasi-fixed input DDF model

The traditional DEA model assumes that all inputs might be adjusted freely and instantly to the best practices or projections (i.e., target levels) according to the given radial and slack improvements. However, due to adjustment costs, regulation, and indivisibilities, this assumption might overestimate DMU's capacity to adjust, as argued by Ouellette and Vierstraete (2004). Regarding energy-related studies, a quasi-fixed input DEA model would define that only energy inputs can be changed, while other non-energy inputs would be fixed in the short run (Hu and Chang, 2016; Shi et al., 2010).

Assume that there are N DMUs, which consume energy and M non-energy inputs to produce R desirable and K undesirable outputs. Therefore, for the given o-th DMU, the energy input and m-th non-energy input variables can be denoted by e_o and x_{mo}, respectively. Similarly, the r-th desirable and k-th undesirable output variables can be represented by y_{ro} and u_{ko}, respectively.

The DDF model (Chung et al., 1997), as a typical representative of DEA techniques, has the advantage over the traditional DEA model of simultaneously expanding desirable outputs and contracting undesirable outputs (Wu et al., 2023a). Under the quasi-fixed inputs assumption, we consider the input-oriented DDF model, and the efficiency score of the o-th DMU can be derived by solving the following optimization problem (Hu and Chang, 2016):

$$\begin{aligned}
&\overrightarrow{D}_i(e_o, x_{mo}, y_{ro}, u_{ko}; g_e) = \max \beta \\
&s.t. \sum_{n=1}^{N} \lambda_n e_n \le e_o - \beta g_e, \\
&\sum_{n=1}^{N} \lambda_n x_{mn} \le x_{mo}, m = 1, 2, \ldots, M, \\
&\sum_{n=1}^{N} \lambda_n y_{rn} \ge y_{ro}, r = 1, 2, \ldots, R, \\
&\sum_{n=1}^{N} \lambda_n u_{kn} = u_{ko}, k = 1, 2, \ldots, K, \\
&\lambda_n \ge 0, n = 1, 2, \ldots, N.
\end{aligned} \tag{1}$$

where g_e denotes the directional vector for energy input. If $g_e = e_o$, β represents the proportional contraction in energy to achieve best practice or efficient frontier. If $g_e = 1$, β could be viewed as the number of decreases in energy input, that is so called energy slack. However, those kinds of directional vector selection may reduce the discernment of efficiency among DMUs.

According to the range directional model (RDM) proposed by Portela et al. (2004), we can define the directional vector considering the range of possible improvement as $g_e = e_o - \min\{e_n\}$. The evaluation index of the tourism economy considering the quasi-fixed non-energy inputs can be calculated using the following equation. Similarly, we can derive the evaluation index of the tourism economy without making the assumption of quasi-fixed inputs, that is DDF-RDM.

$$\mathrm{QFI-DDF-RDM} = \frac{e_o - \beta g_e}{e_o} \tag{2}$$

3.2. Coupling coordination model

The coupling degree model of two systems, that is ecological environment and tourism economy systems in this paper, can be formulated as follows:

$$C = \left[(u_1 \times u_2) \Big/ ((u_1 + u_2)/2)^2 \right]^{1/2} \tag{3}$$

where C denotes the degree of coupling, reflecting the degree of mutual dependence and restriction between the focused two systems (Li et al., 2022b). u_1 represents the evaluation index of the ecological environment, consisting of industrial wastewater, sulfur dioxides, and smoke dusts. u_2 denotes the evaluation index of the tourism economy, which can be represented by the optimal value of the quasi-fixed input DDF model.

We then standardize u_1 and u_2 to eliminate the potential influence of dimension, magnitude by the following formula:

$$\begin{cases} Positiveindicator : y_{ij} = (x_{ij} - x_{\min}) \big/ (x_{\max} - x_{\min}) \\ Negativeindicator : y_{ij} = (x_{\max} - x_{ij}) \big/ (x_{\max} - x_{\min}) \end{cases} \tag{4}$$

where x_{ij} denotes the value of indicator j of city i; y_{ij} denotes the standardized data. After calculating the degree of coupling, the coupling coordination degree model is given as follows:

$$D = \sqrt{C \times T}, T = \alpha u_1 + \beta u_2 \tag{5}$$

where D represents the degree of coupling coordination, which measures the degree of coupling relationship between the focused two systems and reflects the quality of coordination (Li et al., 2022b); T denotes the evaluation index as a comprehensive value between the two focused systems; α and β are undetermined coefficients with the sum of 1. In this paper, we suppose that the two focused systems are equally important, so the coefficients are assigned as $\alpha = \beta = 0.5$. The value of C and D are bounded in interval $[0, 1]$.

According to the coordination degree interval, we can derive five coordination levels (Tang, 2015). Specifically, coordination level can be defined as "superior coordination", "good coordination", "moderate coordination", "slight imbalance", and "serious imbalance" with the intervals of $0.8 < D \le 1$, $0.6 < D \le 0.8$, $0.4 < D \le 0.6$, $0.2 < D \le 0.4$ and $0 \le D \le 0.2$, respectively.

3.3. Tapio decoupling model

Based on the decoupling indicator proposed by the OECD (2002), Tapio (2005) provided a theoretical framework for decoupling using elasticity values and further explained the difference between decoupling, coupling, and negative decoupling. The Tapio decoupling index can be measured by the ratio of percentage change between the focused relationship, that is tourism carbon emission and tourism economy, during a given study period (Wang et al., 2017). If we focused on the percentage change from year T-1 to year T, then the Tapio decoupling index could be calculated using the following equation:

$$D_{T-1}^{T} = \frac{\Delta C_{T-1}^{T}}{\Delta E_{T-1}^{T}} = \frac{(C^T - C^{T-1}) / C^{T-1}}{(E^T - E^{T-1}) / E^{T-1}} \tag{6}$$

where, D_{T-1}^{T} presents the decoupling index from year T-1 to year T; ΔC_{T-1}^{T} and ΔE_{T-1}^{T} denotes the percentage change of tourism carbon emission and tourism economy, respectively.

According to the proposed framework (Tapio, 2005) and the detailed explanation of Wang et al. (2017), eight logical possibilities can be summarized and distinguished, as shown in Table 2. For the state of decoupling, strong decoupling means that the tourism economy increases while tourism carbon emission decreases; weak decoupling means that the increase pace of tourism carbon emission is significantly lower than the tourism economy; and recessive decoupling means that the decrease pace of tourism carbon emission is significantly higher than the tourism economy.

For the state of negative decoupling, strong negative decoupling indicates that the tourism economy decreases while tourism carbon

Table 2
The states and related indicators of Tapio decoupling model.

State	Type	D^T_{T-1}	ΔC^T_{T-1}	ΔE^T_{T-1}
Decoupling	Strong decoupling	$(-\infty, 0]$	< 0	> 0
	Weak decoupling	$(0, 0.8]$	> 0	> 0
	Recessive decoupling	$(1.2, +\infty)$	< 0	< 0
Negative decoupling	Strong negative decoupling	$(-\infty, 0]$	> 0	< 0
	Weak negative decoupling	$(0, 0.8]$	< 0	< 0
	Expansive negative decoupling	$(1.2, +\infty)$	> 0	> 0
Coupling	Recessive coupling	$(0.8, 1.2]$	< 0	< 0
	Expansive coupling	$(0.8, 1.2]$	> 0	> 0

emission increases; weak negative decoupling means that the decrease pace of tourism carbon emission is significantly lower than the tourism economy; and expansive negative decoupling means that the increase pace of tourism carbon emission is significantly higher than the tourism economy. For the state of coupling, recessive coupling means that the decrease pace of tourism carbon emission is approximately equal to the tourism economy, while expansive coupling means that the increase pace of tourism carbon emission is approximately equal to tourism economy.

4. Data and variables

4.1. Indicator selection and estimate

Fig. 1 shows the geographical location of cities in the YRD region. Please note that we have named Taizhou, Jiangsu Province as Taaizhou to avoid confusion with Taizhou, Zhejiang. Considering the availability of data, the selection of input, output, and environment variables is similar to previous studies implemented by Wu et al. (2023b) and Zha et al. (2019). Employed labor (unit: 10 thousand persons), capital stock (unit: billion CNY), energy consumption (unit: 10 thousand metric tons of standard coal equivalent), and resource endowment are selected as input variables. Tourism revenue (unit: 100 million CNY) and reception (unit: 100 thousand person-time) are considered as desirable output variables, while the air quality index proxies an undesirable output variable, representing the negative impacts of tourism economy (Wu et al., 2024). Besides, two environment variables, namely tourism carbon emissions (unit: 10 thousand tons) and environment pollution emissions (unit: 100 thousand tons), are selected to investigate their potential relationships with tourism economy growth.

(1) *Environment variables*. Environmental pollution emissions consist of industrial wastewater, sulfur dioxides, and smoke dusts (Wang et al.,

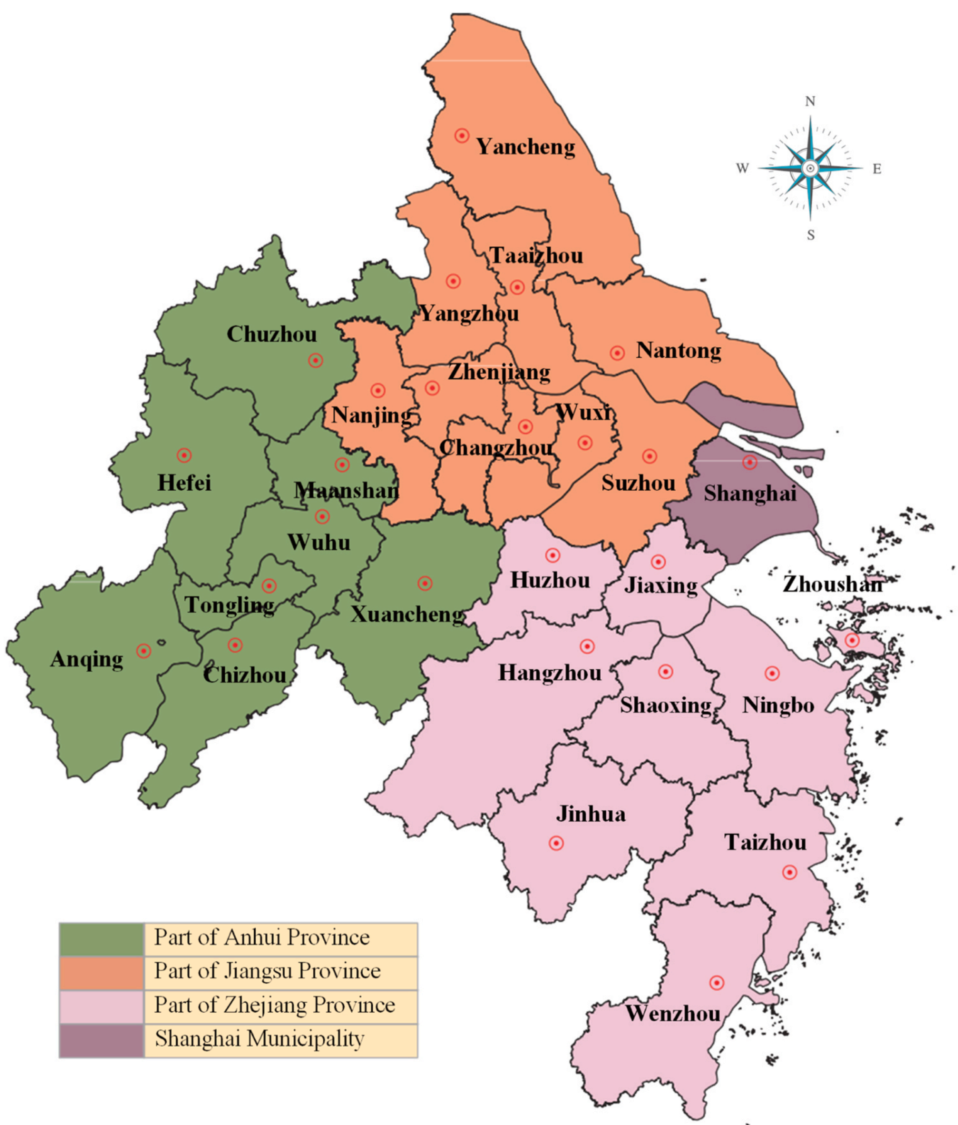

Fig. 1. The geographical location of cities in the YRD region.

2023). As for the estimate of tourism carbon emissions, the “bottom-up” method is usually adopted (Zha et al., 2020), whereby tourism is divided into three sectors: transportation, accommodation, and activities. This paper adopted the tourism carbon emissions measures proposed by Wu et al. (2023b), which focused on the carbon emissions from tourism transportation (Liu et al., 2011). The estimation formula is $C_T = \sum_{i=1}^{n}(P_{Ti} \times N_i \times D_i \times f_i)$, and the specific explanations can be seen in the work of Wu et al. (2023b).

(2) *Input variables*. The number of persons employed to represent the labor factor. Economic growth relies on a great deal of energy usage (Ren et al., 2024), so we choose the total energy consumption, which is converted into standard coal equivalent. Due to the availability of prefecture-level city data, electricity, coal, natural gas, and liquefied petroleum gas consumptions are converted to standard coal by the reference coefficient method (Wang et al., 2023). Investment in urban fixed assets is used to represent the capital factor. The number of star-rated hotels, travel agencies, and A-level tourist attractions is collected to represent tourism resource endowment (Wu et al., 2024). The Entropy weight method is used to aggregate these three tourism resource indices. The perpetual inventory method to transform fixed asset investment into base capital stock (Wang et al., 2023), which is calculated using the formula $K_{i,t} = I_{i,t} + (1 - \delta_{i,t})K_{i,t-1}$.

(3) *Output variables*. The total number of inbound and domestic tourist receptions and the total revenue of inbound and domestic tourism are adopted to represent the desirable outputs (Wu et al., 2023b). Besides, we consider the air quality index (AQI) to be a proxy for undesirable output (Wu et al., 2024). The higher its value is, the more serious the air pollution is and the greater the harm to human health. Data is collected from the Ministry of Ecology and Environment of China (www.mee.gov.cn/) using Python 3.10 software.

4.2. Data source and description

The panel data for the years 2010–2019 is used to evaluate the tourism efficiency of 27 cities in the YRD region. The data was derived from the EPS database (www.epsnet.com.cn), the *China City Statistical Yearbook*, the *China Tourism Statistical Yearbook*, the statistical yearbooks of each province and city, and the statistical bulletin of national economic and social development (Wu et al., 2024). Data processing and standardization are also carried out.

Table 3 shows that there are large differences in the magnitude of the resource input and output indicators among the 27 cities in the YRD region. Comparing the minimum and maximum values of the input and output variables of DEA, we can conclude that there exist huge differences among the cites in the YRD region. Therefore, it is necessary and practical to allocate resources for the inefficient cities through benchmarking analysis. The variable of tourism carbon emissions has a mean of 12.91 and a standard deviation of 10.81, with a minimum value of 1.39 and a maximum value of 56.47. The variable of environmental pollution emission has a mean of 1424.80 and a standard deviation of 1397.09, with a minimum value of 48.82 and a maximum value of 8048.00.

Table 3
Descriptive statistics of the indicators.

Variable	Min	Max	Mean	Std. Dev.
Employed labor	3.83	528.97	47.75	75.28
Capital stock	349.69	5939.88	2064.89	1323.33
Energy consumption	15.72	3278.91	428.65	599.59
Resource endowment	17.78	544.38	95.77	89.65
Tourism revenue	22.80	3758.13	480.93	661.09
Tourist reception	41.14	3703.82	654.94	580.14
Air quality index	52.00	122.93	79.09	11.53
Tourism carbon emission	1.39	56.47	12.91	10.81
Environment pollution emission	48.82	8048.00	1424.80	1397.09

5. Empirical results

In this section, we present the empirical results based on the comprehensive method framework. Energy and tourism economy growth related issues are analyzed and discussed by taking tourism destinations in the YRD region as a case study.

5.1. Tourism economy efficiency evaluation and evolution

In this paper, tourism economy efficiency is calculated using the quasi-fixed input DDF model. This model assumes that only the energy input can be freely adjusted, and non-energy inputs are quasi-fixed. This hypothesis is consistent with reality and also highlights the role of energy in tourism and economic growth. For comparison, we also calculate and provide model results without considering quasi-fixed input assumptions. Table 4 presents the average tourism economy efficiency of 27 cities in the YRD region with different models.

The average tourism economy efficiency from 2010 to 2014 was 0.781 (DDF-RDM) and 0.943 (QFI-DDF-RDM). With different models, there are 8 (29.63 %) and 16 (59.26 %) efficient DMUs, respectively. Similarly, the average tourism economy efficiency from 2015 to 2019 is 0.798 (DDF-RDM) and 0.918 (QFI-DDF-RDM). With different models, there are 8 (29.63 %) and 14 (51.85 %) efficient DMUs, respectively. We can find that the DDF-RDM model has better identification ability, while the QFI-DDF-RDM model is closer to the actual situation.

Fig. 2 shows the comparison between the DDF-RDM and QFI-DDF-RDM models. The average tourism economy efficiency from 2010 to 2019 is 0.789 (DDF-RDM) and 0.930 (QFI-DDF-RDM). This result indicates that the overall tourism economy efficiency in the YRD region is relatively high. Comparing the results of the two models, there are eight cities that are rated as efficient throughout the sample observation period, namely Shanghai, Wuxi, Suzhou, Huzhou, Jinhua, Zhoushan, Taizhou, and Chizhou. Those cities can be deemed as best practices or benchmarks for inefficient DMUs to improve their capacity for resource allocation.

Table 4
Tourism economy efficiency of different time series.

City	2010–2014		2015–2019		2010–2019	
	DDF-RDM	QFI-DDF-RDM	DDF-RDM	QFI-DDF-RDM	DDF-RDM	QFI-DDF-RDM
Shanghai	1.000	1.000	1.000	1.000	1.000	1.000
Nanjing	0.853	0.802	0.929	0.986	0.891	0.894
Wuxi	1.000	1.000	1.000	1.000	1.000	1.000
Changzhou	0.722	1.000	0.762	0.928	0.742	0.964
Suzhou	1.000	1.000	1.000	1.000	1.000	1.000
Nantong	0.479	0.959	0.468	0.765	0.473	0.862
Yancheng	0.324	1.000	0.299	0.935	0.311	0.967
Yangzhou	0.863	0.944	0.851	0.865	0.857	0.904
Zhenjiang	0.916	0.930	0.965	0.987	0.940	0.959
Taaizhou	0.439	0.947	0.384	0.813	0.412	0.880
Hangzhou	0.981	1.000	0.960	1.000	0.970	1.000
Ningbo	0.857	1.000	0.955	1.000	0.906	1.000
Wenzhou	0.954	1.000	0.917	1.000	0.935	1.000
Jiaxing	0.860	0.956	0.823	0.852	0.841	0.904
Huzhou	1.000	1.000	1.000	1.000	1.000	1.000
Shaoxing	0.958	1.000	0.951	1.000	0.954	1.000
Jinhua	1.000	1.000	1.000	1.000	1.000	1.000
Zhoushan	1.000	1.000	1.000	1.000	1.000	1.000
Taizhou	1.000	1.000	1.000	1.000	1.000	1.000
Hefei	0.645	1.000	0.643	1.000	0.644	1.000
Wuhu	0.484	0.938	0.659	0.956	0.572	0.947
Maanshan	0.487	0.839	0.563	0.771	0.525	0.805
Tongling	0.752	0.784	0.717	0.478	0.735	0.631
Anqing	0.627	0.575	0.718	0.748	0.672	0.661
Chuzhou	0.376	0.775	0.400	0.712	0.388	0.744
Chizhou	1.000	1.000	1.000	1.000	1.000	1.000
Xuancheng	0.506	1.000	0.585	1.000	0.546	1.000
Average	0.781	0.943	0.798	0.918	0.789	0.930

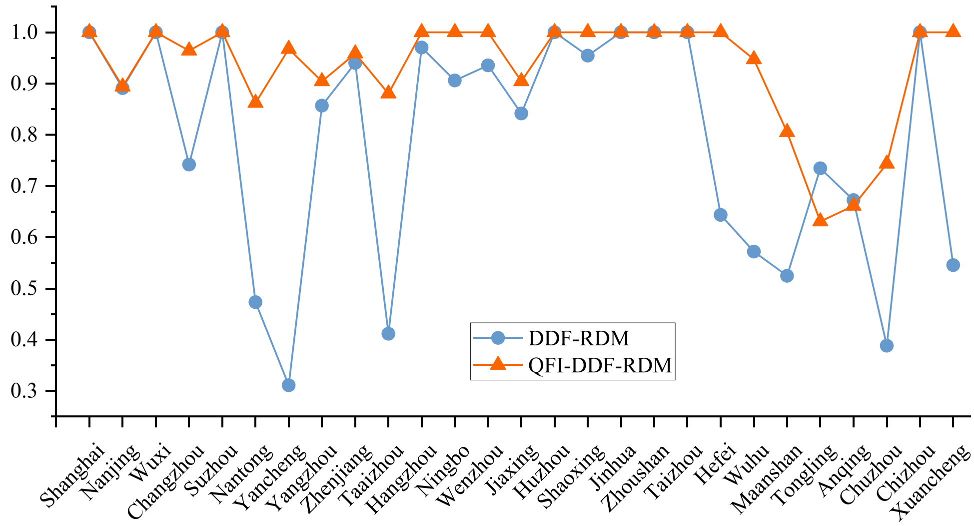

Fig. 2. Model comparison between DDF-RDM and QFI-DDF-RDM.

5.2. Coupling coordination analysis between environment and economy systems

Table 5 shows the coupling coordination degree based on DDF-RDM efficiency. We can derive the average value of coupling degree, comprehensive evaluation index, and coupling coordination degree, respectively. According to the coupling coordination level, we can find that only Shanghai, Suzhou, and Hangzhou are rated as having superior coordination. Besides, 11 cities (40.74 %) are deemed to have developed coordination (i.e., superior, good, and moderate coordination) between environment and economic systems, while 16 cities (59.26 %) are viewed as having developed imbalance (i.e., slight and serious imbalance).

Fig. 3 shows the coupling coordination degree based on QFI-DDF-RDM efficiency. Comparing the coupling coordination level as shown in Table 5, most of the results are consistent except for some slight changes. The coupling coordination levels of Hefei and Chuzhou are rated as slight imbalances in Table 5 and serious imbalances in Fig. 3. Based on the above analysis, coordination between the development of the environment and economic systems in the YRD region still has a lot of room for improvement. The findings suggest that there is a need for more effective policies and measures to promote sustainable economic and environmental development in the YRD region. Such policies may include promoting the use of clean energy, reducing carbon emissions, protecting natural resources, and improving waste management practices. These efforts can help to address the imbalances in the coupling coordination levels and promote more sustainable and equitable development in the region.

Fig. 4 presents the evolution of coupling coordination degree in major years. Upper and lower layers represent the results based on DDF-RDM and QFI-DDF-RDM models, respectively. We found that the visualizations generated by two different models exhibit overall similarity, which to some extent validates the robustness of the models. The coordinated development level of the observed cities is on the rise, but there is still a gap to achieve integrated development. Different cities can adopt different strategies according to the current situation to close before achieving coordinated development. The results of the paper indicate that there is a need for ongoing monitoring and evaluation of the effectiveness of policies and measures aimed at promoting sustainable development in the YRD region. Such monitoring and evaluation can help to identify areas where improvements can be made and ensure that policies are having the desired effect. Overall, the research highlights the importance of coordinated efforts to promote sustainable development in the YRD region, and the need for ongoing attention and action to achieve this goal.

5.3. Decoupling between tourism carbon emissions and tourism development

Fig. 5 shows the changing trend of energy, environment, and economic indexes from 2010 to 2019 in the YRD region. We can see that tourism carbon emissions (unit: 100 tons) and environmental pollution emissions (unit: 10 thousand tons) have an overall downward trend. While energy consumption (unit: 10 thousand TCE) and tourism revenues (unit: 100 million CNY) show an upward trend on the whole. It is obvious that the ecological environment is improving year by year, which is consistent with the Chinese government's pursuit of green and sustainable development.

Table 6 shows the Tapio decoupling index and decoupling type at the beginning, the intermediate, and the end of the observed period. For the period of 2010–2011, the decoupling type in Shanghai, Changzhou, and Wenzhou is strong decoupling, which indicates that the tourism economy increases while tourism carbon emissions decrease. The decoupling type in Taaizhou and Anqing is expansive decoupling, which means that the increase in tourism-related carbon emissions is approximately equal to the tourism economy. There are 15 cities (55.56 %) that are rated as having expansive negative decoupling, which indicates that the increase in tourism-related carbon emissions is obviously bigger than the tourism economy. Besides, there are 7 cities (25.93 %) that are rated as having weak decoupling, which means that the increase in tourism-related carbon emissions is obviously smaller than the tourism economy. For the periods 2014–2015 and 2018–2019, 20 cities (74.07 %) and 23 cities (85.19 %) respectively demonstrated strong decoupling, indicating a tendency for coordinated relations between tourism economic development and tourism carbon emissions.

The results suggest that during the study period, the relationship between tourism economic development and tourism carbon emissions tended to become more coordinated in the majority of the cities analyzed. However, there were still some cities where tourism-related carbon emissions increased at a faster rate than the tourism economy, indicating the need for measures to reduce tourism carbon emissions in these cities. On the other hand, some cities experienced a decrease in tourism-related carbon emissions relative to their tourism economy, indicating that these cities were able to achieve economic growth while maintaining environmental sustainability.

Fig. 6 shows the decoupling analysis and its evolution in the YRD region. From the perspective of time evolution, the decoupling type of cities in the YRD region changes from expansive negative decoupling to

Table 5
Coupling coordination degree based on DDF-RDM efficiency.

City	Coupling degree	Comprehensive evaluation index	Coupling coordination degree	Coupling coordination level
Shanghai	0.924	0.851	0.887	Superior coordination
Nanjing	0.677	0.628	0.651	Good coordination
Wuxi	0.663	0.703	0.682	Good coordination
Changzhou	0.559	0.500	0.526	Moderate coordination
Suzhou	0.997	0.990	0.993	Superior coordination
Nantong	0.823	0.369	0.550	Moderate coordination
Yancheng	0.952	0.277	0.513	Moderate coordination
Yangzhou	0.220	0.495	0.326	Slight imbalance
Zhenjiang	0.169	0.532	0.298	Slight imbalance
Taaizhou	0.438	0.261	0.337	Slight imbalance
Hangzhou	0.890	0.797	0.842	Superior coordination
Ningbo	0.542	0.600	0.570	Moderate coordination
Wenzhou	0.123	0.517	0.246	Slight imbalance
Jiaxing	0.691	0.602	0.643	Good coordination
Huzhou	0.216	0.577	0.350	Slight imbalance
Shaoxing	0.782	0.721	0.750	Good coordination
Jinhua	0.165	0.564	0.302	Slight imbalance
Zhoushan	0.003	0.505	0.028	Serious imbalance
Taizhou	0.157	0.563	0.271	Slight imbalance
Hefei	0.160	0.362	0.232	Slight imbalance
Wuhu	0.099	0.313	0.170	Serious imbalance
Maanshan	0.365	0.325	0.338	Slight imbalance
Tongling	0.071	0.395	0.165	Serious imbalance
Anqing	0.068	0.361	0.153	Serious imbalance
Chuzhou	0.197	0.222	0.203	Slight imbalance
Chizhou	0.001	0.501	0.003	Serious imbalance
Xuancheng	0.068	0.292	0.130	Serious imbalance

strong decoupling. This shows that the YRD region, as an economically developed region in China, is transforming to achieve sustainable economic development. The result suggests that sustainable development practices are becoming more widely adopted in China's most prosperous regions. It underscores the importance of promoting sustainable tourism practices to achieve a more harmonious relationship between tourism economic development and environmental sustainability.

6. Conclusion and implications

6.1. Discussion of main findings

The relationship between tourism and economic development has been subject to ongoing debate, with empirical evidence largely supporting the positive impact of tourism on socio-economic development (Alcalá-Ordóñez and Segarra, 2023). Considering the United Nations SDGs, it is necessary to comprehensively analyze the relationship between energy and tourism economic growth from economic, social, and environmental dimensions. Therefore, understanding the measures of tourism sustainable performance and the interactions among tourism carbon emissions, environmental pollution, and tourism economic development is crucial for achieving sustainable development for tourism destinations.

In this paper, we examine the relationship between energy and tourism economic growth in the context of achieving carbon neutrality. We conduct empirical studies using a comprehensive analytical framework, including index measurement, coupling coordination, and decoupling analysis. To begin, we present an innovative approach to data envelopment analysis that integrates quasi-fixed factors, providing a nuanced measurement of tourism economy efficiency. Expanding our inquiry, we delve into the intricate connections between environmental pollution, tourism-related carbon emissions, and the growth of tourism economies. This exploration employs coupling coordination and decoupling models to illuminate these relationships. Finally, our analysis extends to tourism destinations within the YRD region, where we offer practical insights to guide future sustainable development endeavors.

The results of sustainable performance evaluation show that the overall tourism economy efficiency in the YRD region is relatively high, with the DDF-RDM (0.789) and QFI-DDF-RDM (0.930) models showing promising results. Throughout the observation period, eight cities consistently demonstrated efficiency. These cities include Shanghai, Wuxi, Suzhou, Huzhou, Jinhua, Zhoushan, Taizhou, and Chizhou. This finding shares similarities with previous research (Wu et al., 2023b), suggesting that tourism destinations in the YRD region are actively responding to the United Nations SDGs, thus exhibiting a superior level of sustainability performance.

In terms of the coupling coordination analysis, the findings show that despite a positive trend, there is still room for improvement in achieving integrated development between the environment and economic systems in cities across the YRD region. The potential reason lies in the collaborative efforts of cities in the YRD region to advance integration and sustainable development, with full consideration given to ecological carrying capacity and natural restoration, thus promoting the sustainable development of ecotourism (Tang et al., 2022). Additionally, we observed heterogeneity in the coupling coordination development of tourism destinations, mirroring previous findings (Liu et al., 2021; Fei et al., 2021).

Finally, our discovery contrasts with evidence from Chengdu city, China, where a weak decoupling of tourism growth from carbon emissions was identified (Zha et al., 2021). We believe that the decoupling type of cities in the YRD region has shifted from expansive negative decoupling to strong decoupling and the relationship between tourism economic development and carbon emissions tends to be coordinated. The YRD region serves not only as a national demonstration area for integrated development but also as a crucial area with highly concentrated energy consumption and carbon emissions, striving to achieve the "carbon neutrality" goals (Wang et al., 2023). Under the integrated development strategy of the YRD region, the effectiveness of carbon reduction has been highlighted, demonstrating greater coordination with the development of the tourism economy.

6.2. Theoretical and practical implications

This paper has theoretical implications as it provides innovative methods that consider the practical issues of tourism sustainability and "carbon neutrality". First, the DEA approach has been further developed as a benchmarking tool to measure sustainable tourism performance or the efficiency of the tourism economy (Zhou et al., 2018). Second, the quasi-fixed energy input DDF model has been improved by introducing

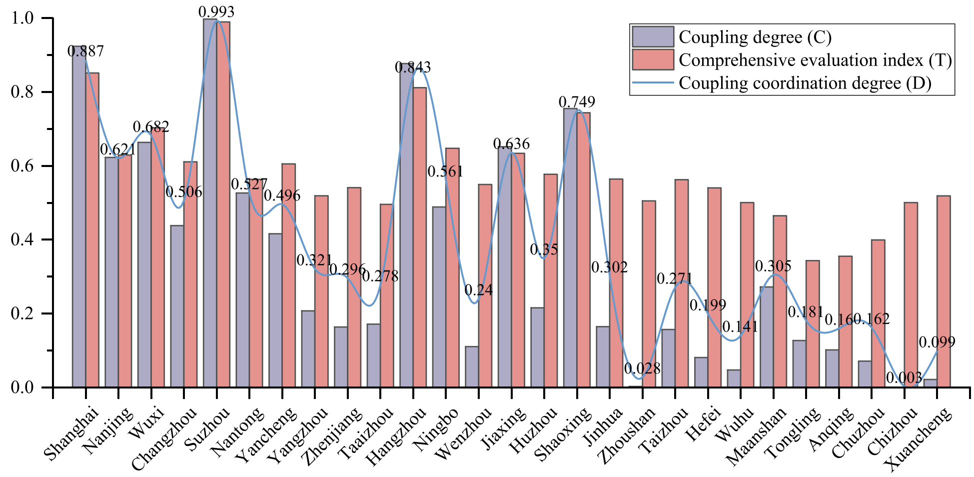

Fig. 3. Coupling coordination degree based on QFI-DDF-RDM scores.

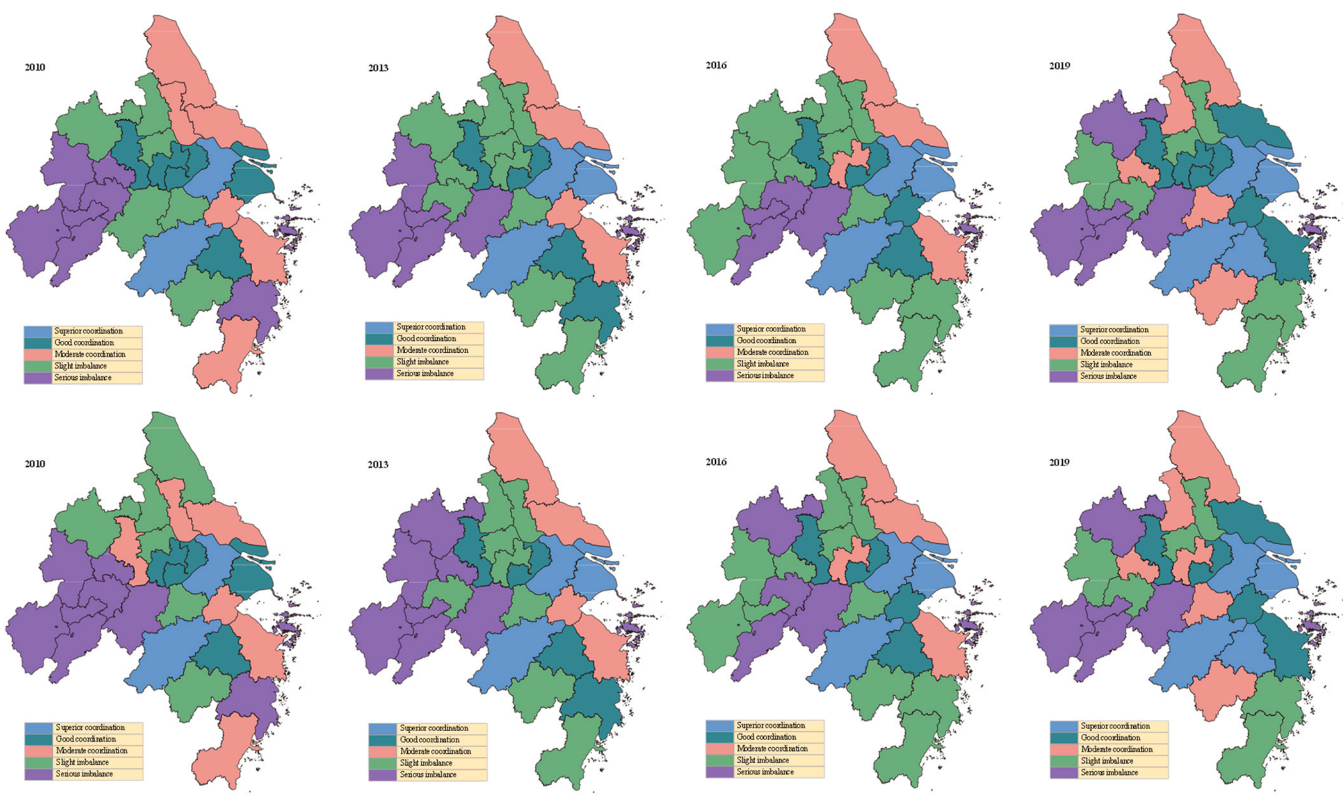

Fig. 4. The evolution of coupling coordination degree in major years.

the RDM setting of directional vectors (Hu and Chang, 2016). The role of energy in tourism economy efficiency has been investigated by assuming that energy input can be separated and disposed of freely, while non-energy inputs remain quasi-fixed. Third, the air quality index has been introduced as an undesirable output to proxy the environmental dimension of sustainability. Finally, the coupling coordination between the environment and tourism economy systems (Liu et al., 2021) and the decoupling status between tourism carbon emissions and economic growth (Zha et al., 2021) have been explored using the coupling coordination model and the Tapio decoupling model. This is an early attempt to investigate the coupling coordination degrees and decoupling status at the prefecture-city level in the YRD region.

Empirical results suggest several policy implications in response to the United Nations SDGs. First, managers of tourism departments in the YRD region should actively implement sustainable and integrated development strategies and strengthen the coordinated development of energy conservation, emission reduction, and environmental protection between tourism and other industries (Wu et al., 2024). Second, the realization of the sustainable development goal of the tourism industry has a strong external dependence, and the adjustment of the energy structure is the biggest force to achieve “carbon neutrality”. The use of renewable energy could help reduce environmental degradation derived from tourism-related activities (Sharif et al., 2020). Finally, under the new mode of “government guidance-enterprise operation-public participation”, the role of each component should be given full play to improve the level of tourism infrastructure integration (Wu et al., 2019). Tourists are the main participants in tourism activities and the main consumers of tourism products; therefore, low-carbon behavior at the

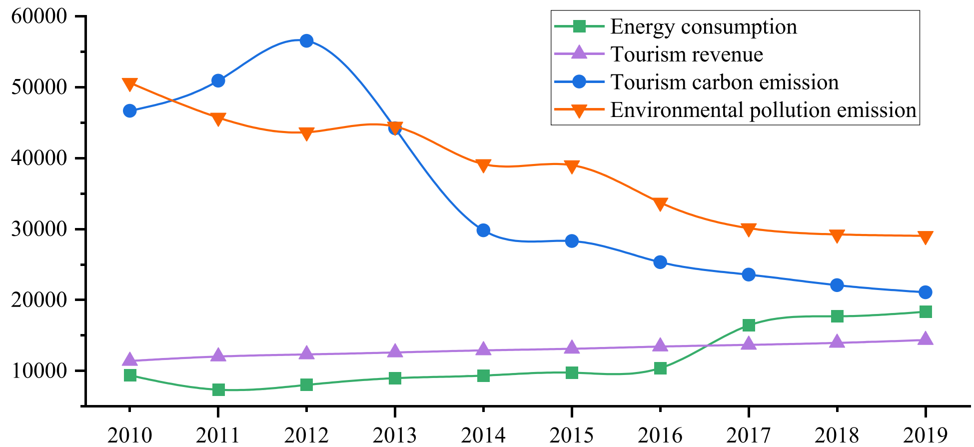

Fig. 5. The changing trend of energy, environment, and economic indicators.

Table 6
The Tapio decoupling index and decoupling type.

City	2010–2011				2014–2015				2018–2019			
	$\Delta C/C$	$\Delta E/E$	D	Type	$\Delta C/C$	$\Delta E/E$	D	Type	$\Delta C/C$	$\Delta E/E$	D	Type
Shanghai	−0.088	0.052	−1.689	*SD*	0.008	0.024	0.323	*WD*	0.025	0.025	1.002	*WD*
Nanjing	0.088	0.053	1.652	*END*	0.041	0.017	2.394	*END*	−0.070	0.031	−2.248	*SD*
Wuxi	0.117	0.053	2.212	*END*	−0.041	0.017	−2.389	*SD*	−0.008	0.031	−0.270	*SD*
Changzhou	−0.418	0.053	−7.878	*SD*	−0.041	0.017	−2.397	*SD*	−0.007	0.031	−0.240	*SD*
Suzhou	0.138	0.053	2.608	*END*	−0.041	0.017	−2.389	*SD*	−0.008	0.031	−0.253	*SD*
Nantong	0.181	0.053	3.409	*END*	−0.004	0.017	−0.233	*SD*	−0.046	0.031	−1.476	*SD*
Yancheng	0.112	0.053	2.122	*END*	−0.004	0.017	−0.241	*SD*	−0.046	0.031	−1.476	*SD*
Yangzhou	0.165	0.053	3.113	*END*	−0.041	0.017	−2.396	*SD*	−0.046	0.031	−1.474	*SD*
Zhenjiang	0.215	0.053	4.058	*END*	−0.041	0.017	−2.396	*SD*	−0.027	0.031	−0.866	*SD*
Taaizhou	0.048	0.053	0.897	*ED*	0.017	0.017	0.986	*ED*	−0.027	0.031	−0.871	*SD*
Hangzhou	0.075	0.054	1.393	*END*	−0.057	0.014	−4.092	*SD*	−0.157	0.029	−5.412	*SD*
Ningbo	0.016	0.054	0.289	*WD*	−0.166	0.014	−11.869	*SD*	−0.069	0.029	−2.372	*SD*
Wenzhou	−0.011	0.054	−0.204	*SD*	−0.056	0.014	−3.975	*SD*	−0.062	0.029	−2.145	*SD*
Jiaxing	0.038	0.054	0.705	*WD*	−0.039	0.014	−2.792	*SD*	0.019	0.029	0.646	*WD*
Huzhou	0.016	0.054	0.288	*WD*	−0.056	0.014	−3.983	*SD*	0.045	0.029	1.553	*END*
Shaoxing	0.036	0.054	0.658	*WD*	−0.065	0.014	−4.673	*SD*	−0.024	0.029	−0.811	*SD*
Jinhua	0.036	0.054	0.657	*WD*	0.052	0.014	3.685	*END*	−0.070	0.029	−2.425	*SD*
Zhoushan	0.036	0.054	0.671	*WD*	0.067	0.014	4.793	*END*	0.070	0.029	2.421	*END*
Taizhou	0.012	0.054	0.214	*WD*	−0.044	0.014	−3.173	*SD*	−0.028	0.029	−0.958	*SD*
Hefei	0.878	0.056	15.682	*END*	−0.183	0.013	−14.073	*SD*	−0.098	0.027	−3.620	*SD*
Wuhu	0.132	0.056	2.360	*END*	−0.426	0.013	−32.750	*SD*	−0.154	0.027	−5.708	*SD*
Maanshan	0.231	0.056	4.125	*END*	0.025	0.013	1.944	*END*	−0.017	0.027	−0.634	*SD*
Tongling	0.151	0.056	2.689	*END*	−0.022	0.013	−1.710	*SD*	−0.195	0.027	−7.208	*SD*
Anqing	0.049	0.056	0.882	*ED*	−0.021	0.013	−1.585	*SD*	−0.037	0.027	−1.376	*SD*
Chuzhou	0.296	0.056	5.279	*END*	0.020	0.013	1.565	*END*	−0.032	0.027	−1.188	*SD*
Chizhou	0.174	0.056	3.099	*END*	−0.082	0.013	−6.331	*SD*	−0.175	0.027	−6.471	*SD*
Xuancheng	0.112	0.056	2.004	*END*	−0.169	0.013	−12.985	*SD*	−0.001	0.027	−0.047	*SD*

Note: *SD* denotes strong decoupling; *WD* denotes weak decoupling; *END* denotes expansive negative decoupling; *ED* denotes expansive decoupling.

consumption end is also the responsibility of tourists.

6.3. Limitations and research recommendations

This paper has potential drawbacks that could be addressed in future research. First, due to the impact of the COVID-19 pandemic on the tourism industry, core variables such as tourism carbon emissions, tourist arrivals, and tourism revenue data are either unavailable or subject to significant bias. To mitigate the influence of data noise, this paper primarily focuses on the sustainable tourism development situation before the pandemic to provide reference for the future scenarios without significant influence from the pandemic. Second, due to a lack of data, the “bottom-up” method, which considers tourism transportations, is used to measure tourism carbon emissions. However, this approach does not account for carbon emissions from the financial, storage, or construction industries that are related to tourism activities. Third, this paper does not analyze the driving mechanism of the decoupling effect of tourism carbon emissions in the YRD region, resulting in a deficiency in clarifying the degree of influence of different factors on the decoupling effect.

Regarding the future sustainable development of tourism destinations in the YRD region, trans-regional cooperation and integrated development have always been hot topics in academic and practical circles, especially for the post-COVID-19 period. Pursuing the United Nations SDGs, the establishment of destination resilience and social responsibility is indispensable, serving as crucial drivers for the tourism industry’s recovery from crises. In addition, investigating the coordination of stakeholder relationships is also a valuable research direction. Sustainable tourism necessitates collaboration among diverse stakeholders, including governments, businesses, local communities, and tourists, to strike a harmonious balance between economic prosperity, environmental stewardship, and social inclusivity. Finally, while this paper focuses on the sustainable development of tourism destinations in the YRD region, we believe that the comprehensive analytical

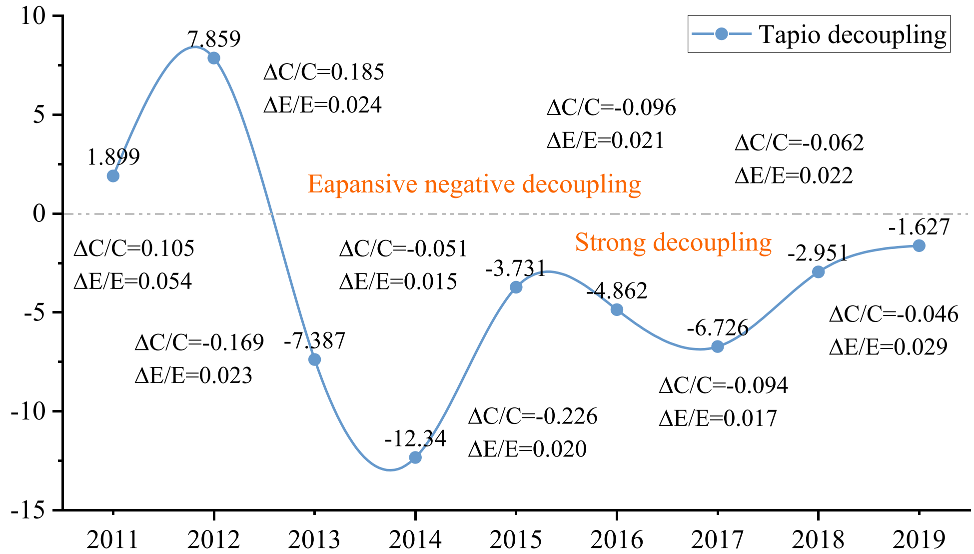

Fig. 6. Decoupling analysis and its evolution in the YRD region.

framework proposed in this paper has broader applicability. We encourage considering how our approach can be adapted and applied to benefit a wider audience beyond the specific context of our study area.

CRediT authorship contribution statement

Hui Li: Funding acquisition, Supervision, Writing – review & editing. **Dongdong Wu:** Conceptualization, Data curation, Methodology, Writing – original draft, Writing – review & editing. **Youyang Ren:** Data curation, Formal analysis, Software. **Wei Liu:** Conceptualization, Software, Validation, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

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