Coupling and interaction between tourism eco-efficiency and new urbanization in the Yangtze River Economic Belt: based on the perspective of uncoupling coordination

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Abstract

Facing the severe situation of environmental problems, coordinating the sustainable development of tourism and the construction of new urbanization is conducive to regional sustainable development. Based on the perspective of uncoupling coordination, this paper evaluates the coordination relationship between the sustainable development of tourism and the development of new urbanization, analyzes their temporal and spatial characteristics, and analyzes the restriction mechanism behind the uncoordinated relationship from the dynamic interaction. The findings are as follows: (1) At present, Shanghai, Jiangsu and Anhui are at a low level of uncoordinated development, while other regions are at an antagonistic uncoordinated development stage. (2) The regional difference of uncoupling coordination degree between tourism eco-efficiency and new urbanization is getting smaller and smaller, and it tends to develop in a balanced way, which accords with the strategic goal of coordinated development. However, the degree of uncoupling coordination changes from relatively weak aggregation to relatively strong aggregation. (3) From the long-term dynamic impact, the eco-efficiency of tourism has a negative impact on the development of new urbanization in Shanghai, Chongqing, Yunnan and a positive impact on Jiangsu and Hubei, with the contribution rates of 26%, 66%, 58%, 24% and 51%, respectively. New urbanization has a positive impact on the eco-efficiency of tourism in Anhui and a negative impact on Guizhou, with the contribution rates of 65% and 57%, respectively. The uncoupling coordination relationship and the interaction between the two systems are closely related.

Keywords Tourism eco-efficiency · New urbanization · Uncoupling coordination · VAR model · The Yangtze River Economic Belt

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1 Introduction

In the past few decades, a series of eco-environmental problems, such as resource shortage, ecological destruction and environmental pollution, brought about by economic and social development, have been widely concerned. Human economic activities cannot be separated from a good ecological environment. Under the background of global natural environment problems and sustainable development goals, China strongly advocates building an ecological civilized society and developing a low-carbon economy. Cities are the biggest contributors to carbon emissions. The complex relationship between urbanization and ecological environment is an important issue related to global sustainable development (Qi et al., 2020). Aware of the severe environmental problems, China is committed to implementing the new urbanization (NU) strategy, which is to develop urbanization with the basic characteristics of urban–rural plan as a whole, urban–rural integration, city–industry interaction, conservation and intensification, ecological livability, and harmonious development, and urbanization in which large, medium and small cities, small towns, and new rural communities develop in a coordinated and mutually reinforcing manner. In the process of urbanization, China has experienced a rapid growth in the scale of tourism development. There is no doubt that rapid urbanization has created conditions for the development of tourism, adding value to tourism and promoting its economic growth. In 2019, the number of domestic tourists in China exceeded 6 billion, with a total tourism revenue of 6.63 trillion yuan and a combined contribution to GDP of 10.94 trillion yuan, accounting for 11.05% of total GDP, indicating that the tourism industry is becoming an important engine of China's economic growth (Xinhua News Agency, 2020, March 10). As a pillar industry of China's national economy, tourism not only plays an increasingly important role in the economy, but also plays an important role in the construction of NU with its low resource consumption, high industrial ties, close regional ties, remarkable effect of enriching the people and outstanding sustainable features (Zhang & Li, 2020). Tourism is a comprehensive industry that provides travel and excursion services by virtue of tourism resources and facilities, and involves a wide range of tourism-related industries. Tourism urbanization, triggered by the agglomeration of tourism industries, is an important mode of urbanization in which tourism is a key component of the geography and economy of expanding cities (Mullins, 1991). Tourism can advance regional economic development as well as promote regional environmental optimization and social construction. Tourism and urbanization process complement each other.

The Yangtze River Economic Belt (YREB) is an important strategic development region in China, its economic status is unshakeable, and it is the main body of NU development in China. The average urbanization rate of provinces and cities in the YREB was 61.7% in 2019, exceeding the national average (Yangtze River Economic Network, 2021, January 22), and there are 76 national comprehensive pilots of new urbanization in the region, accounting for 30.4% of the country (Paper, 2020, June 24). Therefore, NU construction is also an important part of the YREB that cannot be ignored. The construction of NU requires that the economic development mode should be changed from the traditional extensive mode to the intensive and innovative mode, and a green and low-carbon circular development economic system should be established and improved, so as to realize the coordination between economic development and ecological environment protection (Chen et al., 2018). Therefore, ecological priority and green development are important ways to realize NU construction. Tourism is a typical green industry with low consumption, low pollution and recyclability. The Yangtze River is the main concentration area of China's highly influential natural landscape and humanistic tourism

resources, and in 2014, the *Guidance on Promoting the Development of Yangtze River Economic Belt by Relying on the Golden Waterway issued by the State Council* proposed to cultivate the YREB into an international golden tourism belt. Since then, based on the strategic positioning of the development of the YREB, eco-tourism has become an important means to coordinate ecological protection and economic development. In 2017, the *Outline of the Development Plan for the International Golden Tourism Belt of Yangtze River* was officially proposed. The YREB concentrates the most developed provinces in the tourism industry in the eastern, central and western regions of China. In 2019, the YREB received a total of about 8.6 billion tourists, and the total tourism revenue exceeded 10 trillion yuan, accounting for about 40% of the total national tourism revenue (Wang et al., 2022). Therefore, Yangtze River tourism is of great importance in the development of China's tourism industry and regional economy. Tourism is not only one of the core industries of the modern service industry in the YREB, which is driven by innovation and promotes industrial transformation and upgrading, but also the main assisting industry in promoting NU in an all-round way, especially the development of urban agglomerations in the upstream (Ge & Xi, 2015). Similarly, the industrial optimization and upgrading, infrastructure improvement and ecological optimization transformation brought by NU construction can provide important support and basic guarantee for the sustainable development of tourism (Sun & Huang, 2020). However, whether it is the development of urbanization or tourism industry, the threat of its own development attributes to the environment cannot be ignored. Tourism eco-efficiency (TEE) is an effective tool to measure the sustainable development of tourism, which measures the environmental efficiency from the perspective of economic benefits (Peng et al., 2017; Qin et al., 2021). Therefore, analyzing the coordination relationship between TEE and NU is helpful to promote the sustainable development of tourism and the construction of NU, and solve many problems such as severe ecological environment situation and unbalanced regional development in the YREB so as to realize China's goal of high-quality development and sustainable development.

Previous studies have shown that the relationship between urbanization and tourism, as well as between urbanization, tourism and ecological environment, has improved, but there is still room and potential for improvement in their coordination level (Li, Yang, et al., 2021a; Xie et al., 2021; Zhang & Li, 2020). Therefore, based on the perspective of uncoupling coordination, this paper evaluates the coordination relationship between tourism sustainable development and NU development, analyzes their temporal and spatial variation characteristics, and explores the restriction mechanism behind the uncoordinated relationship from the dynamic interaction between the two. This paper breaks through the limitations of simple measurement and comparison of coupling coordination degree in the past, and reveals the coordinated development trend and mutual restriction mechanism of tourism sustainable development and NU construction in important strategic areas. Through this research, on the one hand, it can provide practical guidance and scientific reference for future work, and promote the coordinated development of tourism and urbanization under the background of sustainable development goals. On the other hand, it can provide reference for the coordinated development of important strategic development areas in other countries in the world and research in similar fields.

2 Literature review

The Chinese government put forward the first ecological civilization strategy in 2007. In 2014, the Chinese government put forward the NU strategy after putting forward the idea of ecological civilization into the whole process of China's urbanization, emphasizing the all-round integration of ecological concepts into urbanization and promoting the green development of cities. Relevant research found that rapid urbanization caused serious ecological damage (Zhang & Xu, 2017) and interfered with ecological function expression (Yi et al., 2018). The pilot policy of NU is conducive to improving the quality of urban environment (Wu et al., 2021), and NU strategy has significant energy-saving effect in some areas (Lin & Zhu, 2021). That is to say, NU construction is conducive to the sustainable development of environmental friendliness. Urbanization provides basic guarantee for the development of tourism (Liu et al., 2021) and brings influence (Luo, Qiu, & Lam, 2015b). However, previous literatures discussed the impact of urbanization on regional ecological environment (Aguilera et al., 2020; Fang, Liu, et al., 2021a), agriculture (Cai et al., 2021) and construction industry (Zhang et al., 2021), but seldom discusses the impact of urbanization on the ecological development of tourism.

Similarly, the development of tourism also affects urbanization. For example, tourism industry agglomeration has a positive impact on urbanization (Zhao & Dong, 2017). In the long-term development, there is an obvious Kuznets curve effect between tourism economic development and urban ecological efficiency (Bai et al., 2018). In addition, related research found that the increase of tourist traffic brought benefits to the economy and society (Lanzara & Minerva, 2019), but aggravated the challenge of urban sustainability (Lee & Liao, 2021); developing rural tourism is one of the effective ways of urban transformation (Zeng et al., 2021); low-carbon tourism helps to solve urban environmental problems (Zhang, 2017; Zhang & Zhang, 2020). All these studies show the importance of ecological development of tourism to urban development, but they mainly focus on a single perspective, and do not study the impact of comprehensive ecological development level of tourism on urban development, that is, the impact of sustainable development of tourism on urbanization. At the same time, TEE, as an important index to evaluate the sustainable development ability of tourism, has not been fully applied in the research on the coordinated development of tourism and urbanization under the goal of sustainable development.

Because of the complex relationship between tourism, urbanization and ecological environment, the coupling, coordination and mutual influence among them have been widely concerned by scholars. In the research on the relationship between tourism, urbanization and ecological environment, the early research focused on the one-way impact relationship (Burak et al., 2004; Luo, Qiu, Goh, et al., 2015a; Zhao & Dong, 2017), with the continuous deepening of research, gradually turned to a higher level of interactive symbiotic relationship research (Li, Yang, et al., 2021a; Satrovic & Muslija, 2019; Shen et al., 2022). The research methods include coupling coordination degree(Cui et al., 2019), spatial correlation model (Yuan et al., 2019) and panel vector autoregression (PVAR) model (Adedoyin & Bekun, 2020) and so on. In the study of coupling relationship, most scholars pay attention to the evaluation, comparison and spatial–temporal distribution characteristics of coupling degree and coupling coordination degree (Fan et al., 2020; Fang, Shi, et al., 2021b; Li, Wang, et al., 2021c; Xie et al., 2021).

To sum up, previous studies focused on the three as three independent systems, ignoring the ecological attributes of tourism and urbanization. Therefore, the study on the relationship between TEE and the development level of NU is more conducive to the coordinated

development of tourism and urbanization under the background of sustainable development goals. In addition, coupling relationship and mutual influence relationship are often regarded as two independent research directions, and few studies combine them, which is not conducive to in-depth and comprehensive relationship analysis.

3 Research methods and data sources

3.1 Research method

3.1.1 Super-SBM model

At present, TEE evaluation is usually measured by data envelopment analysis (DEA), which overcomes the limitations of life cycle method, stochastic frontier analysis and other methods, and has strong objectivity and comprehensiveness (Sun & Pratt, 2014). Among them, the Super-SBM model not only overcomes the errors caused by the slack variables of the traditional DEA models (CCR and BBC), but also solves the problem of ineffective sequencing of multiple decision units (DMUs), thus accurately measuring data. The calculation formula for TEE value δ_{TCE} is (Tone, 2002):

$$\min \delta_{TCE} = \frac{1 + \frac{1}{m} \sum_{i=1}^{m} s_i^- / x_{ik}}{1 - \frac{1}{s} \sum_{r=1}^{s} s_r^+ / y_{rk}} \tag{1}$$

s.t

$$\sum_{j=1, j \neq k}^{n} x_{ij} \lambda_j - s_i^- \leq x_{ik}$$

$$\sum_{j=1, j \neq k}^{n} y_{ij} \lambda_j + s_r^+ \geq y_{rk}$$

$$\lambda, s^-, s^+ \geq 0$$

$$i = 1, 2, \ldots, m; \ r = 1, 2, \ldots, s; \ j = 1, 2, \ldots, n (j \neq k)$$

In Eq. (1), δ_{TEE} is the target efficiency value, i.e., tourism eco-efficiency value, m and s were the number of input and output, indicators $S_i^- \geq 0$, $S_r^+ \geq 0$ represented the slack variables of input and output, respectively, x and y represented the input and output variables, respectively, $\lambda_j \geq 0$ ($j = 1, 2, \ldots, n$) represented the weight vector.

Labor, capital and energy are the basic factors of production related to the development of tourist destinations, and they are the important directions of input indicators. Generally speaking, the development of tourism will produce social, economic and environmental outputs. Usually, the total tourism revenue is the expected output, while the environmental pressure represents the unexpected output of tourism carbon emissions. In this paper, considering the synergy among population, economy and environment, and comprehensively referring to the existing research results, the index system shown in Table 1 is constructed.

Table 1 Input–output index system of tourism eco-efficiency

Measurement target	Indicator type	Main references	Indicator name	Primary
Tourism eco-efficiency (TEE)	Input indicators	(Peng et al., 2017; Zha et al., 2020)	Labor input	Number of people employed in tourism
			Capital input	Tourism fixed asset investment
			Energy input	Total tourism energy consumption
	Desirable output indicator	(Zha et al., 2019)	Total tourism economy	Total tourism revenue
	Undesirable output indicator	(Gössling et al., 2005)	Tourism environmental pollution	Tourism CO_2 emissions

3.1.2 Entropy method

Based on the objective consideration, this paper uses information entropy to calculate the weight of each index, and then comprehensively measures the NU level of each province and city in the YREB. The specific calculation steps are as follows (Yang & Sun, 2015):

$$\text{Normalization of indicators :} \quad P_{ij} = Z_{ij} \Big/ \sum_{a=1}^{h} \sum_{i=1}^{m} Z_{aij}$$

$$\text{Calculate the entropy of each indicator: } E_j = -k \sum_{a=1}^{h} \sum_{i=1}^{m} P_{aij} \ln P_{aij}, \quad k = 1/\ln(hm)$$

$$\text{Calculate the entropy redundancy of each indicator: } D_j = 1 - E_j \tag{2}$$

$$\text{Calculate the weight of each indicator: } W_j = D_j \Big/ \sum_{j=1}^{n} D_j$$

$$\text{Entropy :} \quad \text{NU}_i = \sum_{j=1}^{n} Z_{ij} W_{ij}$$

The evaluation of NU mostly focuses on five aspects: population, economy, space, society and ecology. The traditional evaluation index of urbanization level mainly involves population, economy and space, which is reflected in the expansion of quantity and scale. The evaluation of NU level is more focused on the improvement of urbanization quality. Therefore, based on people's pursuit of a harmonious and fair society and a beautiful living environment, taking into account the urbanization development in social and ecological environment. Based on the existing research results, the index system shown in Table 2 is constructed.

3.1.3 Uncoupling coordination degree model

Coupling degree refers to the interaction between two or more systems, and the coupling coordination degree model is used to analyze the coordinated development level of things. On the basis of the existing research (Li, Zhao, et al., 2021b), this paper constructs an uncoupling coordination model.

$$\begin{cases} ND = 1 - D \\ D = (C \cdot T)^{1/2} \\ C = 2 \left[\dfrac{U_1 \cdot U_2}{\left(U_1 + U_2\right)^2} \right]^{1/2} \\ T = aU_1 + bU_2 \end{cases} \tag{3}$$

Table 2 Comprehensive evaluation index system of new urbanization

The target layer	Rule layer		Index layer	The weight
Comprehensive development level of new urbanization (NU)	Population urbanization	(Yao et al., 2021)	Proportion of urban population in total permanent population	0.0231
			Proportion of employed persons in tertiary industry	0.0521
			Registered urban unemployment rate	0.0607
	Economic urbanization	(Fan et al., 2020; Zhou et al., 2019)	GDP per capita	0.0748
			Proportion of total output value of secondary and tertiary industries in GDP	0.0189
			Local fiscal revenue per capita	0.1443
			Living expenditure of urban residents per capita	0.1059
	Spatial urbanization	(Liang et al., 2019)	Urban population density	0.0521
			Urban built-up area	0.0620
			Road area per capita	0.0251
	Social urbanization	(Liang et al., 2019; Xiong & Xu, 2018; Yu, 2021)	Water penetration rate	0.0473
			Gas penetration rate	0.0241
			Beds in medical institutions	0.0569
			Number of Internet access ports	0.0711
			Proportion of education expenditure in government expenditure	0.0351
	Ecological urbanization	(Wang et al., 2019; Yao et al., 2021)	Afforestation coverage rate of built-up area	0.0413
			Park green space area per capita	0.0342
			Harmless treatment rate of household garbage	0.0276
			Comprehensive utilization rate of industrial solid waste	0.0432

In Eq. (3), *ND* represents the degree of uncoupling coordination; *D* represents coupling coordination degree; *C* represents coupling degree; *T* represents the comprehensive level of NU and TEE; *a* and b represent undetermined coefficients. This paper considers that the two systems are equally important, so $a = b = 0.5$ is taken accordingly. According to the existing research results, the uncoupling coordination degree is divided into four stages (Table 3).

3.1.4 Vector autoregression (VAR) model

The vector autoregression (VAR) model can simulate the dynamic interaction between TEE and NU. At the same time, impulse response function and variance decomposition analysis are used to discuss the response and contribution degree to disturbance terms. The specific formula is as follows (Chu et al., 2021):

$$Y_t = C + a_1 y_{t-1} + a_2 y_{t-2} + \cdots + a_p y_{t-p} + b x_t + \varepsilon_t \tag{4}$$

In Eq. (4), *t* represents time; y_t is endogenous variable, x_t is exogenous variable; *C* is a constant vector; a_p and *b* are coefficient matrices to be estimated; *p* is the lag order of the model; ε_t is a random disturbance term.

3.2 The data source

Due to the incomplete data statistics of Tibet, the required data are seriously missing. This paper takes other 30 provinces and cities in Mainland China as the research object. According to the principles of truthfulness, scientific, objectivity and accessibility of data acquisition, the data are mainly from *China Statistical Yearbook*, *China Tourism Statistical Yearbook*, *China Tourism Yearbook*, *Tourism sample Survey Data*, *China Traffic Statistical Yearbook*, *Tertiary Industry Statistical Yearbook* and provincial statistical yearbook from 2007 to 2020. For some missing data, interpolation method is used to supplement and perfect them.

Table 3 Classification of uncoupled coordination degree

Uncoupling coordination degree	Uncoupling coordination degree	Uncoupling coordination degree	Uncoupling coordination degree
$0 \leq ND \leq 0.2$	Low-level uncoupling coordination	$0.5 \leq ND \leq 0.8$	Running-in uncoupling coordination
$0.2 \leq ND \leq 0.5$	Antagonistic uncoupling coordination	$0.8 \leq ND \leq 1$	High-level uncoupling coordination

4 Result analysis

4.1 Tourism eco-efficiency and new urbanization level measurement results

The comprehensive evaluation indexes of TEE and NU in the YREB from 2006 to 2019 were calculated by Super-SBM model and entropy method, and the comprehensive evaluation indexes of 2006, 2011, 2016 and 2019 were visualized by ArcGIS 10.6 software (Fig. 1).

From the distribution characteristics of TEE, TEE in the YREB showed an upward trend from 2006 to 2019, and the difference between the east and the west gradually decreased. The top TEEs in YREB are Shanghai, Jiangsu and Guizhou, and their efficiency values are all greater than 1, leading the downstream and upstream TEEs; Sichuan, Hubei and Hunan are ranked lower, and their efficiency values are all less than 0.7, which to some extent restricts the TEE level in the upstream and midstream. The main reason is that the downstream of the YREB are located in the eastern part of China, which is the most developed economic region in China with strong support from policies, capital, technology and other resources. In 2006, TEE was lower in Sichuan and Hunan, and higher in Guizhou and Jiangsu, which showed the distribution characteristics of high in the east and low in the west. In 2011, the main changes of spatial distribution were that TEE in Shanghai and Zhejiang increased obviously and TEE in Chongqing decreased obviously. Compared with the distribution pattern in 2006, there was little change in the overall regional difference. In 2015, the TEE in the YREB was generally improved, and the gap between the east and the west was significantly reduced. The TEE level in Shanghai, Jiangsu, Guizhou, Yunnan was higher, while that in Chongqing, Hubei and Hunan was lower. In 2019, regional TEE
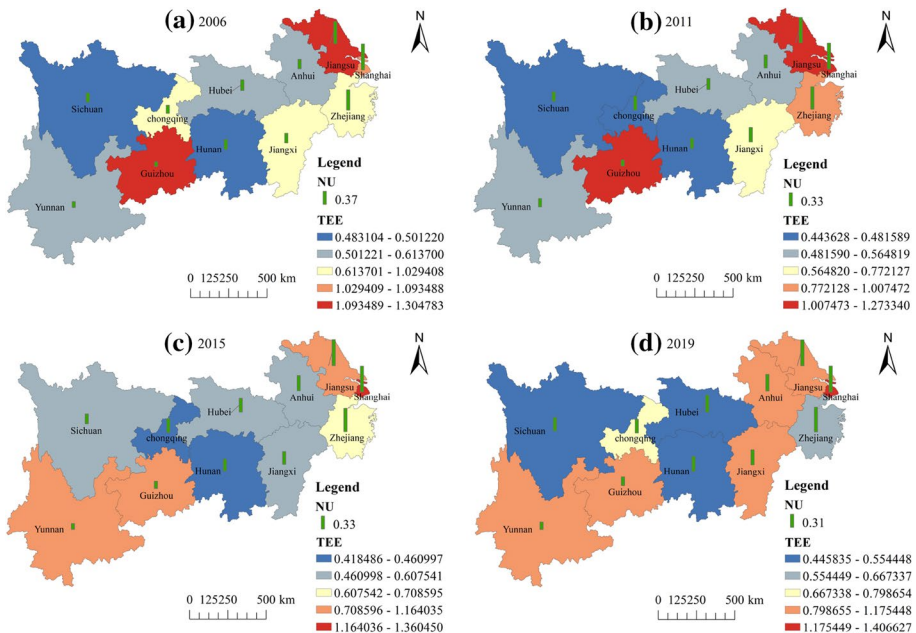

Fig. 1 Spatial distribution of tourism eco-efficiency and new urbanization level

was further improved, with TEE levels in Shanghai, Jiangsu, Guizhou, Yunnan, Anhui and Jiangxi all reaching a high level, while TEE levels in Sichuan, Hubei and Hunan were lower. From the perspective of relative differences within regions, with the adjustment of national regional development strategies and the implementation of policies, regional development differences generally decrease, which is in line with the strategic goal of China's regional coordinated development. On the whole, the characteristics of TEE region in the YREB are as follows: downstream > upstream > midstream. The upstream of YREB is located in the western part of China, with rich and under-explored natural and human landscape resources, and its TEE has great potential to be improved under the trend of western development, so its efficiency value is gradually catching up with the midstream region and gradually approaching with the downstream region.

From the distribution characteristics of NU, the overall development quality of NU in the YREB from 2006 to 2019 was relatively stable, but the difference between east and west was obvious. The difference between the east and the west of NU is closely related to the great differences in topography, transportation, resources, climate and infrastructure between the eastern and western regions of China. From these aspects, the urbanization development in the western region of China is very limited, with a small number, low density, unbalanced distribution, large scale and grade difference and strong regional dependence. In 2006, the development level of NU in Shanghai, Jiangsu and Zhejiang was obviously higher than that in other regions, while Guizhou and Yunnan were relatively backward, showing the spatial distribution characteristics of "high in the east and low in the west". In 2011, the difference between the central and western regions decreased, and the development level of NU in Anhui, Jiangxi, Chongqing, Sichuan and other places improved significantly. In 2015, the spatial distribution characteristics of the decline of the development level of NU in the YREB from the downstream area to the upstream area became more and more obvious. In 2019, on the whole, the regional differences did not change much, which was basically consistent with the spatial distribution pattern in 2015. It indicates that the urbanization construction level in the upper and midstream of the YREB has improved under the strategic layout of the western development and the rise of central China, however, the capacity of small towns to gather industries and population is limited, the infrastructure is backward, and thus the urbanization construction still cannot catch up with the downstream located in the east. On the whole, the regional characteristics of TEE in the YREB are as follows: downstream > midstream > upstream.

4.2 Uncoupling coordination degree between tourism eco-efficiency and new urbanization development

4.2.1 Evaluation results of uncoupling coordination degree

In order to reveal the difference of uncoupling coordination among regions in the YREB, according to the measurement results of the uncoupling coordination degree between TEE and NU, this paper makes visual processing of the uncoupling coordination degree values in 2006, 2011, 2015 and 2019. According to Table 2, the uncoupling coordination degree of the two systems is divided into four grades. The higher the degree of uncoupling coordination, the stronger the mutual exclusion between TEE and NU development in a region, so the lower the level of uncoupling coordination, the better the coupling effect between the two systems. The results show that from 2006 to 2019, the degree of uncoupling coordination between the two systems is in two stages: low-level and antagonistic uncoupling

coordination, and there is no running-in and high-level uncoupling coordination stage, which indicates that the degree of uncoupling between the two systems is poor and the degree of coupling is good. In addition, the uncoordinated degree of TEE and NU development in the YREB generally shows a downward trend, which means that the uncoordinated relationship between the two systems has improved with time. The main reason is that since the 18th National Congress of the Communist Party of China, the country has gradually promoted the development strategy of the YREB, adhered to the strategic positioning of ecological priority and green development, and regarded "building the core area of the international golden tourism belt of the Yangtze River" as one of the strategic measures for the green development of the YREB.

However, as shown in Fig. 2, at present, most provinces are in the stage of antagonistic uncoupling coordinated development, and only a few provinces are in the stage of low-level uncoupling coordinated development. This means that the coupling development relationship between TEE and NU development systems in the YREB needs to be further improved. This is mainly because many problems that the YREB faced in the past, such as the severe ecological environment, the bottleneck of the Yangtze River waterway, the outstanding imbalance of regional development, the arduous task of industrial transformation and upgrading, and the imperfect regional cooperation mechanism, have not been completely solved. In fact, from 2006 to 2016, the regions in the low-level uncoupling coordination stage were always three provinces in the downstream areas, such as Jiangsu, Shanghai and Zhejiang. Since 2017, the situation has changed slightly, and Zhejiang has withdrawn from the low-level uncoupling coordination stage. By 2019, Anhui will enter a low-level uncoupling coordination stage, and a new situation will begin to appear in the midstream. This is bound to be closely related to the Outline of the YREB Development Plan issued by China in 2016. Based on the important ecological and economic status of
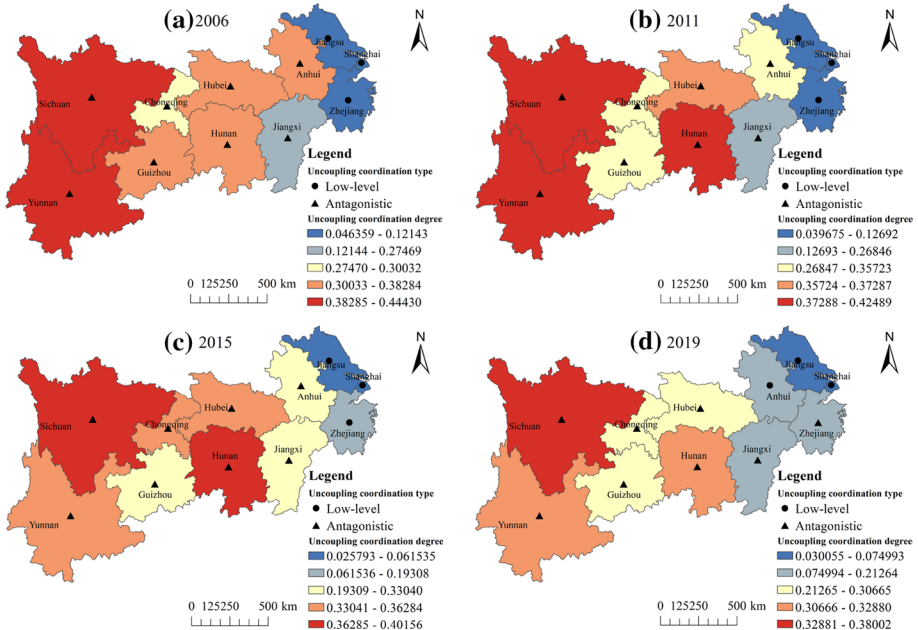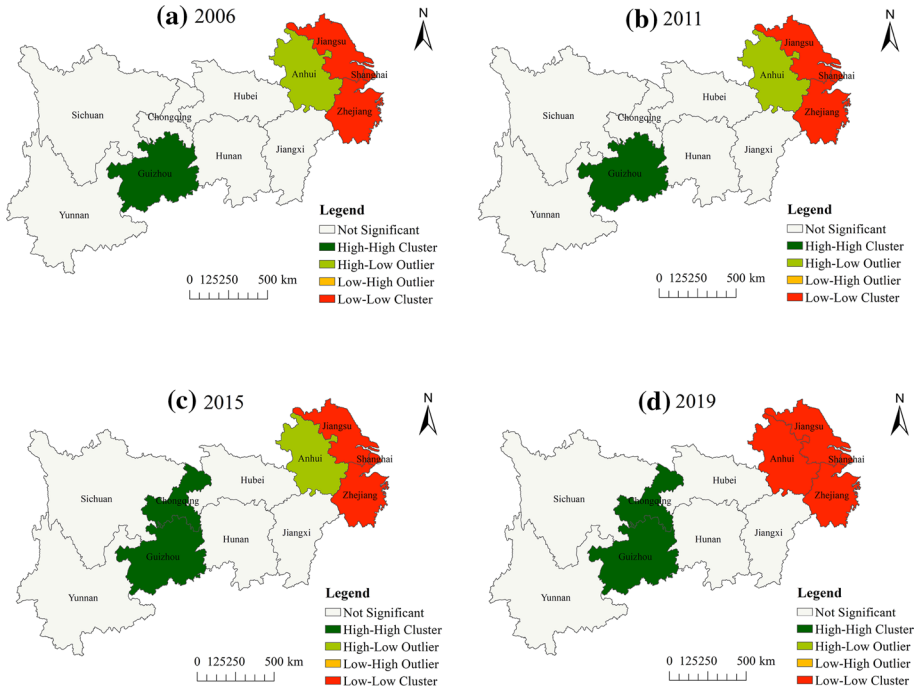

Fig. 2 Distribution of uncoupling coordination degree between tourism eco-efficiency and new urbanization

the YREB, the outline puts forward the development requirements of vigorously protecting the Yangtze River ecological environment, innovating to drive industrial transformation and upgrading, actively promoting NU, and innovating the system and mechanism of regional coordinated development, which promotes the solution of regional development problems. From Fig. 2, it can be seen that the easing of the relationship between TEE and NU development in the central region has long been predicted. From 2006 to 2019, the gap of uncoupling coordination degree in central China increased first and then decreased, and the uncoupling coordination degree continued to decrease. In addition, the disharmony between Yunnan and Guizhou provinces in the upstream has been obviously improved. Therefore, the overall regional differences of the YREB are narrowing, considering the changes of the uncoupling coordination levels in the upper, middle and downstream of the YREB, that is, the western, middle and eastern regions. The main reason is that China vigorously promotes the coordinated regional development of the YREB, which is positively influenced by the overlapping effects of the policy dividends of several, such as the Western Development, the Yangtze River Economic Belt development strategy, the regional integration of the Yangtze River Delta and the construction of the twin-city economic circle in the Chengdu-Chongqing region. As shown in the changes of the four time periods in Fig. 2, the number of provinces with higher or lower level of uncoupling coordination degree is gradually decreasing, and the value of uncoupling coordination degree is gradually approaching the intermediate value. The law of change is that the weak become stronger and the strong become weaker, which accords with the theory of unbalanced growth and also reflects China's regional coordinated development strategy. In summary, the uncoupled coordination relationship between TEE and NU development in the YREB and the mutual influence between the two systems are closely related.
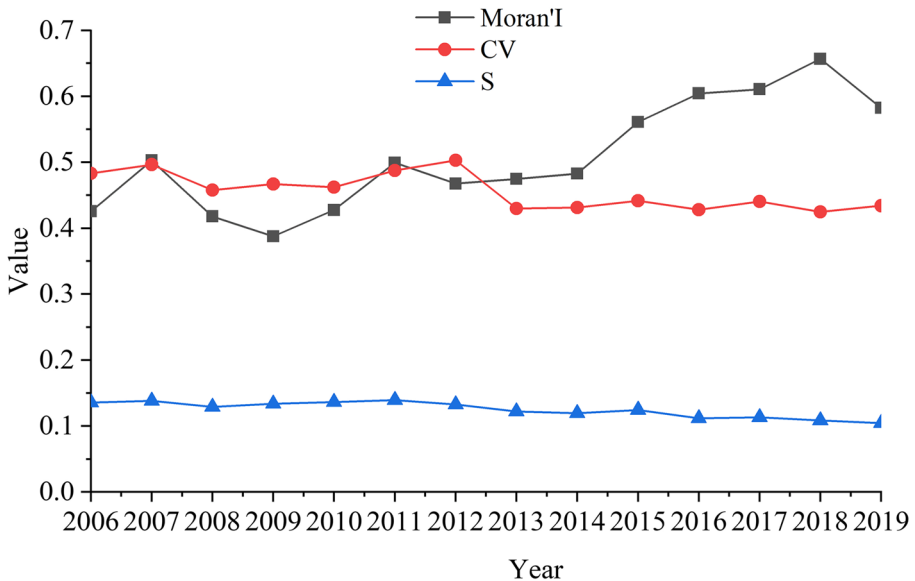
Fig. 3 Moran's I, coefficient of variation (CV) and standard deviation (S) of uncoupling coordination degree between tourism eco-efficiency and new urbanization

Fig. 4 LISA agglomeration characteristics of tourism eco-efficiency and new urbanization uncoupling coordination degree

4.2.2 Spatial and temporal evolution characteristics of uncoupling coordination degree

The time series change characteristics of the uncoupling coordination degree between TEE and NU development in the YREB are shown in Fig. 3. From the standard deviation point of view, the absolute difference of regional uncoupling coordination degree gradually decreases with a small change range; from the coefficient of variation, the relative difference of regional uncoupling coordination degree fluctuates, showing a downward trend on the whole. Generally speaking, the development trend of absolute difference and relative difference indicates that the regional difference of uncoupling coordination degree between TEE and NU in YREB is getting smaller and smaller, and tends to develop in a balanced way.

Moran's I in the YREB passed the test at the significance level of 5%, showing a significant spatial positive correlation and being in a relatively concentrated state. The Moran's I of the region is between 0.38 and 0.66, showing a gradual change. On the whole, the degree of regional uncoupling coordination changes from relatively weak aggregation to relatively strong aggregation. Before 2012, the change of Moran's I was extremely unstable, and the minimum value appeared in 2009. This is because in the early years, restricted by objective conditions such as administrative system and transportation infrastructure, regional development was extremely unbalanced and spatial dependence was weak. Fortunately, since 2009, the call to upgrade the development of the YREB to a national strategy has been increasing, so the coordinated regional development has been eased. In 2013, the

development of the YREB was established as a major national strategy in the new era, which further promoted the formation of a coordinated economic belt that spanned east and west and connected north and south, and enhanced its spatial dependence. Therefore, from 2013 to 2018, Moran's I in the YREB kept climbing, reaching its peak in recent years. However, in 2019, Moran's I suddenly dropped, the spatial agglomeration effect weakened, and the spillover effect increased. This may be related to the weakening of uncoordinated development between TEE and NU in the YREB.

The local spatial variation characteristics of the uncoupling coordination degree between TEE and NU development in the YREB are shown in Fig. 4. From 2006 to 2019, the local agglomeration characteristics of the YREB mainly changed in the downstream and upstream areas, mainly involving six provinces and cities such as Jiangsu, Shanghai, Zhejiang, Anhui, Guizhou and Chongqing. Among them, Jiangsu, Shanghai and Zhejiang have been in low–low value agglomeration for a long time, and Guizhou has been in high–high value agglomeration for a long time. From 2006 to 2011, there was no obvious change in the agglomeration characteristics of the YREB. In 2015, it was observed that Chongqing entered a high–high value agglomeration state, and in 2019, Anhui Province went from high–low value to low–low value agglomeration state. This means that due to the positive influence of the regional integration construction in the Yangtze River Delta, Anhui has gradually improved its own coordination state. It shows that further strengthening regional linkage, promoting policy support, talent flow and technology diffusion will help improve the coordination between green innovation development of tourism and NU construction. This further shows that the midstream are expected to improve their development status due to the spillover effect. However, according to the agglomeration characteristics of Guizhou and Chongqing, the coordination state of the upstream is not optimistic. The uncoupling coordination degree between Guizhou and Chongqing is far higher than that of its surrounding areas, which is the shortcoming of regional coordinated development, and has an overflow trend. Although the upstream of the YREB have made great progress, there is still a big gap between the development level and the developed areas in the downstream. From the macro level, the downstream area has a low degree of external development, the allocation of resource elements needs to be optimized urgently, and the internal development is seriously unbalanced. Its NU construction has a long way to go, and it still needs to make great efforts. At the same time, the ecological status of the downstream area is very important, and the tourism advantage is obvious, which needs the support of infrastructure construction, scientific and technological innovation and development, and so on. Therefore, the contradiction between the ecological development of tourism and the construction of NU is more prominent. Faced with such a situation, the provinces and cities in the downstream areas should strengthen regional cooperation according to their own development advantages and enhance their internal vitality by taking advantage of the opportunities of the new double-circulation pattern and the high-quality construction of "the belt and road initiative".

4.3 The interactive relationship between tourism eco-efficiency and new urbanization

4.3.1 Impulse response analysis

On the basis of not changing the correlation of variables, in order to weaken the collinearity and heteroscedasticity of the model, the original data are processed by natural

Table 4 Unit root test and cointegration test

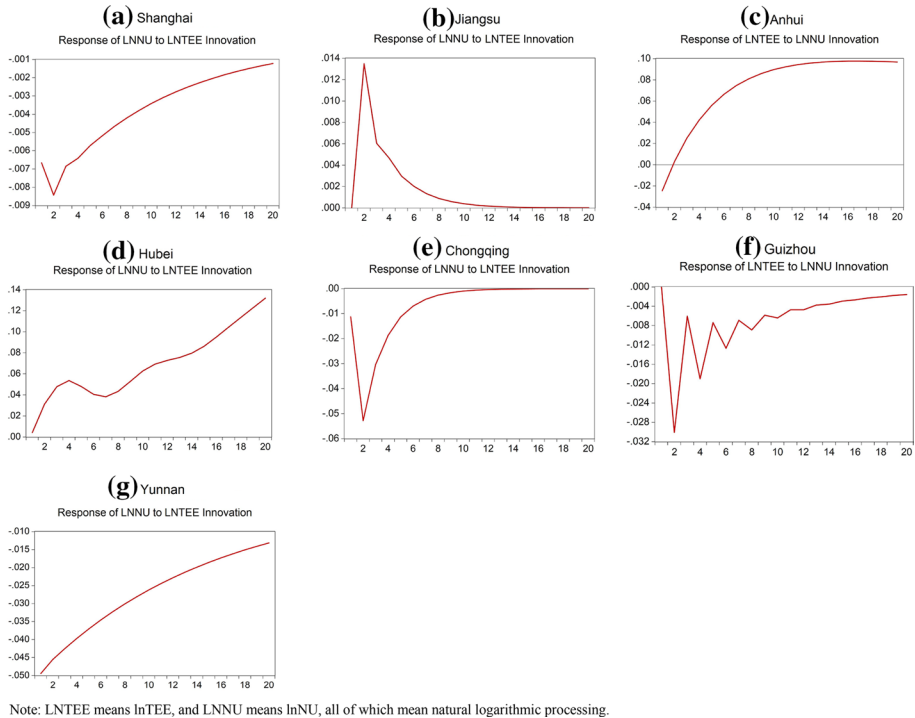| Region	Variable	Unit root test					Cointegration test	
		ADF	1%	5%	10%	*P*-value	Assumption	*P*-value
Shanghai	lnTEE	−3.957514	−5.124875	−3.933364	−3.420030	0.0484	–	–
	lnNU	−5.035368	−4.886426	−3.828975	−3.362984	0.0080	–	–
Jiangsu	D(lnTEE)	−6.279660	−4.992279	−3.875302	−3.388330	0.0018	None *	0.0375
	D(lnNU)	−5.610496	−4.992279	−3.875302	−3.388330	0.0044	At most 1 *	0.0038
Zhejiang	D(lnTEE)	−3.589570	−4.297073	−3.212696	−2.747676	0.0285	None *	0.0451
	D(lnNU)	−4.094311	−5.124875	−3.933364	−3.420030	0.0402	At most 1	0.0580
Anhui	D(lnTEE)	−5.610790	−5.124875	−3.933364	−3.420030	0.0055	None *	0.0005
	D(lnNU)	−4.698193	−5.124875	−3.933364	−3.420030	0.0176	At most 1 *	0.0082
Jiangxi	D(lnTEE)	−5.068146	−4.992279	−3.875302	−3.388330	0.0090	None *	0.0073
	D(lnNU)	−4.761467	−4.992279	−3.875302	−3.388330	0.0139	At most 1 *	0.0117
Hubei	D(lnTEE)	−4.829676	−5.295384	−4.008157	−3.460791	0.0177	None *	0.0442
	D(lnNU)	−2.120604	−2.771926	−1.974028	−1.602922	0.0375	At most 1 *	0.2306
Hunan	D(lnTEE)	−4.407998	−5.295384	−4.008157	−3.460791	0.0303	None *	0.0740
	D(lnNU)	−3.405118	−4.121990	−3.144920	−2.713751	0.0327	At most 1 *	0.3019
Chongqing	D(lnTEE)	−4.584732	−4.992279	−3.875302	−3.388330	0.0179	None *	0.0049
	D(lnNU)	−4.285818	−3.460791	−5.295384	−4.008157	0.0352	At most 1 *	0.1346
Sichuan	D(lnTEE)	−6.249186	−4.121990	−3.144920	−2.713751	0.0004	None *	0.0209
	D(lnNU)	−5.944226	−5.124875	−3.933364	−3.420030	0.0037	At most 1 *	0.1740
Guizhou	D(lnTEE)	−2.260113	−2.816740	−1.982344	−1.601144	0.0295	None *	0.0409
	D(lnNU)	−4.467316	−4.121990	−3.144920	−2.713751	0.0057	At most 1 *	0.0825
Yunnan	D(lnTEE)	−3.691723	−4.121990	−3.144920	−2.713751	0.0203	None *	0.0175
	D(lnNU)	−4.523821	−4.992279	−3.875302	−3.388330	0.0195	At most 1	0.2247

* Means a significance level below 5%

logarithm. According to the unit root test (Table 4), the original sequences of TEE and NU in Shanghai are stationary sequences, and other provinces are first-order difference stationary sequences. In order to further test whether there is a long-term stable equilibrium relationship between TEE and NU in the first-order difference stationary sequence, the cointegration test is carried out. The results (Table 4) show that there is at least one cointegration relationship in other provinces and cities except Hunan Province. Based on this, the VAR model is constructed. According to the lag order information criterion, the model obtains the optimal lag order, and then makes Granger causality test. The results (Table 5) show that, at 5% significance level, NU in Anhui and Guizhou is the one-way Granger cause of TEE; TEE in Shanghai, Jiangsu, Hubei, Chongqing and Yunnan is the one-way Granger reason of NU; there is no Granger causality between TEE and NU in Zhejiang, Jiangxi and

Table 5 Granger causality test

Dependent variable		Shanghai	Jiangsu	Anhui	Hubei	Chongqing	Guizhou	Yunnan	Shanghai	Jiangsu	Anhui	Hubei
lnTEE	Chi-sq	2.017568	0.389541	5.886459	7.548221	4.513843	0.604438	–	0.009830	3.762262	28.11075	2.337186
	P-value	0.1555	0.5325	0.2365	0.0060	0.1044	0.7392	–	0.9210	0.1524	0.0000	0.1263
lnNU	Chi-sq	7.926603	5.807693	130.1283	0.013984	1.917872	11.34282	–	7.792030	3.445567	0.055105	4.079401
	P-value	0.0049	0.0160	0.8832	0.9059	0.3833	0.0034	–	0.0052	0.1786	0.8144	0.0434

(a) Shanghai — Response of LNNU to LNTEE Innovation

(b) Jiangsu — Response of LNNU to LNTEE Innovation

(c) Anhui — Response of LNTEE to LNNU Innovation

(d) Hubei — Response of LNNU to LNTEE Innovation

(e) Chongqing — Response of LNNU to LNTEE Innovation

(f) Guizhou — Response of LNTEE to LNNU Innovation

(g) Yunnan — Response of LNNU to LNTEE Innovation

Note: LNTEE means lnTEE, and LNNU means lnNU, all of which mean natural logarithmic processing.

Fig. 5 Impulse response of tourism eco-efficiency and new urbanization

Sichuan provinces, which shows that the growth of TEE and the development of NU in these provinces and cities do not disturb each other. In order to describe the dynamic relationship between TEE and NU in the provinces and cities of the YREB, this paper selects the impulse response model with 20 lag periods (in years) for further analysis.

The results show (Fig. 5) that when TEE is given a positive impact, NU in Shanghai, Chongqing and Yunnan will have a negative impact effect; Jiangsu and Hubei NU will have a positive impact effect. Given a positive impact of NU, in the long run, TEE in Anhui will have a positive impact effect, while TEE in Guizhou will have a negative impact effect. This is basically consistent with the uncoupling coordination between TEE and NU in the YREB. For Shanghai (Fig. 5a), the response value of NU to the disturbance from TEE was −0.0067 in the first year, and reached the peak value of −0.0084 in the second year. After that, the impact effect gradually tended to be gentle with time. Generally speaking, the response period of LNNU in Shanghai is long, but the response value is relatively small, which shows that the impact of TEE promotion in Shanghai on the development of NU is minimal. For Jiangsu (Fig. 5b), the promotion of TEE will promote the development of NU, lasting for 16 years, and can reach the maximum impact of 0.0135 in the second year. From the eastern region, the influence relationship between regional TEE and NU is positive or not significant. Therefore, the downstream of the YREB has been in a low-level or low-concentration uncoordinated state. However, Anhui, which is located in the long delta region with Jiangsu, Shanghai and Zhejiang, is gradually getting better because of the positive influence of NU on TEE. For Anhui (Fig. 5c), the improvement of NU development level will bring a short-term negative

impact on TEE in the first year, and then turn into a continuous positive impact after the third year, with the highest impact effect of 0.097. In addition, for Hubei (Fig. 5d), from the whole impulse response, TEE promotion has a long-term positive impact on the development of NU in Hubei, and the impact has steadily increased since the 7th year. Therefore, the coupling relationship in the midstream has turned for the better. For Chongqing (Fig. 5e), the disturbance of TEE has a negative impact on NU for 12 years, and it can reach the peak value of −0.053 in the second year. For Yunnan (Fig. 5g), the promotion of TEE has a long-term significant negative impact on the development of NU, and it can reach the maximum impact effect of −0.0494 in the first year. For Guizhou (Fig. 5f), NU also has a long-term significant negative impact on TEE. The response time of negative impact effect appears in the second year, and it can reach the maximum impact response of −0.0301. Therefore, the uncoupling coordination degree between TEE and NU in the upstream of the YREB is high, and the high–high value agglomeration is obvious.

4.3.2 Variance decomposition analysis

In order to further explore the contribution degree of each other, this paper makes variance decomposition analysis on the basis of impulse response, and the results are shown in Table 6. From the variance decomposition of TEE, the contribution rate of NU development to TEE in Anhui and Guizhou provinces is about 65% and 57%, respectively, which is obviously greater than the contribution rate to NU itself, indicating the importance of NU development to TEE. Combined with impulse response analysis, it shows that the negative impact of NU on TEE in Anhui Province is not high in the short term (1–2 years), and in the long term, NU can effectively promote the promotion of TEE.

From the variance decomposition of NU, the contribution rate of TEE to the development of NU in Shanghai and Jiangsu is similar, which is stable at about 26% and 24%, respectively, but the contribution rate of Jiangsu Province is growing faster. From the numerical point of view, TEE's contribution is small, indicating that there are factors with higher contribution to the development of NU in Shanghai and Jiangsu. That is to say, although the promotion of TEE in Shanghai has a certain negative impact on the development of NU, it is not the most important factor. Similarly, the development of NU in Jiangsu Province has more important driving factors. The reason may be that Shanghai and Jiangsu are located in the eastern coastal areas, and they have obvious advantages in many aspects, such as location, traffic conditions, economic development level, technological innovation ability and industrial support. It is difficult for TEE to dominate the development of its NU. The contribution rate of TEE in Hubei Province is about 51%. The contribution rate of TEE to the development of NU is greater than its own, which indicates that the promotion of TEE can significantly and effectively promote the development of NU in Hubei Province. TEE in Chongqing and Yunnan, the two upstream provinces and cities, contributed about 66% and 58% to the development of NU. On the whole, TEE's contribution rate to NU's development is obviously greater than its own, which indicates that the promotion of TEE will greatly restrain NU's development in Chongqing and Yunnan.

Table 6 Variance decomposition of variables

Lag period	Shanghai		Jiangsu		Anhui		Hubei		Chongqing		Guizhou		Yunnan	
	lnNU		lnNU		lnTEE		lnNU		lnNU		lnTEE		lnNU	
	lnTEE	lnNU	lnTEE	lnNU	lnTEE	lnNU	lnTEE	lnNU	lnTEE	lnNU	lnTEE	lnNU	lnTEE	lnNU
1	4.448	95.552	0	100	90.472	9.528	1.579	98.421	5.442	94.558	100	0	19.382	80.618
2	10.473	89.527	18.720	81.280	94.662	5.338	36.786	63.214	56.927	43.073	54.161	45.839	30.443	69.557
3	13.802	86.198	21.423	78.577	92.617	7.383	52.551	47.449	63.502	36.498	56.666	43.334	37.316	62.684
4	16.682	83.318	23.034	76.966	86.792	13.208	58.462	41.538	65.473	34.527	49.837	50.163	42.072	57.928
5	18.769	81.231	23.655	76.345	79.585	20.415	58.032	41.968	66.151	33.849	49.487	50.513	45.517	54.483
10	24.010	75.900	24.151	75.849	52.066	47.934	52.135	47.865	66.536	33.464	44.047	55.953	53.980	46.020
15	25.804	74.196	24.159	75.841	40.157	59.843	51.638	48.362	66.539	33.461	42.941	57.059	57.018	42.982
20	26.389	73.611	24.159	75.841	34.549	65.451	51.481	48.519	66.539	33.461	42.645	57.355	58.334	41.666

5 Discussion

Due to the increasingly prominent ecological and environmental problems, sustainable development has become the proposition of the times, and has attracted wide attention from all walks of life. Exploring the relationship between TEE and the development level of NU is conducive to the coordinated development of tourism and urbanization under the background of sustainable development goals. This paper breaks through the limitation of simple evaluation and comparison in the current study of coupling relationship. Based on the perspective of uncoupling coordination, this paper evaluates the coordination relationship between tourism sustainable development and NU development and the influence mechanism between the two systems by combining uncoupling coordination degree model and VAR model.

The results show that Shanghai, Jiangsu and Zhejiang are the regions with low degree of uncoupling coordination in the YREB, all of which are the downstream of the Yangtze River. Among them, Shanghai and Jiangsu are developing steadily, and they are always in a low-level uncoupling coordination stage, which shows that there is a good coordination between the sustainable development of tourism and the development of NU. This is inseparable from the stability and high quality of TEE and NU's own development in Shanghai and Jiangsu. Besides, it also benefits from the regional integration of the Yangtze River Delta and the influence of the development planning of the Yangtze River Delta urban agglomeration. Anhui, which is located in the midstream of the YREB, has gradually entered a significant low–low agglomeration state and Jiangxi's disharmony has gradually weakened, which further confirms the significant spatial spillover effect and leading role of regional development in the Yangtze River Delta. In addition, the areas with high uncoupling coordination degree in the YREB are the upstream, especially Sichuan and Yunnan, because the ecological effect of tourism in Sichuan and the level of modernization in Yunnan are at a low level. Although the state is committed to the western development and the development of Chengdu-Chongqing twin-city economic circle, there are many development restrictions in the upstream of the Yangtze River, especially the low level of economic development, imperfect infrastructure and extremely unbalanced regional development, so the coordinated development of tourism and NU is still difficult to achieve a high level. From the overall development trend of the YREB, the regional difference of uncoupling coordination between the two systems is getting smaller and smaller, and it tends to develop in a balanced way, which is basically consistent with the development trend of regional TEE and NU. Therefore, no matter from which perspective, the coordinated development between TEE and NU needs self-improvement. As the construction of TEE and NU in the YREB is mainly restricted by the middle and upper reaches, and the restricted factors are mainly topography, traffic, ecological environment, infrastructure, etc., it is necessary to start from policies, funds and technology, and give priority to focus on the development of those places with obvious location advantages, strong resource and environmental carrying capacity and (tourism) resource advantages that are particularly outstanding, especially small and medium-sized cities and towns.

In addition, from the macro-level, the improvement of regional coordinated development level should be based on downstream areas, with upstream areas as an important breakthrough point. It should take advantage of the superimposed effect of the policy dividends of the western development, the development strategy of the YREB, the regional integration of the Yangtze River Delta and the construction of the twin-city economic circle in the Chengdu-Chongqing area, further strengthen the regional linkage by relying on

the advantages of the golden waterway conditions and expand the overall level of opening to the outside world of the YREB. Especially in the upstream of the Yangtze River, attention should be paid to the high-value agglomeration status of Chongqing and Guizhou, and also to the control and linking role of the two cities of Chengdu and Chongqing to strengthen regional cooperation and collaboration among various government departments. At the same time, it is necessary to guard the ecological base and ensure the development confidence.

From the current research results, the uncoupling coordination relationship between regional TEE and NU development and the interaction between the two systems are also closely related. Because the influence relationship between TEE and NU is positive or insignificant, the downstream area has been in a low-level or low-value agglomeration uncoordinated coupling state. Similar to the eastern region, the coupling and coordination relationship in the central region has turned for the better. However, the upstream area is mainly affected by negative impact, which makes the uncoupling coordination degree high and the high–high value agglomeration obvious. Therefore, the interactive influence relationship between TEE and NU should be fully understood. As far as the YREB is concerned, facing the negative impact of TEE promotion on the development of NU, Shanghai, Chongqing and Yunnan should improve the scientific management level of tourism resources, pay attention to the cultivation of tourism talents and the investment and application of green technology, improve the utilization efficiency of tourism resources, avoid excessive resource consumption, and make tourism pursue economic and ecological balance while reducing the impact on regional social and economic development. At the same time, it is necessary to give full play to the role of TEE promotion in promoting the development of NU in Jiangsu and Hubei, strengthen environmental protection in the process of tourism development and make rational use of tourism resources endowment for tourism development. Facing the impact of NU development on TEE, Anhui should strengthen urbanization, improve infrastructure, expand tourism investment scale and improve service quality. As far as Guizhou is concerned, it should pay attention to talent cultivation and technological innovation, improve resource utilization rate, strengthen pollution control, expand urban construction land in an orderly manner, avoid over-exploitation and commercialization of scenic spots and pay attention to the protection of tourism resources and ecological environment in the process of tourism development. In addition, when formulating and implementing enhancement strategies for the coordinated development of TEE and NU in the YREB, it is important to focus not only on the direction of development, but also on the dynamic influence patterns between the two systems, and to set reasonable targets and plans. For example, in Chongqing, facing the disturbance of TEE, NU should take immediate measures, because it will be most affected in the second year after the disturbance. The further impact contribution also implies that these improvements are effective for the coordinated development between TEE and NU in most areas.

6 Conclusion

Taking the YREB as the research area, this paper estimates the TEE and NU levels of each province from 2006 to 2019, and measures the uncoupling coordination degree between the two systems. This paper mainly analyzes the space–time evolution characteristics of the uncoupling coordination between regional NU and TEE and the dynamic law of interaction

and then discusses how to promote the coordinated development between the two systems. The main conclusions are as follows:

(1) The overall TEE of YREB shows an upward trend, as the upstream area is located in western China, where tourism resources are extremely rich and under-explored, the difference between east and west is gradually decreasing under the trend of western development. The overall regional characteristics are as follows: downstream > upstream > midstream. Among them, TEE in Shanghai, Jiangsu and Guizhou are in the forefront, with efficiency values greater than 1, while those in Sichuan, Hubei and Hunan are relatively backward.

(2) The overall development quality of NU in the YREB is relatively stable, but it varies significantly from east to west due to topography, transportation, resources, climate, infrastructure and other factors. The regional characteristics generally show a decreasing trend from the downstream to the upstream. Among them, NU in Shanghai, Jiangsu and Zhejiang are in the forefront, while Guizhou and Yunnan are relatively backward.

(3) The regional difference of uncoupling coordination degree between TEE and NU in the YREB is getting smaller and smaller, and it tends to develop in a balanced way, which accords with the strategic goal of coordinated development and is basically consistent with the overall development trend of TEE and NU in the region. The main reason is that China vigorously promotes the development of the YREB, involving the overlapping policy dividends from several of the Western Development, the Yangtze River Economic Belt Development Strategy, the regional integration of the Yangtze River Delta and the construction of the twin-city economic circle in the Chengdu-Chongqing region, while adhering to the strategic positioning of ecological priority and green development and developing tourism as one of the strategic initiatives for regional development. Among them, the regions with lower uncoupling coordination are Shanghai, Jiangsu and Zhejiang, and the higher regions are Sichuan and Yunnan. At present, Shanghai, Jiangsu and Anhui are at a low level of uncoordinated development, while other regions are at an antagonistic uncoordinated development stage.

(4) The uncoupling coordination degree of the YREB has changed from relatively weak aggregation to relatively strong aggregation. Among them, Jiangsu, Shanghai and Zhejiang have been in low–low value agglomeration for a long time, and Guizhou has been in high–high value agglomeration for a long time.

(5) From the long-term dynamic impact, the TEE has a negative impact on the development of NU in Shanghai, Chongqing and Yunnan, and a positive impact on Jiangsu and Hubei, with the contribution rates of 26%, 66%, 58%, 24% and 51%, respectively. NU has a positive impact on TEE in Anhui and a negative impact on Guizhou, with the contribution rates of 65% and 57%, respectively. The uncoupling coordination relationship between regional TEE and NU development and the interaction between the two systems are closely related.

The results of this study are conducive to the coordinated development between tourism and NU under the goal of sustainable development, and can provide an important reference for regional ecological construction and sustainable development. This paper breaks through the limitations of simple measurement and comparative analysis in the past, and similar methods and ideas can also be applied to research in other regions or fields, aiming at systematically grasping the future development direction and providing scientific basis for formulating policies and work plans. Finally, the research of this paper needs to be

improved. Considering the integrity of the data, this paper takes the provincial administrative region as the research scale, which can be deepened in the future and consider the city scale. In addition, according to the progress of related research, the selection of indicators can be further improved in the future.

Author Contributions All authors contributed to the study conception and design. XY contributed to conceptualization, methodology, formal analysis, writing—original draft, and writing—review and editing. FZ contributed to conceptualization, data curation, writing—original draft, and writing—review and editing. YX, CJ, HT, and GG performed writing—review and editing. YA performed conceptualization and writing—review and editing.

Availability of data and materials The datasets generated during the current study are available from the author on reasonable request.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

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References

Adedoyin, F. F., & Bekun, F. V. (2020). Modelling the interaction between tourism, energy consumption, pollutant emissions and urbanization: renewed evidence from panel VAR. *Environmental Science and Pollution Research, 27*(31), 38881–38900. https://doi.org/10.1007/s11356-020-09869-9

Aguilera, M. A., Tapia, J., Gallardo, C., Núñez, P., & Varas-Belemmi, K. (2020). Loss of coastal ecosystem spatial connectivity and services by urbanization: Natural-to-urban integration for bay management. *Journal of Environmental Management, 276*, 111297. https://doi.org/10.1016/j.jenvman.2020.111297

Bai, Y., Deng, X., Jiang, S., Zhang, Q., & Wang, Z. (2018). Exploring the relationship between urbanization and urban eco-efficiency: Evidence from prefecture-level cities in China. *Journal of Cleaner Production, 195*, 1487–1496. https://doi.org/10.1016/j.jclepro.2017.11.115

Burak, S., Dogˇan, E., & Gaziogˇlu, C. (2004). Impact of urbanization and tourism on coastal environment. *Ocean & Coastal Management, 47*(9–10), 515–527. https://doi.org/10.1016/j.ocecoaman.2004.07.007

Cai, J., Li, X., Liu, L., Chen, Y., Wang, X., & Lu, S. (2021). Coupling and coordinated development of new urbanization and agro-ecological environment in China. *Science of The Total Environment, 776*, 145837. https://doi.org/10.1016/j.scitotenv.2021.145837

Chen, M., Liu, W., Lu, D., Chen, H., & Ye, C. (2018). Progress of China's new-type urbanization construction since 2014: A preliminary assessment. *Cities, 78*, 180–193. https://doi.org/10.1016/j.cities.2018.02.012

Chu, Y., Huang, X., & Jin, T. (2021). Political relations and tourism: evidence from China. *Applied Economics, 53*(45), 5281–5302. https://doi.org/10.1080/00036846.2021.1922591

Cui, X., Fang, C., Liu, H., & Liu, X. (2019). Assessing sustainability of urbanization by a coordinated development index for an urbanization-resources-environment complex system: A case study of Jing-Jin-Ji region, China. *Ecological Indicators, 96*, 383–391. https://doi.org/10.1016/j.ecolind.2018.09.009

Fan, W., Wang, H., Liu, Y., & Liu, H. (2020). Spatio-temporal variation of the coupling relationship between urbanization and air quality: A case study of Shandong Province. *Journal of Cleaner Production, 272*. https://doi.org/10.1016/j.jclepro.2020.122812

Fang, C., Liu, H., & Wang, S. (2021a). The coupling curve between urbanization and the eco-environment: China's urban agglomeration as a case study. *Ecological Indicators, 130*. https://doi.org/10.1016/j.ecolind.2021a.108107

Fang, X., Shi, X., Phillips, T. K., Du, P., & Gao, W. (2021b). The coupling coordinated development of urban environment towards sustainable urbanization: An empirical study of Shandong Peninsula, China. *Ecological Indicators, 129*. https://doi.org/10.1016/j.ecolind.2021b.107864

Ge, Q., & Xi, J. C. (2015). Strategic choices of regional tourism under the new normal of China's economic growth. *Progress in Geography, 34*(7), 793–799. https://doi.org/10.18306/dlkxjz.2015.07.001

Gössling, S., Peeters, P., Ceron, J.-P., Dubois, G., Patterson, T., & Richardson, R. B. (2005). The eco-efficiency of tourism. *Ecological Economics, 54*(4), 417–434. https://doi.org/10.1016/j.ecolecon.2004.10.006

Lanzara, G., & Minerva, G. A. (2019). Tourism, amenities, and welfare in an urban setting. *Journal of Regional Science, 59*(3), 452–479. https://doi.org/10.2139/ssrn.3198062

Lee, Y.-C., & Liao, P.-T. (2021). The effect of tourism on teleconnected ecosystem services and urban sustainability: An emergy approach. *Ecol Modell, 439*. https://doi.org/10.1016/j.ecolmodel.2020.109343

Li, L., Yang, Q., Sun, C., Xie, X., Zhang, F., & Teodoro, A. C. (2021a). Coupling coordinated evolution and forecast of tourism-urbanization-ecological environment: The Case Study of Chongqing, China. *Mathematical Problems in Engineering, 2021a*, 1–15. https://doi.org/10.1155/2021/7271637

Li, Q., Zhao, Y., Li, S., & Zhang, L. (2021b). Spatial-temporal characteristics of the coupling coordination of social security and economic development in China during 2002–2018. *Regional Sustainability, 2*(2), 116–129. https://doi.org/10.1016/j.regsus.2021b.04.001

Li, W., Wang, Y., Xie, S., & Cheng, X. (2021c). Coupling coordination analysis and spatiotemporal heterogeneity between urbanization and ecosystem health in Chongqing municipality, China. *Sci Total Environ, 791*, 148311. https://doi.org/10.1016/j.scitotenv.2021c.148311

Liang, L., Wang, Z., & Li, J. (2019). The effect of urbanization on environmental pollution in rapidly developing urban agglomerations. *J. Clean. Prod., 237*. https://doi.org/10.1016/j.jclepro.2019.117649

Lin, B., & Zhu, J. (2021). Impact of China's new-type urbanization on energy intensity: A city-level analysis. *Energy Economics, 99*. https://doi.org/10.1016/j.eneco.2021.105292

Liu, S., Geng, Y., Zhang, J., Kang, X., Shi, X., & Zhang, J. (2021). Ecological trap in tourism-urbanization: Simulating the stagnation and restoration of urbanization from the perspective of government incentives. *Ecological Indicators 185*. https://doi.org/10.1016/j.ecolecon.2021.107054

Luo, J., Qiu, H., Goh, C., & Wang, D. (2015a). An analysis of tourism development in China from urbanization perspective. *Journal of Quality Assurance in Hospitality & Tourism, 17*(1), 24–44. https://doi.org/10.1080/1528008x.2015a.1016594

Luo, J. M., Qiu, H., & Lam, C. F. (2015b). Urbanization impacts on regional tourism development: a case study in China. *Current Issues in Tourism*. https://doi.org/10.1080/13683500.2015b.1033385

Mullins, P. (1991). Tourism urbanization. *International Journal of Urban Regional Research, 15*(3), 326–342. https://doi.org/10.1111/j.1468-2427.1991.tb00642.x

Paper. (2020). Front line research | rural land system reform in the process of urbanization in the upper reaches of the Yangtze River Economic Belt - Based on the comprehensive pilot of new urbanization in 32 countries. Retrieved from https://www.thepaper.cn/newsDetail_forward_7978593

Peng, H., Zhang, J., Lu, L., Tang, G., Yan, B., Xiao, X., & Han, Y. (2017). Eco-efficiency and its determinants at a tourism destination: A case study of Huangshan National Park, China. *Tour Management, 60*, 201–211. https://doi.org/10.1016/j.tourman.2016.12.005

Qi, Y., Stern, N., He, J. K., Lu, J. Q., & Wu, T. (2020). The policy-driven peak and reduction of China's carbon emissions. *Advances in Climate Change Research, 11*(2). https://doi.org/10.1016/j.accre.2020.05.008

Qin, M., Sun, M., & Li, J. (2021). Impact of environmental regulation policy on ecological efficiency in four major urban agglomerations in eastern China. *Ecological India, 130*. https://doi.org/10.1016/j.ecolind.2021.108002

Satrovic, E., & Muslija, A. (2019). The empirical evidence on tourism-urbanization-Co2 Emissions Nexus. *Advances in Hospitality and Tourism Research (AHTR)*. https://doi.org/10.30519/ahtr.484287

Shen, W., Huang, Z., Yin, S., & Hsu, W.-L. (2022). Temporal and spatial coupling characteristics of tourism and urbanization with mechanism of high-quality development in the Yangtze River Delta Urban Agglomeration, China. *Applied Sciences, 12*(7). https://doi.org/10.3390/app12073403

Sun, W., & Huang, C. (2020). How does urbanization affect carbon emission efficiency? Evidence from China. *Journal of Cleaner Production, 272*. https://doi.org/10.1016/j.jclepro.2020.122828

Sun, Y. Y., & Pratt, S. (2014). The economic, carbon emission, and water impacts of Chinese Visitors to Taiwan: Eco-efficiency and impact evaluation. *The Journal of Travel Research, 53*(6), 733–746. https://doi.org/10.1177/0047287513517420

Tone, K. (2002). A slacks-based measure of super-efficiency in data envelopment analysis. *European Journal of Operational Research, 143*(1), 32–41. https://doi.org/10.1016/S0377-2217(01)00324-1

Wang, S., Han, L., & Xie, S. (2022). Spatial distribution features and influencing factors of the ecotourism demonstration areas in the Yangtze River Economic Belt. *Ecological Science, 41*(2), 75–83.

Wang, Z., Sun, Y., & Wang, B. (2019). How does the new-type urbanisation affect CO_2 emissions in China? An empirical analysis from the perspective of technological progress. *Energy Economics, 80*(MAY), 917–927. https://doi.org/10.1016/j.eneco.2019.02.017

Wu, Y., Cui, Z., & Hu, C. (2021). Does the new urbanization influence air quality in China? *Frontiers in Environmental Science, 9*. https://doi.org/10.3389/fenvs.2021.645010

Xie, X., Sun, H., Gao, J., Chen, F., & Zhou, C. (2021). Spatiotemporal differentiation of coupling and coordination relationship of tourism–urbanization–ecological environment system in China's Major Tourist Cities. *Sustainability, 13*(11). https://doi.org/10.3390/su13115867

Xinhua News Agency (2020). The number of domestic tourists in China exceeded 6billion in 2019. Retrieved from http://www.gov.cn/xinwen/2020-03/10/content_5489697.htm

Xiong, X., & Xu, Z. (2018). Research on the measurement of the level and dynamic factors of China's new urbanization Research on quantitative economy and technical economy. *2*, 44–63. https://doi.org/10.13653/j.cnki.jqte.20180203.002

Yang, L., & Sun, Z. (2015). Evaluation of the development level of new urbanization in Western China based on entropy method. *Economic Problems 3*, 115–119. https://doi.org/10.16011/j.cnki.jjwt.2015.03.023

Yangtze River Economic Network. (2021). Yangtze River Economic Belt social development report (2019 ~ 2020). Retrieved from https://cjjjd.ndrc.gov.cn/zhongshuochangjiang/xsyj/202101/t20210122_1265736.htm

Yao, J., Xu, P., & Huang, Z. (2021). Impact of urbanization on ecological efficiency in China: An empirical analysis based on provincial panel data. *Ecol Indi, 129*, 107827. https://doi.org/10.1016/j.ecolind.2021.107827

Yi, L., Chen, J., Jin, Z., Quan, Y., Han, P., Guan, S., & Jiang, X. (2018). Impacts of human activities on coastal ecological environment during the rapid urbanization process in Shenzhen, China. *Ocean & Coastal Management, 154*, 121–132. https://doi.org/10.1016/j.ocecoaman.2018.01.005

Yu. (2021). Ecological effects of new-type urbanization in China. *Renewable and Sustainable Energy Reviews, 135*, 110239.

Yuan, M., Yin, C., Sun, Y., & Chen, W. (2019). Examining the associations between urban built environment and noise pollution in high-density high-rise urban areas: A case study in Wuhan, China. *Sustainable Cities and Society, 50*, 101678. https://doi.org/10.1016/j.scs.2019.101678

Zeng, J., Wen, Y., Bi, C., & Feiock, R. (2021). Effect of tourism development on urban air pollution in China: The moderating role of tourism infrastructure. *Journal of Cleaner Production, 280*. https://doi.org/10.1016/j.jclepro.2020.124397

Zha, J., He, L., Liu, Y., & Shao, Y. (2019). Evaluation on development efficiency of low-carbon tourism economy: A case study of Hubei Province, China. *Socio-Economic Planning Sciences, 66*, 47–57. https://doi.org/10.1016/j.seps.2018.07.003

Zha, J., Yuan, W., Dai, J., Tan, T., & He, L. (2020). Eco-efficiency, eco-productivity and tourism growth in China: a non-convex metafrontier DEA-based decomposition model. *Journal of Sustainable Tourism, 28*(5), 663–685. https://doi.org/10.1080/09669582.2019.1699102

Zhang, T., & Li, L. (2020). Research on temporal and spatial variations in the degree of coupling coordination of tourism–urbanization–ecological environment: a case study of Heilongjiang, China. *Environment, Development and Sustainability, 23*(6), 8474–8491. https://doi.org/10.1007/s10668-020-00976-8

Zhang, W., & Xu, H. (2017). Effects of land urbanization and land finance on carbon emissions: A panel data analysis for Chinese provinces. *Land Use Policy, 63*, 493–500. https://doi.org/10.1016/j.landusepol.2017.02.006

Zhang, J., & Zhang, Y. (2020). Assessing the low-carbon tourism in the tourism-based urban destinations. *Journal of Cleaner Production, 276*. https://doi.org/10.1016/j.jclepro.2020.124303

Zhang, S., Li, Z., Ning, X., & Li, L. (2021). Gauging the impacts of urbanization on CO2 emissions from the construction industry: Evidence from China. *Journal of Environmental Management, 288*, 112440. https://doi.org/10.1016/j.jenvman.2021.112440

Zhang, J. (2017). Evaluating regional low-carbon tourism strategies using the fuzzy Delphi-analytic network process approach. *Journal of Cleaner Production, 141*, 409–419. https://doi.org/10.1016/j.jclepro.2016.09.122

Zhao, L., & Dong, Y. (2017). Tourism agglomeration and urbanization: empirical evidence from China. *Asia Pacific Journal of Tourism Research, 22*(5), 512–523. https://doi.org/10.1080/10941665.2016.1277545

Zhou, C., Wang, S., & Wang, J. (2019). Examining the influences of urbanization on carbon dioxide emissions in the Yangtze River Delta, China: Kuznets curve relationship. *Science of the Total Environment, 675*, 472–482. https://doi.org/10.1016/j.scitotenv.2019.04.269

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