Study on the coupling and coordination degree between urban tourism development and habitat environment in the Yangtze River Delta in China

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Abstract
By constructing the two evaluation systems of urban tourism development (TD) and habitat environment (HE), the dynamic response relationship between the two systems in the Yangtze River Delta urban agglomeration from 2001 to 2020 is explored by using panel vector autoregression (PVAR) model and coupled coordination degree model. The study unearthed four intriguing findings: (1) the level of TD in the study area has been continuously rising from 2001 to 2020, with an initial slow growth rate and then fast. The level of HE is increasing steadily at an average annual rate of 7.05%. There exists a reciprocal response relationship between the two systems, with a strong shock effect in the short term and a synergistic evolution in the long term. (2) The coupling degree between the urban TD and HE has an increasing trend, and the coupling coordination degree of the two systems has an average annual rate of 4.165%, implying the interaction and promotion effect between the two systems is improving. (3) Most of the cities in the Yangtze River Delta gradually realize the evolution from dysfunctional type to coordinated type, but the overall coordination intensity is low. (4) The barrier degrees of TD system indicators show a small annual increasing trend, while the barrier degrees of HE system indicators show a substantial and continuous decreasing trend. In terms of the barrier degree factors, some important factors that restrict the coupled and coordinated development of the two systems are also reported. This research can provide a useful reference for the synergistic improvement of urban tourism economy and habitat environment.

Keywords Urban habitat · Tourism industry · Coupling and coordination degree · Yangtze River Delta urban agglomeration
Introduction

The urban habitat environment is an important place for urban residents to live, work, and improve their lives (Li et al. 2017; Chen 2022), and it is also the carrier of the regional tourist system and the core area of tourism development (Edwards et al. 2008; Dai et al. 2019). The continuous improvement of urban habitat quality is increasingly becoming an important part of enhancing the attractiveness and competitiveness of tourist destinations (Wang et al. 2020). However, with rapid urbanization and over-industrialization, the urban habitat environment has seen many problems such as single production function, disorganized urban management, fractured cultural genes, fragmented living environment, and fragile ecosystem (Wu et al. 2014; Xiang and Hu 2018; Niu et al. 2022). Tourism, as an important engine for regional economic and social development, relies heavily on the local economy, society, and ecological environment (Yang et al. 2022). In the context of promoting the construction of ecological civilization, the improvement of urban habitat environment has become an important means to create a livable, workable, and tourable city quality. Therefore, achieving coordination between the two systems of the tourism industry and habitat environment is important for the sustainable development of tourism as well as society, and this relies on a systematic analysis of the relationship between the two systems, their dynamic interaction effects, the degree of coupling and coordination, and potential barrier factors.

With the rapid development of industrialization and urbanization, urban habitat environment has improved significantly, but it has also suffered unprecedented damage and challenges, which has drawn the attention of scholars from different fields and disciplines. Related studies mainly involved the connotation of the human habitat (Andrews 2001; Shekhar et al. 2019), the evaluation of urban habitat quality (Yuliastuti and Saraswati, 2014; Li et al. 2014; Kang et al. 2021), the relationship between urban habitat and resident health (Mills et al. 2017; Zhang et al. 2021), and the influencing factors of urban habitat (Wang et al. 2017, 2021a; Xie et al. 2022), which provides a reasonable reference for the analysis of human habitat in tourist places. Some researchers focus on the changes in habitat in tourist places. For example, Yan et al. (2019) applied the stress theory to explore the evolution process and mechanism of habitat change in rural tourist areas, while others are more concerned with coupling characteristics of tourism development with particular aspects of urban habitat. For example, Wang et al. (2019) empirically investigated the coupling coordination between the tourism industry and low-carbon cities using the coupling coordination degree model. Liu et al. (2019) analyzed the spatio-temporal coupling characteristics between the tourism industry, urbanization, and ecological environment in cities of Shaanxi Province from 2000 to 2017. Deng et al. (2020) built a comprehensive evaluation subsystem of tourism, transportation, and low-carbon city and analyzed their coupling coordination trend in Chongqing city. Huang et al. (2021) explored the interactive relationship between tourism development and intensive land use in major tourist cities in China. All of these studies indicate that the level of the habitat environment will directly affect the local tourism environment quality, tourism image, tourism attractiveness, etc.

Tourism is one of the strategic pillar industries, and its development has a significant impact on both the natural ecology and the economic and social environment. On the one hand, the development of the tourism industry can provide a solid economic and material basis for the improvement of urban habitat environment, which is conducive to urban infrastructure construction, ecological environmental protection, harmonious development of people and society, and the improvement of transportation facilities. On the other hand, excessive and unrestricted tourism development can also bring local problems of traffic congestion, environmental pollution, and cultural shock, which may result in a negative impact on the carrying capacity of the urban habitat environment and disrupt the local socio-economic functioning (Filimonau et al. 2014; Peterson 2020; Butler and Dodds 2022). Figueroa and Rotaru (2016) noted uncontrolled tourism development had brought negative environmental impacts on Easter Island. Castilho et al. (2021) found tourism arrivals reduced short- and long-term eco-efficiency in 22 Latin American and Caribbean countries. Amrhein et al. (2022) confirmed that overtourism caused serious impacts on residents’ personal development, fundamental perspectives, and professional decisions. Overall, tourism is one of the key elements influencing the evolution of urban habitats, and the different stages of tourism development also affect the differences in the development level of urban habitats.

In view of the close relationship between tourism development and habitat environment, researchers have begun to explore the interaction effects between the two systems. There exist mutual influence and obvious coupling characteristics between tourism development and habitat environment, and each system layer depends on each other, promotes each other, and constrains each other (Nepal 2005; Apollo et al. 2020; Pulido-Fernández and Cárdenas-García, 2021). Xiang and Hu (2018) empirically studied the temporal coupling coordination degree between the tourism industry and habitat environment in 11 provinces of the Yangtze River Economic Belt from 2005 to 2014 and found that the two systems were highly correlated. Wu et al. (2019) analyzed the coupling relationship between tourism industry and human habitat and its barriers in 31 Chinese provinces in 2016 and found that the two systems in most Chinese
provinces were low and still in the phase of antagonistic coupling. Zhang and Li (2021) explored the spatio-temporal coupling coordination degrees of the three subsystems of tourism, urbanization, and ecological environment in prefecture-level cities in Heilongjiang Province from 2003 to 2017.

Although extensive studies have been conducted on the relationship between tourism development and urban habitat, there are still gaps to improve. First, since the regional tourism industry and urban habitat environment are open systems with high complexity, uncertainty, and dynamic coupling characteristics, few studies have deeply revealed the spatio-temporal interaction mechanism between the two systems. Second, current studies usually focus on the one-way relationship between tourism development and urban habitat and generally adopt a single or few comprehensive indicators to quantify tourism development and urban habitat, ignoring the two-way interaction and the multidimensional characteristics of the two systems. Third, studies on the coupling coordination between the two systems are concentrated at the national or provincial scale, and relatively few studies have been conducted on the coupling characteristics and barrier factors between the two systems at the city level, especially in urban agglomerations, which serves as an important carrier for tourism development and improvement of habitat quality.

As a highland of science and technology innovation with global influence and the most economically dynamic resource allocation center in China, the Yangtze River Delta urban agglomeration occupies an important strategic position in the national modernization and all-around opening pattern. However, the synergistic development of urban habitat and tourism is highly spatially heterogeneous across cities, which to some extent hinders the advancement of the integrated development process of the Yangtze River Delta region. In the context of high-quality development of tourism development and urban agglomerations, how to promote the harmony of the tourism industry and human habitat and achieve the coordinated development of both is of great significance to the sustainable development of tourism and human society. Then, the intriguing questions are whether there is a long-term and stable interactive effect between tourism development and human habitat, what is the evolutionary trend of the degree of coupling and coordination between tourism development and human habitat, and how to integrate tourism industry development with urban habitat improvement to promote the high-quality development of the Yangtze River Delta urban agglomeration. Therefore, this study takes the Yangtze River Delta urban agglomeration as an empirical research case, constructs a comprehensive evaluation system of tourism development and urban habitat and analyzes the spatio-temporal interaction effect and coordination mechanism between tourism development and urban habitat by using the PVAR model and coupled coordination degree model, which aims to provide a practical reference for related decision-making.

The rest of the study is organized as follows: the “Coordination and interaction mechanism between tourism development and urban habitat” section deals with the coordination and interaction mechanism between tourism development and urban habitat, while the “Methodology and data sources” section describes the empirical model and data used in this study. The “Results” section discusses the empirical findings, whereas we conclude the study with some policy implications in the “Conclusions and recommendations” section.

Coordination and interaction mechanism between tourism development and urban habitat

The habitat environment is an important basis and carrier for the sustainable development of urban economy, bearing and restraining the key elements of the development of tourism industry. The tourism industry is a pillar industry in the national economy, and it is an important channel for the city’s economic and social development to step into quality and efficiency, upgrading, and virtuous development (Nepal 2005; Zhang et al. 2011; Apollo et al. 2020; Pulido-Fernández and Cárdenas-García, 2021). As two independent systems, the tourism industry and urban habitat feed each other, influence each other and interact with each other, and the system of urban habitat and tourism industry realize the synergistic development of both through the coupling and mutual feedback between each element (Fig. 1).

Mechanism of the effect of the tourism industry on urban habitat

Tourism, as an important part of urban socio-economic development (Rej et al. 2022; Onifade et al. 2022; Adedoyin et al. 2021), is also an important factor driving the evolution of the human habitat. Firstly, the rapid development of the tourism industry drives the city to generate huge economies of scale and linkage effects (Akama and Kieti 2007; Ma et al. 2018; Li et al. 2020). As a labor-intensive modern service industry, the tourism industry has the characteristics of high relevance, wide coverage, high consumption potential, and strong integration, which can effectively realize the rapid spatial agglomeration of capital flow, human flow, information flow, and logistics. Secondly, the development of the tourism industry coerces the governance and optimization of the urban ecological environment. The improvement and optimization of urban ecological environment are the core element for the tourism industry to achieve competitiveness and attractiveness. Besides, the development of the tourism industry is particularly urgent for a high-quality ecological environment, which contributes to strengthening the
protection and treatment of the ecological environment and raising residents' awareness of ecological and environmental protection. Thirdly, the development of tourism industry helps to alleviate the employment and contradiction problems of urban society. Tourism not only effectively relieves the employment pressure of social labor and provides new jobs for urban development, but also effectively absorbs a large number of surplus laborers re-employment. Besides, the expansion of the tourism industry indirectly promotes the improvement of urban infrastructure and public service support facilities, enhances the protection and inheritance of traditional culture, and improves the exchange and connection between cities.

**Mechanism of the effect of urban habitat on the tourism industry**

The habitat environment is an important material carrier for human survival and life and urban tourism development. The level of development and construction quality of the habitat environment will directly affect the environmental quality of urban economic production and residents' life, and further affect the construction of urban infrastructure, the shaping of the internal and external image of the city, and the enhancement of attractiveness and competitiveness of tourism resources (Ma et al. 2015; Xiang and Hu 2018; Neuts 2020). Firstly, urban economic development provides abundant material support for tourism development. The rapid urban economic growth brings the gathering of population, capital, information, transportation, and other factors, which will radiate the rapid expansion of tourism scale, and provide a good consumption environment, sufficient source market, and sufficient human and material financial support for tourism. Secondly, habitat environment helps to promote the transformation and upgrading of tourism industry structure. The quality of human habitat environment is the core element to attract tourists and will directly affect the perception and experience of tourists. However, the development of tourism activities inevitably discharges pollution waste into the ecological environment, and the polluted habitat environment in turn will also affect the behavior and welfare of tourism economic activities. Thirdly, along with the rise of mass tourism, tourists have raised higher requirements and expectations on infrastructure, public services, and ecological environment, and the pursuit of personalized, characteristic, quality, and high-end tourism products and services has become more obvious. In the process of urban economic growth, creating a decent ecological and livable environment is conducive to the rational allocation and flow of resources elements to meet the diversified needs of tourists.

Fig. 1 Coordination and interaction framework between tourism industry and human habitat
Methodology and data sources

Panel vector autoregression (PVAR) model

Panel vector autoregression (PVAR) constructs a model with lagged values of each variable in the system as endogenous variables. It is widely used to analyze the dynamics of two systems (Cui et al. 2022). The model equation is as follows:

\[ Y_{it} = a_0 + \sum_{j=1}^{p} a_j Y_{i,t-j} + f_i + d_t + \epsilon_{it} \]  

(1)

where \( i \) and \( t \) denote the sample unit and year, respectively; \( Y_{it} \) are the endogenous column vectors of tourism development and urban habitat; \( p \) is the lag order of the model; \( a_0 \) denotes the intercept term vector; \( a_j \) denotes the coefficient matrix of the lagged variable; \( f_i \) represents the individual fixed effect vector; and \( d_t \) is the time-fixed effect vector. \( \epsilon_{it} \) is the perturbation term. There are three steps required to execute this model. First, the stationary of urban habitat and tourism development is tested using unit root tests. Second, the Pedroni co-integration test is applied to verify the co-integration relationship between the two systems and explore whether there is a long-run equilibrium between the two systems. Third, if there is a long-term equilibrium relationship between the two systems, a panel data error correction model is constructed to further test the influence intensity.

Coupling coordination degree model

The coupling degree is a classical index reflecting the degree of interaction relationship between two systems (Xing et al. 2019; Shi et al. 2020). The coupling degree model of urban tourism development and habitat environment is constructed as follows:

\[ C = m \times n / [(m + n) / 2]^2 \]  

(2)

where \( C \) is the coupling degree between urban tourism development and habitat environment, and \( a \) and \( b \) represent the system of urban tourism development and habitat environment, respectively. The higher the \( C \) value is, the better the coupling degree is. Since the coupling degree only reflects the strength of the interaction between urban tourism development and the habitat environment, it does not reflect the benefits or functions of coordinated development between the two systems. Hence, it is necessary to build a coupling coordination degree model, which can truly reflect the coordinated development status between urban tourism development and habitat environment. The specific formula is as follows:

\[ D = \sqrt{C \times T}, \quad T = am + bn \]  

(3)

where \( D \) is the coupling coordination degree of urban tourism development and habitat environment; \( T \) is the comprehensive evaluation index of urban tourism development and habitat environment; and \( \alpha \) and \( \beta \) are coefficients to be determined. Since both systems are equally important, then both \( \alpha \) and \( \beta \) are assigned and are considered 0.5. In order to reflect the coupling coordination development level of the two systems more directly, the uniform distribution function method divides the interval and grade of coupling coordination degree.

Obstacle degree model

To clarify the improvement direction and path of the coupled and coordinated development of urban tourism and habitat environment, the obstacle degree model is used to diagnose the barrier factors affecting the coordinated coupling development between the two systems. The formula is as follows (Wang et al. 2021b; Li et al. 2022):

\[ O_{ij} = \frac{(1 - X'_{ij}) \times w_{ij} \times 100}{\sum (1 - X'_{ij}) \times w_{ij}} \]  

(4)

\[ O_i = \sum O_{ij} \]  

(5)

Where \( O_{ij} \) represents the obstacle degree of the \( j \) indicator; \( X'_{ij} \) is the standardized value of the \( j \) indicator of system \( i \); and \( w_{ij} \) represents the weight of the \( j \) index of system \( i \). \( O_i \) is the obstacle degree of system \( i \).

The evaluation system of urban tourism development and habitat environment

Based on the theory of sustainable development and related researches (Liu et al. 2019; Li and Yi 2020; Sudipa et al. 2020; Bekun et al. 2021, 2022; Xie et al. 2022) and following the principles of science, comparability, and data accessibility, a three-level hierarchical index system that takes into account the target, guideline, and indicator levels is constructed (Table 1). In terms of urban habitat, 22 indicators from three major aspects of economic development environment, living environment, and social development are selected to characterize the development level of habitat. In terms of tourism development, 12 indicators from three major aspects of tourism industry scale, market scale, and industrial economy are selected to synthesize urban tourism development level.

Data source and processing

The related evaluation indicators are selected from Shanghai Statistical Yearbook and Shanghai Environmental Quality
Bulletin from 2001 to 2021, Zhejiang Statistical Yearbook and Zhejiang Environmental Quality Bulletin from 2001 to 2021, Jiangsu Statistical Yearbook and Jiangsu Environmental Quality Bulletin from 2001 to 2021, Anhui Statistical Yearbook and Anhui Environmental Quality Bulletin from 2001 to 2021, each city’s statistical yearbooks, Social Development Statistical Bulletins of each city, etc. GDP and other economic data are discounted using the GDP deflator. It is worth noting that the administrative division of Anhui Province has undergone several adjustments and changes, and for the purpose of economic and social construction, Chaohu City was divided into three in 2011 and merged into Hefei City, Maanshan City, and Wuhu City respectively. To keep the consistency of the study data, the corresponding data aggregation is adjusted according to the administrative division of Anhui Province in 2016.

Before analyzing the coupling coordination degree between the two systems, it is necessary to conduct a comprehensive evaluation of the two systems through the following steps. First is carrying out data standardization for original indicators and positive processing for the negative indicators. Second is measuring the correlation coefficients of the evaluation indexes of both urban tourism development and habitat environment by using the SPSS26.0 software. It was found that the correlation between the indicators was generally higher than 0.4, indicating it was suitable to perform principal component extraction analysis. In addition, the Kaiser–Meyer–Olkin (KMO) test for urban tourism development and habitat environment was higher than 0.8, and Bartlett’s test of sphericity was significant at a 1% level. Third, the common factors of the two systems were extracted respectively based on the common factor eigenvalues greater than 1. Then, multiply each common factor with the corresponding variance contribution and finally sum up to obtain the comprehensive evaluation score. Finally, the minimum–maximum value standardization method was adopted to map the negative comprehensive evaluation score to the 0~1 interval.

**Results**

**Temporal evolution characteristics of urban tourism development and habitat environment**

The annual average of urban tourism development and habitat environment was calculated and plotted (Fig. 2). In Fig. 2a, the development level of urban habitat in the Yangtze River Delta region showed a year-on-year upward trend and continued to increase at an average annual rate of 7.05%, with the initial overall fast growth rate and then slow. From the provincial perspective, the development level of Shanghai’s urban habitat showed an overall upward trend with an average annual increase of 5.30%, except for a small decline in 2012. The development level of urban habitat in Jiangsu Province showed a similar evolutionary trend to the average.
level of the whole region. The development level of urban
habitat in Zhejiang Province was the highest and increased at
an average annual rate of 5.82%. The development of urban
habitat in Anhui Province was the lowest, but growing at an
average annual rate of 8.99%.

This was mainly due to the large differences in regional
industrial structure, economic development level, urbaniza-
tion development process, ecological and environment
protection intensity, and regional geographical conditions.
Although Shanghai is the national economic center with a
developed economy, frequent foreign trade and economic
exchanges, a high degree of urbanization, and perfect infra-
structure, the per capita public resources are low, and the
rapid development of industry consumes a large amount
of natural resources, which has not resulted in the highest
level of urban habitat development. As a developed coastal
province in China, Zhejiang Province has formed a circu-
lar economy development model oriented to manufacturing
services, which has less consumption of natural resources,
less environmental pollution, and high urban coverage
green. The industrial structure of Jiangsu Province, which is
mainly based on heavy industry, has excessive consumption
of resources and serious environmental pollution, resulting
in poor environmental quality in cities, while Anhui Prov-
ince is located in the inland area, limited by its geographi-
cal location and transportation capacity, with a low level of
economic development, low level of urbanization, imper-
fect social security system, and caught in the trap of the
“resource curse” due to its rich mineral resources, which
results in the lowest level of urban habitat development.

It can be seen from Fig. 2b that the overall level of
urban tourism development in the whole region from 2001
to 2019 generally showed a gradual upward trend with an
average annual growth rate of 9.01%, and the growth rate
was initially slow and then fast. This was mainly due to
the increasing disposable income of urban residents and
the strong demand for tourism, which has directly driven
the rapid development of tourism. But in 2020 with the
impact of the new crown pneumonia epidemic, tourism as
cross-regional mobility of the service industry suffered an
unprecedented blow and hard hit, making the level of tour-
ism development fall significantly. In terms of the provincial
scale, the level of tourism development in Shanghai was
higher than that of the other three provinces, increasing at an
average annual rate of 7.34% from 2001 to 2019, achieving
a leapfrogging growth, especially since 2009, but also with
the largest decline of 11% from 2019 to 2020. The level of
tourism development in Jiangsu Province generally showed
a slow upward trend with an average annual rate of 8.45%,
and it was higher than the level of tourism development in
Zhejiang and Anhui provinces until 2014 and was overtaken
by Zhejiang Province after 2014.

The level of tourism development in Zhejiang Province
increased at an average annual rate of 9.25% and fluctuated
up and down around the average level of the region, while
Anhui Province had the lowest level of tourism develop-
ment and slower growth rate due to the constraints of eco-

domic development, location, and transportation. Moreover,
affected by the new crown epidemic, tourism development
levels in Jiangsu, Zhejiang, Shanghai, and Anhui had all
declined to varying degrees. In general, the development
level of tourism and regional economic development level
are closely related; economically developed areas have
strong economic strength, convenient transportation, perfect
infrastructure, strong service reception capacity, etc., and the
comprehensive development level of tourism is higher, while
less economically developed areas have geographical con-
straints, inconvenient transportation, shortage of funds, the
lack of domestic demand, and other obstacles, and the comprehensive development level of tourism is relatively low.

**Dynamic interaction between urban tourism development and habitat environment**

Before using the PVAR model to test whether there is a long-term equilibrium and causal relationship between urban tourism development and habitat environment, some tests need to be performed. First, to avoid pseudo-regressions, the LLC, IPS, ADF-Fisher, and HT unit root tests were performed to check the unit root of urban tourism development and habitat environment (Table 2). As can be seen from the table, the original unit root of urban tourism development and habitat environment did not pass the 10% significance test, and further differential treatment is required for testing. The results showed the first-order difference of urban tourism development and habitat environment was through a 1% significance level. Second, the co-integration test was performed to test whether there was a long-term stable equilibrium relationship between urban tourism development and habitat environment (Table 3). The test results of the statistics all rejected the original hypothesis, indicating the existence of co-integration relationship between the two systems. After determining the optimal lag period to be 1 according to the AIC, BIC, and HQIC criteria, a further Granger causality test was performed to confirm the causal link between the two systems (Table 4). The results showed that urban habitat environment was the Granger cause of tourism development at the 1% significance level, and tourism development was the Granger cause of habitat environment at the 5% significance level, implying that there were positive effects of mutual feedback and mutual promotion between urban habitat environment and tourism development in the Yangtze River Delta.

Note: d_Habitat environment and d_Tourism development are the first-order difference of habitat environment and tourism development, respectively.

The impulse response functions were further plotted after 500 Monte-Carlo simulations to analyze the dynamic shock effects and variation characteristics of the standard deviation of the random disturbance terms on the current value and future values for the two systems (Fig. 3). As shown in Fig. 3, the impact of habitat environment on self-shock showed a significant positive shock effect of 0.06 in period 1, followed by a rapid decline and eventual zero after period 2. For the shock effect of the standard deviation of tourism development, urban habitat environment showed a significant positive response effect with a rising peak in period 1, but the extent of the impulse effect rapidly diminished and eventually converged to zero from period 2 onwards. This indicates that the impact of urban habitat environment on tourism development showed a significant reinforcing effect and positive driving effect in the long term, and the intensity of its effect was more obvious in the short term.

The shock effect of tourism development on urban habitat environment was not significant, showing an inverted “V” shape of rising and then falling, with a negative effect in period 0 and a weak positive effect in period 1, then gradually converging to zero, which implied that tourism development would initially be constrained by the quality of urban habitat. The shock effect of the tourism development to itself showed a significant positive impulse response effect in periods 0 and 1, and then remained more stable and converged to 0 from period 2 onwards. It can be concluded that influenced
by the internal structure of urban habitat and external tourism development, urban habitat environment can continuously improve and maintain a relatively stable state, and the intensity of the impact brought by tourism development was stronger than urban habitat itself, while the stability of tourism development mostly depends on the dual role of its own internal structure and urban habitat in the long run.

**Temporal coupling coordination degree between urban tourism development and habitat environment**

The coupling coordination degree between urban tourism development and habitat environment was calculated for each city, and its time-series mean value was plotted (Fig. 4). On the whole, the coupling coordination degree of the two systems in the Yangtze River Delta had been increasing from 2001 to 2020 and showed the characteristics of three stages of change, among which the period from 2001 to 2006 was in the moderate dissonance type, the period from 2007 to 2013 was in the mild dissonance type, and the period from 2014 to 2020 transitioned to a near dissonance type, which indicated that the coupling coordination level of urban tourism development and habitat environment continued to improve. More specifically, the coupling coordination degree in Shanghai city, Jiangsu Province, Zhejiang Province, and Anhui Province from 2001 to 2019 all maintained a consistent upward trend, while the coupling coordination degree of Shanghai was far ahead of that of Jiangsu Province, Zhejiang Province, and Anhui Province, and gradually evolved from mild dissonance and near dissonance type to barely coordinated and mildly coordinated type, indicating the relationship between tourism development and habitat environment was getting closer and closer.

The coupling coordination degree of Jiangsu and Zhejiang provinces had been increasing at an average annual rate of 3.98% and 4.12% from 2001 to 2019, respectively. The two provinces have rich tourism resources, obvious advantages in tourism development, and rapid economic growth, which can provide strong support for high-quality socioeconomic development and promote the sustainable and healthy development of tourism, while the booming tourism...
industry in turn will bring significant economic, social, and environmental benefits, contributing greatly to improving the image of the city, promoting local cultural characteristics, increasing employment opportunities for residents, and harmonizing environmental and social development, while the coupling coordination degree in Anhui Province was far lagged behind other regions due to the relatively low level of tourism development and habitat environment constrained by regional geographical location, traffic conditions, shortage of funds, low level of education and technology, and other factors.

**Heterogeneous spatial coupling coordination degree between urban tourism development and habitat environment**

With the help of ArcGIS10.8 software, six time points, 2001, 2005, 2009, 2012, 2016, and 2020, were selected to visualize the spatial differences of the coupling coordination degree between urban tourism development and habitat environment, which were classified into six types, including severe dissonance, moderate dissonance, mild dissonance, near dissonance, barely coordinated, and mildly coordinated (Fig. 5). As can be seen from Fig. 5, the type of coupling coordination among the Yangtze River Delta cities gradually evolved from severe dissonance, moderate dissonance, and mild dissonance to near dissonance, barely coordinated, and mildly coordinated, with the degree of integration and mutual interaction between the two systems increasing and strengthening, and showing the obvious coupling coordination characteristics of overall differentiation but local convergence.

In 2001, the delta region was dominated by the moderate dissonance type, and the severe dissonance type was mainly distributed in Chuzhou, Anqing, Chizhou, and Xuancheng, while Shanghai and Hangzhou were mild dissonance types, with a coupling coordination degree of 0.384 and 0.336, respectively, much higher than other cities in the delta. In 2005, the delta region was dominated by mild and moderate dissonance types, with Nanjing, Wuxi, Suzhou, and Ningbo joining the mild dissonance group, Zhenjiang and Tongling transitioning from severe to moderate dissonance, and Shanghai and Hangzhou taking the lead in transforming into near dissonance types. In 2009, all severe dissonance cities had evolved into moderate dissonance types, and the number of mild and near dissonance cities increased significantly. The mild dissonance type covered and dominated most cities in the region, while Nanjing, Wuxi, Suzhou, and Ningbo evolved from the mild dissonance type to the near dissonance type, and the moderate dissonance type was mainly located in southern Anhui Province.

In 2012, the delta region remained mild dissonance, with most moderate dissonance types transitioning to the mild dissonance type. Shanghai and Hangzhou had transitioned from near dissonance to barely coordinated, and Anqing and Chuzhou became the only moderate dissonance cities. In 2016, the near dissonance type dominated, with most eastern coastal cities in the delta evolving from near dissonance to barely coordinated and also from mild dissonance to near dissonance, with Anqing and Chuzhou converting to mild dissonance, while Wuxi, Suzhou, Ningbo, and Zhoushan joined the barely coordinated type. In 2020, the delta region was dominated by near dissonance type and barely coordinated type, with Anqing evolving into near dissonance type; Chuzhou and Maanshan changing from mild dissonance to barely coordinated; barely coordinated type mainly in northern Zhejiang, central Anhui, southern Jiangsu, and other cities; mild dissonance mainly in Tongling and Xuancheng; and Shanghai stepping into mildly coordinated.
Barrier factor analysis of the coupling coordination degree between urban tourism development and habitat environment

The five indicators with the highest barrier degree were selected for analysis and comparison over three time periods: 2001, 2010, and 2020 (Table 5). The average barrier degree of the indicator layer was measured to be 2.941%, and the barrier degree of most indicators did not differ much, with only individual cities exhibiting divergent situations. Specifically, in 2001, the five indicators with the highest barrier degree in most cities were Y8, Y6, Y5, Y4, and Y3, which became the obstacles that impeded the coupled and coordinated development of the two systems. In 2010, Y8 remained the most important factor, followed by Y5, Y6, Y4, and Y3 which also played a greater role in hindering the coupled and coordinated development between urban tourism development and the habitat environment. In 2020, the main barrier indicators changed significantly, and the barrier degree of indicators from the tourism system increased, with the main obstacles being Y8, X12, Y5, X11, Y7, X7, X10, and X9. For example, the ranking of the barrier factors in Shanghai becomes Y5, X11, X10, X9, and Y2. Overall, the indicators of foreign direct investment, average wage of employees, per capita consumption level, per capita savings deposit balance, per capita inbound tourism consumption, tourism foreign exchange income, and per capita tourism income of destination were important obstacle factors that restricted the coupling and coordination between urban tourism development and habitat environment. Most cities had a relatively stable ranking of barrier indicators, and only a few cities exhibited inter-annual differences in barrier indicators, while economically developed cities had more significant changes in barrier indicators.

In addition, the barrier degree of the target layers of the two systems was aggregated separately according to their indicator layers (Table 6). It can be seen that the barrier degree of the tourism development system, whether at the regional, provincial, or city scale, showed a gradual upward trend ranging from 31.733% to 52.125%, and the barrier degree of developed tourism cities was obviously smaller than that of less developed tourism cities. While the barrier degree of the habitat environment system tended to decrease gradually ranging from 47.875% to 68.374%, the overall barrier degree of the habitat environment system was significantly higher than that of the tourism development system, indicating that the habitat environment system was the main obstacle factor affecting...
the coupled and coordinated development of regional tourism development and habitat environment system.

In 2020, the social demand for tourism received a dampening due to the outbreak of COVID-19, and the tourism industry experienced an unprecedented decline, causing the barrier degree of the tourism development system to rise to 52.125%, which required effective improvement and consolidation of the tourism system in the future. The barriers of the two systems did not differ much at the provincial level, with the barriers of the tourism development system being Zhejiang > Anhui > Jiangsu > Shanghai and the barriers of the habitat environment development system being Shanghai > Anhui > Jiangsu > Zhejiang. At the city scale, the five cities with the highest barriers to tourism development were Zhoushan, Jiaxing, Shaoxing, Hangzhou, and Huzhou, while the five cities with the lowest barriers were Shanghai, Chizhou, Anqing, Chuzhou, and Yangzhou. In terms of the habitat environment system, cities in the delta region were not only concerned with the scale and speed of GDP growth but also gradually paid attention to the quality and efficiency of urban development, which brought the effective improvement of the habitat environment.

### Conclusions and recommendations

#### Conclusion

Based on the panel data of 26 cities in the Yangtze River Delta from 2001 to 2020, we applied the PVAR model to analyze the dynamic interaction between urban tourism development and the habitat environment. Furthermore, we analyzed the coupling coordination degree of the two systems and diagnosed the obstacle factors of the two systems. The following conclusions were obtained.

First, the development level of the urban habitat environment in the Yangtze River Delta urban agglomeration gradually increased at an average annual rate of 7.05% from 2001 to 2020. The development of tourism kept rising at an average annual rate of 9.01% from 2001 to 2019, with a slow growth rate followed by a fast growth rate, and the development level of tourism in the whole region decreased in 2020 due to the outbreak of COVID-19. There were mutual influences and interactions between the two systems of urban tourism development and habitat, and especially the urban habitat environment showed a
significant positive impact effect on tourism development, which was more significant in the short term and tended to be stable in the long term.

Second, the coupling coordination degree between urban tourism development and habitat environment in the delta region gradually increased from 2001 to 2020, with an average annual increase of 4.165%. The type of coupling coordination continuously evolved from severe dissonance, moderate dissonance, and mild dissonance to near dissonance, barely coordinated and mildly coordinated. While the interaction between the two systems in the delta region is increasing and developing in the direction of coordination and integration, the overall level was still low, and there was a more obvious spatial differentiation.

Third, the overall barrier degree of the habitat environment system in the delta region was significantly higher than that of the tourism development system, with the barrier degree of tourism development ranging from 31.733% to 52.125% and that of habitat environment ranging from 47.875% to 68.374%. The barrier degree of the tourism development system was gradually increasing, while the barrier degree of habitat environment tended to decrease gradually. In terms of the specific indicators, foreign direct investment, average wage of employees, per capita consumption level, per capita savings deposit balance, per capita inbound tourism consumption, tourism foreign exchange income, and per capita tourism income of destination were important obstacle factors that restrict the coupled and coordinated development of the two systems. Besides, the more economically developed cities had greater variation in the barrier degree indicators.

Policy recommendation

Based on the results of the study, the following countermeasures can be proposed to promote the high-quality development of the two systems:
integrated development of regional urban tourism and habitat environment.

First, it should take the metropolitan region as a carrier to achieve regional integrated development and play the role of Shanghai as the leading city in the delta region, which needs to continue to attract and utilize global resources, keep the close division and cooperation with neighboring cities, and rely on advanced science and technology to drive the healthy development and structural optimization of production and living services. Moreover, each city should give full play to its own advantages and form cities with distinctive features, complementary functions, and strong competitiveness. The three sub-center cities of Nanjing, Hangzhou, and Hefei in the delta region should enhance the development of advanced manufacturing. Cities in Anhui Province should implement multidimensional initiatives such as the joint progress of urban expansion and quality of life, the joint creation of industrial revitalization and high-wage employment, the joint construction of urban–rural integration and affluent living, the joint connecting of the infrastructure network, the joint governance and protection of the ecological environment, the joint sharing of public service, and the joint integration of policy mechanism, which actively play the role of radiation driven by the Wanjiang River city belt, the Dabie Mountain Revolutionary Old Area, and the South Anhui International Cultural Tourism Demonstration Zone; pay more attention to the creation of green ecological welfare for urban development; and optimize the environment for habitat and tourism development.

Second, it is necessary to strengthen the ecological environment and infrastructure construction and improve the urban habitat environment. The delta region should focus on the integration of ecological governance; innovate ecological compensation mechanisms for key ecological function areas such as the Xin’an River, the Dabie Mountain area in western Anhui, and the mountainous areas in southern Anhui; and explore the model of joint prevention and treatment of environmental protection to enhance the original color of natural ecology and sustain the color to high-quality development. In addition, the internal transportation system should be upgraded and extended based on the traditional Shanghai-Nanjing, Shanghai-Hangzhou, and Hangzhou-Ningbo corridors to promote the networking of internal transportation corridors. In particular, Anhui Province should focus on improving conditions of the cross Yangtze River, Hangzhou Bay, and access to northern Jiangsu.

Third, it is necessary to promote high-quality tourism development in the delta region. The cities in the region should strive to give full play to their respective advantages and characteristics and seize major national strategies and opportunities such as high-speed railway, internet information, regional integration, and the Belt and Road to expand the scale of the tourism industry and tourism market.

Moreover, the local government should optimize the tourism investment environment, promote the structural transformation of the traditional tourism industry, improve the tourism market supervision mechanism, break the restrictions of administrative divisions, and highlight the characteristics of high-quality and intelligent development. Less developed tourism areas should continuously improve the quality of cities, learn from the successful cases of developed areas, shape a new tourism image, raise local visibility, make up for the deficiencies of the indicator layer of the tourism development system, and achieve the coupled and coordinated development with urban habitat environment.

Admittedly, there are still some deficiencies in this study. First, academics have not reached a consensus on the evaluation system of urban tourism development and habitat environment, and due to the influence of the availability of research data, the selection of evaluation indicators of urban tourism development and habitat environment in this study may be biased and can be further expanded in the future. Second, the bivariate spatial association method can be used to diagnose the spatio-temporal dependence between urban tourism development and habitat environment. Third, the panel regression model can be used to analyze the influencing factors of the coupling coordination degree between urban tourism development and habitat environment.
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