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Investigating the spatial effect of operational performance in China's regional tourism system

Sheng-Hsiung Chiu[1], Tzu-Yu Lin[1] & Wei-Ching Wang[2✉]

For the healthy development of regional tourism systems, performance evaluation is vital for regulators so that they can determine the source of inefficiency to enhance systems' competitiveness through a series of systematic policy plans. Past research has recognized the importance of network collaboration in the tourism sector but has focused mainly on the separate stages of performance (e.g., hotels), with limited discussion on how sectoral interactions can be distilled into collaborative models. Consequently, this paper intends to construct a more comprehensive performance evaluation framework for the Chinese regional tourism system that not only focuses on network interactions and dynamic features among stages but also considers spatial dependency to enhance the accuracy of performance evaluation. Using the panel data of 30 provincial-administrative regions on China's tourism industry from 2012 to 2016, the operating performance of each regional tourism system and its tourist stages are measured by the SBM-DNDEA model. Furthermore, the spatial effect of regional tourism system operational performance and its influencing factors are investigated via the Tobit spatial Durbin model. The results showed that the operational performance of the Chinese regional tourism system was still relatively low, with the attraction stage performing the best, and there were significant differences among the four economic zones. The strength of traffic convenience had a significant positive effect on the operational performance of the local tourism system, but fiscal expenditure on environmental management also had a negative spillover effect on the surrounding region. The urbanization level had not only a significant positive effect on local areas but also a positive spillover effect on adjacent areas. Interregional development may also affect the performance of attractions, highlighting the importance of systematic integration and allocation of resources for tourism development.

[1] Accounting School, Nanfang College, Guangzhou, Guangzhou, China. [2] Business School, Nanfang College, Guangzhou, Guangzhou, China.
✉email: wangwj@nfu.edu.cn

Introduction

Since China's reform and opening-up, the domestic tourism industry, as one of the selected strategic industries, has taken an increasingly important position in its national economy (Ministry of Culture and Tourism PRC, 2011). According to statistics from the Ministry of Culture and Tourism PRC, in 2019, tourism industry employment accounted for 10.31% of the working-age population; its contribution to the country's GDP was 10.94 trillion CNY, accounting for 11.05%; and the number of domestic tourists was 6.006 billion, up 8.4%, from 2018 (UNWTO, 2021). For most provincial-level administrative regions in China, a local tourism system that is organized and operated very well is highly beneficial to their regional economy. Indeed, the economic output of a regional tourism system is influenced by the number of visitors and per capita visitor spending. Another prominent characteristic is that tourist services provided by a regional tourism system are perishable and must be consumed simultaneously; otherwise, they will be wasted. Hence, to promote the healthy development of a regional tourism system, understanding its operational performance is essential. For both regional and central governments, doing so can help control the quality of sustainable operations, clarify the sources of inefficiency in the regional tourism system, and offer direction towards further policy planning for improving the system's shortcomings.

In regard to performance evaluation, Data Envelopment Analysis (DEA) is one of the most commonly used multi-dimensional performance frameworks for measuring the relative performance of decision-making units (DMUs) under multiple input-output variable specifications (Cook et al. 2014; Tone and Tsutsui, 2009, 2010) and can overcome the weakness of partial performance indicators normally employed, such as average length of stay and the number of tourists, which may lead to misleading evaluation results in terms of tourism system performance (Yu et al. 2016). There is an extensive strand of literature on the application of DEA for evaluating the performance of the tourism industry (Huang et al. 2014; Huang, 2018; Köksal and Aksu, 2007; Chiu and Lin, 2018; Niavis and Tsiotas, 2019; Zha et al. 2021). Although Huang (2018) highlighted that network cooperation between tourism divisions should be taken into consideration, most studies have failed to address the intricate relationships among different stages in the system and have considered only stages in the tourism industry, such as hotels (Assaf, 2012; Chiu and Lin, 2018), travel agencies (Assaf, 2012; Fuentes, 2011), or attraction sites (Tsionas and Assaf, 2014). In other words, the literature has focused on separate stages of performance, with few discussions on how sectoral interactions can be distilled into cooperative models.

Huang (2018) first constructed China's regional tourism system of multiple tourist stages from a comprehensive perspective and incorporated tourist education, tourist hotels, travel agencies, and tourist destinations to form a serial tourist supply chain in sequence (Huang, 2018). Although Huang (2018) combined these tourists' performance evaluations into a single slacks-based measure network DEA (SBM-NDEA) model to evaluate China's regional tourism system performance, the study failed to explore the influence of carry-over items. However, in the traditional tourism business mode, travel agencies play an important intermediary role in the tourism system, channelling different service products to tourists. As studies have shown, dining services play an increasing role in the tourism industry, becoming a major attraction for tourists and creating important economic benefits (Hashimoto and Telfer, 2006; Renko et al. 2010). In other words, to satisfy the various needs of tourists in both leisure and business activities, network cooperation is needed to maximize tourism industry performance (Camilleri, 2018; Morrison et al. 2018; Jakulin, 2017).
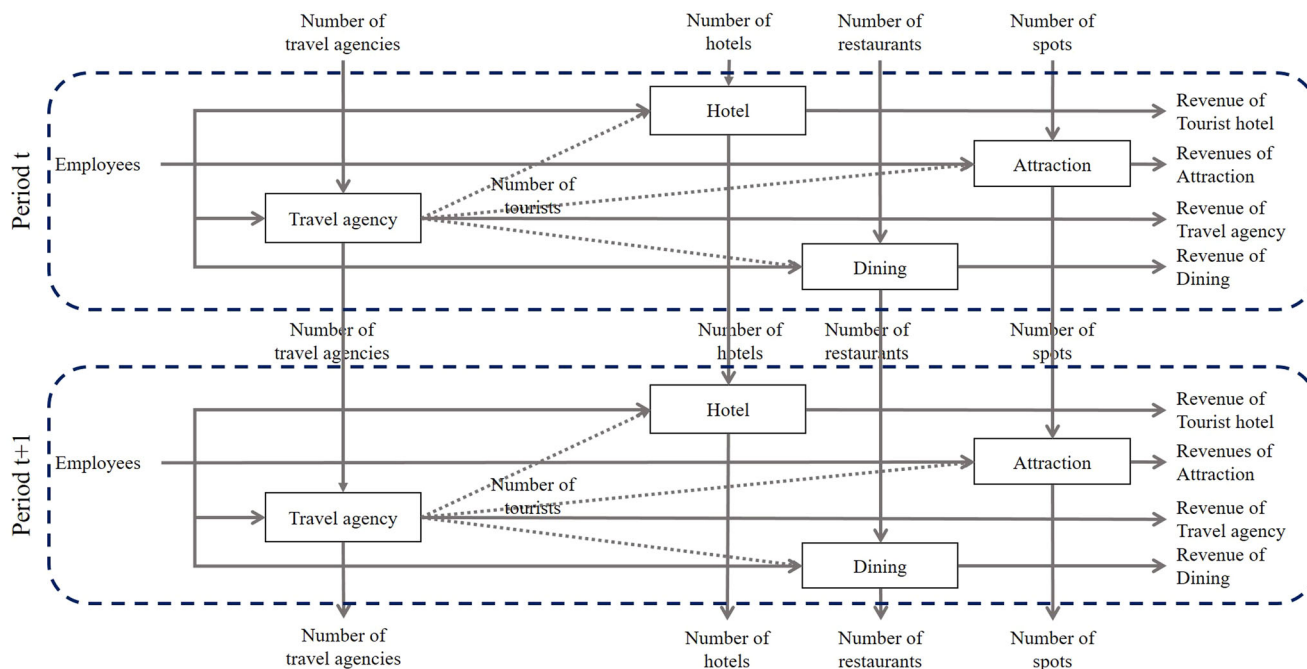
There are three sections in the present study that are quite distinct from those of Huang (2018). First, the tourist education stage is removed due to a lack of data availability; thus, the tourist dining stage is utilized instead. Second, this study emphasizes the intermediation function of travel agencies on the regional tourism system by using the number of tourists received as the intermediate product connecting travel agencies to other tourism service stages. Third, from the dynamic viewpoint, a carry-over item, persisting from one period to another, is also taken into consideration, whereby the number of firms still operating at the end of the fiscal year is applied in each tourist service stage to capture the impacts of accumulated capital expenditure and the degree of market competition. Consequently, the present study fills this gap in the literature by constructing a more comprehensive evaluation model for China's regional tourism system and addressing not only the network interactions among stages but also the dynamic features in each stage. By doing so, this study provides more insights into the long-term development of regional tourism systems.

This study uses the slack-based measure approach of dynamic network DEA (SBM-DNDEA), proposed by Tone and Tsutsui (2014), to investigate the relative operational performance of China's regional tourism system. As shown in Fig. 1, the overall efficiency score of a regional tourism system is designed as a weighted composition of four core divisional performances over the period from 2012 to 2016: travel agency, hotel, attraction, and dining. The SBM-DNDEA model is undoubtedly an effective managerial tool for evaluating the performance of China's regional tourism system in this study but is incapable of considering the influences of the external operating environment. In recent years, environmental awareness has steered the attention of the tourism industry to sustainability, while technological innovations have changed the way tourists access information or experiences (Morrison et al. 2018; Chiappa, 2013; Sharma et al. 2020). Changes in the external environment have an interactive effect on tourism operators' and tourists' travel plans (Chiappa, 2013; Sharma et al. 2020). The development conditions and factors of China's tourism industry differ from those of the past, and changes in the business environment have affected the performance of various stages. It is therefore important to re-examine the performance and correlation between the different stages of the tourism system and the external environment.

A two-stage methodological framework that includes DEA and Tobit regression has been proposed in the extant literature on performance evaluation (Yang et al. 2019; Li et al. 2017). Several studies have adopted spatial econometric models to identify the impact of environmental factors on efficiency in Chinese provinces (Zhao et al. 2020; Wan et al. 2023). Hence, based on the SBM-DNDEA model and Tobit spatial Durbin model, this study investigates the status of operational performance in China's regional tourism system and its tourist service stage and the underlying factors.

The main contributions of this study are summarized as follows. First, the performance evaluation model focuses on travel agencies and explores the cooperation model between travel agencies and other stages. To better understand the impact of contemporary tourism consumption trends on the tourism system, this study also incorporates a dining service stage. Studies on tourist behaviour have also suggested that dining services could add cultural exposure to travel experiences (Du Rand et al. 2003; McKercher et al. 2008; Sthapit et al. 2019; Quan and Wang, 2004). Therefore, adding dining services makes our model more relevant to the real-world tourism industry.

Second, to our knowledge, this study is the first to measure the economic performance of China's regional tourism system by

Fig. 1 Performance framework on regional tourism system. The proposed regional tourism system is composed of four tourist service stages, based on considering the divisional coordination and the Intertemporal influence.

including intermediate and carryover variables in a multistage SBM-DNDEA evaluation framework. This study extends the serial network NDEA model proposed in Huang (2018) by involving not only a carry-over variable (number of still operating firms) but also an intermediate variable (number of tourist visitors served) as a link between stages. Consequently, our model assesses the dynamic effect on operational performance while emphasizing the intermediate function of travel agencies in the operation of the tourism system.

Third, this study analyses the effect of influencing variables on operational performance in China's tourism system (e.g., level of traffic development, urbanization level, and environmental management). The findings appear to be more accurate when spatial dependency is taken into account.

The rest of this paper proceeds as follows. Section 2 presents an overview of the literature on the tourism system, DEA-based tourism efficiency evaluation, and spatial econometric analysis. Section 3 introduces the proposed evaluation framework and applied methodologies, such as the SBM-DNDEA model and the spatial econometric model. In Section 4, the data sources are described, the operational performance of the Chinese regional tourism system and its tourist service stages are analysed, and the effect of influencing factors on regional tourist service stage performance is identified via the Tobit spatial Durbin model. Section 5 offers a summary of the main findings, discussion, managerial implications, and prospects for future research. The SBM-DENDEA model is described in detail in Appendix A.

Literature
This section conducts a literature review of tourism systems and DEA research related to tourism.

Tourism system. Due to the complexity of the tourism industry, defining its operational system from a single viewpoint is difficult. Tourism comprises several interrelated components that emphasize their interdependence, and the different stages share a common goal, which is to provide services to tourists (Gunn and Var, 2002; Leiper, 1979; Morrison et al. 2018). Gunn and Var (2002) identified five supply elements of a tourism system: attraction, service, transportation, information, and promotion. Leiper (1979) noted that the nature of tourism is spatial mobility and proposed a tourism system that consists of dynamic journeys and static stays, which extend the tourist-generating regions. These variables denote the location of the basic market for tourism and the source of potential demand. Tourist destination regions are places where tourists stay for a short period of time and are characterized by their attractions as well as the location of accommodations, entertainment, or service facilities. Transit routes are the linkages between tourist-generating regions and destinations. The system comprises geographic, behavioural, industrial, and environmental characteristics, and there are different tourism stages distributed in the space of tourist generation regions and tourist destination regions; these stages work together to provide a complete tourism product for tourists.

Burns (1999) argued that the accessibility and cultural, political, and/or economic environments of a destination may influence tourists' intention to visit and that the environmental impacts caused by the development of tourism activities are also part of the system. The tourism system is affected by demand, supply, and other external factors (Leiper, 1979; Lohmann and Netto, 2016), and some studies have noted that the tourism system is affected not only by geography and politics but also by migration patterns (Khalilzadeh, 2022). Therefore, each stage and the external business environment are interrelated and ultimately determine the overall quality of tourism services for tourists.

A tourism system is dynamic, changes with different external factors (such as human, sociocultural, economic, technological, natural, political, and legal factors), and affects the flow of tourists (Leiper, 1979; Lohmann and Netto, 2016). Some scholars have emphasized the importance of sustainability for tourism development and the way in which technology is changing information and experience (Morrison et al. 2018). Therefore, considering external factors when assessing the performance of a regional tourism system is a more reasonable and well-established approach.

Tourism research and DEA analysis. Most tourism papers on efficiency have focused on the hotel industry, especially chain hotels (Chen, 2007). There are also studies that include tourism pressure, tourism benefits, service quality, and destination fame in efficiency evaluation models to understand the operational efficiency of a destination (Niavis and Tsiotas, 2019) or the impact of ownership types of travel agencies on performance (Köksal and Aksu, 2007). Studies have also combined more than two tourism stages for industry supply chain discussions (Huang, 2018). In addition to performance evaluation, other studies have assessed the impacts of macrolevel or geographic factors on tourism industry performance, such as the impact of environmental management on the performance of an attraction (Zha et al. 2021) or the relationship between tourism efficiency and spatial distribution (Wang et al. 2020; Liu et al. 2021).

DEA is a nonparametric analytic tool and has become one of the most popular methodologies for evaluating industry performance. Table 1 summarizes the existing DEA applications in China's tourism industry in recent years. Most related studies have targeted the performance of a single tourism service and/or treated the entire production process of tourism service activity with a single-stage setup (Chaabouni, 2019; Liu et al. 2017; Peng et al. 2017; Xu et al. 2016). Only a few studies have investigated regional or city tourism system performance. In Huang's DEA model (2018), he applied a supply chain concept to the serial multistage framework, in which all stages are sequentially linked by intermediate variables. A multistage model could also include not only serial forms but also a parallel or mixed structure, as Cook et al. (2000) suggested. Chaabouni (2019), Liu et al. (2017), and Peng et al. (2017) considered a multiple-period evaluation; however, their model did not include a dynamic feature. The aforementioned studies clearly failed to consider the possible interdependence between consecutive stages.

This study therefore postulates that a dynamic model is more suitable for capturing the intereffects among different tourism services as well as long-term resource optimization. The literature that has modelled the economic performance of China's regional tourism system under a multistage framework with dynamic features is still rare. Hence, building upon the existing research results, this study constructs a multistage (travel agency, hotel, attraction, and dining services) dynamic framework to evaluate the performance of this country's regional tourism system.

Tourism efficiency and spatial research. As transportation development and tourism quality improve, the tourism economy of a region will increase (Feng, 2023; Hou et al. 2021; Shu et al. 2023), and the spatial configuration and integration of tourism will continue to shift (Hall and Page, 2014). Several scholars have indicated that transportation costs affect the spatial structure of an economy and that lower transportation costs can enhance the concentration of economic activities, resulting in spatial agglomeration of tourism activities (Masson and Petiot, 2009). Shu et al. (2023) noted that the opening of high-speed rail in China increased the efficiency of urban tourism and improved the efficiency of resource allocation.

Different spatial management policies lead to different spatial conditions for tourism development and affect the assessment of tourism performance. Studies have shown that environmental management policies (e.g., electricity and water conservation) reduce the internal management costs of travel agencies, optimize the differentiation of company resources (Bagur-Femenías et al. 2015), or enable the reduction of environmental pollution and enhance the quality of tourism (Song and Li, 2019). It has also been noted in some studies that with increasing levels of urbanization, it is important to reduce constraints on tourism

Table 1 DEA research on regional tourism performance in China.

Author(s)	Sample	Period	Method	Input	Intermediate	Carry-over	Output
Xu et al. (2016)	100 national scenic spots	2013	BBC-DEA	1. Time to micro-blog 2. Number of updates 3. Number of pictures 4. Number of followings 5. Tourism-only area 6. Operational expenditure 7. Maintenance expenditure 8. Completed investment in fixed assets	-	-	1. Number of follows 2. Number of visits 3. Ticket fee 4. Public engagement
Liu et al. (2017)	53 coastal cities	2003–2013	CCR-DEA	1. Tourism wastewater discharge 2. Tourism SO2 emission 3. Tourism industrial garbage emission 4. Nearshore seawater quality 5. Tourism energy consumption	-	-	1. Total tourism revenue 2. Total number of tourists
Peng et al. (2017)	Destination (Huangshan)	1981–2014	SBM-DEA	1. Average wage level of employees 2. New fixed asset investment 3. Energy consumption 4. Water consumption 5. F&B consumption	-	-	1. Per capita tourism income 2. Emissions of garbage 3. Emissions of sewage 4. Emissions of waste gas
Yang et al. (2017)	Hotel market	2012	SBM-DEA	1. Hotel (endogenous) factor 2. Regional (exogenous) factor	-	-	1. Average room rate 2. Occupancy rate
Huang (2018)	30 regions	2012	Network DEA	1. Teachers of tourism education (E) 2. Schools of tourism education (E) 3. Fixed assets of tourist hotel (H) 4. Fixed assets of travel agency (A) 5. Tourist spots (D)	1. Employees in tourist hotel (E-H) 2. Employees in tourist agency (E-A) 3. Employees in tourist spot (E-D) 4. Rooms provided for rent (H-A) 5. Guests received by travel agency (A-D)	-	1. Revenue of tourist hotel (H) 2. Revenue of tourist agency (A) 3. Revenue of tourist spots (D) 4. Number of tourists (D)
Chaabouni (2019)	31 regions	2008–2013	Bootstrap-DEA	1. Labor 2. Capital stock 3. Number of arrivals	-	-	1. Tourism GDP

Note: E, H, A, and D are symbols respectively denoting travel education, hotel, travel agency, and attraction phases. F&B denotes food and beverage.

development and attract more people to travel (Song and Li, 2019). The more open a region is to the outside world, the more likely it is to attract foreign investment, which can promote better tourism development (Chaabouni, 2019; Song and Li, 2019). The above spatial conditions vary from one region to another, thus affecting tourism performance.

Methodology

This section presents the tourism evaluation framework, SBM-DNDEA, and spatial econometric models for investigating the operational performance of China's regional tourism system.

Evaluation framework of regional tourism systems. Regarding the performance of tourism supply chains, Huang (2018) arranged 4 stages in sequence: tourism education, hotels, travel agencies, and destinations. Employees in each stage, rooms provided in a hotel, and guests received by a travel agency were considered separate independent intermediate variables. In this paper, the proposed evaluation framework for China's regional tourism system builds upon the basic structure of Huang's (2018) work. First, the tourism education stage is reduced due to a lack of data availability, and the dining stage is included because it is also an important factor in attracting tourists (Hashimoto and Telfer, 2006; Renko et al. 2010). Second, to capture the dynamic character of the operation of the tourism industry, a carry-over variable is used to connect the same stage for two consecutive years. For example, it would be an output of each stage in the preceding year and an input of that in the succeeding year. Finally, as this study postulates, the hotel, attraction, and dining stages all benefit from the number of tourist visitors served by the travel agency. Hence, the travel agency stage provides the starting point for emphasizing the mediating effect of the travel agency stage on the regional tourism system, followed by the hotel stage, the dining stage, and the attraction stage. This study presents the conceptual SBM-DNDEA model in Fig. 1.

The production (value-added) approach is used as a guide for selecting input and output variables for the proposed evaluation framework. In the travel agency stage, two variables, full-time tourist workers (input) and the number of travel agencies still operating at the end of the previous year (carryover), are used as inputs. These inputs generate an intermediate variable, the number of tourists received by the travel agency, which serves as the linkage from the travel agency to the hotel, attraction, and dining stages simultaneously. The hotel stage's operational efficiency depends on 3 variables: full-time workers (input), the number of hotels still operating at the end of the previous year (carryover), and the intermediate variable from the travel agency stage. The revenues from accommodations and other related services are the (desirable) outputs of the stage. In the attraction stage, there are also 3 input variables: full-time workers (input), the number of tourist spots still operating at the end of the previous year (carryover), and the intermediate variable from the travel agency stage. The revenue from the attraction service is the output variable. Similarly, in the dining stage, full-time tourist workers (input), the number of restaurants still operating at the end of the previous year (carryover), and the intermediate variable from the travel agency stage are the input variables. The sales revenue of dining services is the output variable. The input, intermediate, carryover, and output variables of each stage used in the SBM-DNDEA model are summarized in Table 2.

The SBM-DNDEA model. The SBM-DNDEA model, introduced by Tone and Tsutsui (2014), is a non-parametric approach that incorporates multiple input, output, intermediate, and carry-over variables in model programming at the same time. It is used to evaluate the performance of a system of multiple periods and stages, using carry-over variables to reflect long-term effects and intermediate variables for the interaction of two connected stage within a specific period.

Suppose there are n regional (provincial) tourism economic systems in China at a particular period t, during the observed

Table 2 Variables and descriptions.

Variable	Notation	Description
Separate input$^{(TA),(H),(A),(DI)}$: Employees (EE)	X_{jt}^{EE}	The number of employees hired for full-time jobs in the stages of travel agency, hotel, attraction, or dining, respectively.
Output$^{(TA)}$: Service revenue from travel agency (SRTA)	Y_{jt}^{SRTA}	Revenue statistic is limited to the travel agency service.
Shared intermediate$^{(TA-H),(TA-A),(TA-DI)}$: Number of tourists (NT)	Z_{jt}^{NT}	The number of tourists received from the travel agency service stage indicates tourism demand that flows into the operations of the hotel, attraction, and dining service stages.
Carryover$^{(TA)}$: Number of travel agencies (NTA)	$C_{j(t-1,t)}^{NTA}$	Summarizes the number of travel agencies still legal and effective at the end of each year.
Output$^{(H)}$: Service revenue from hotel (SRH)	Y_{jt}^{SRH}	Revenue statistic is limited to the hotel service stage.
Carry-over$^{(H)}$: Number of hotels (NH)	$C_{j(t-1,t)}^{NH}$	Summarizes the number of hotels still legal and effective at the end of each year.
Output$^{(A)}$: Service revenue from attraction (SRA)	Y_{jt}^{SRDE}	Revenue statistic is limited to the attractions service stage.
Carry-over$^{(A)}$: Number of spots (NS)	$C_{j(t-1,t)}^{NS}$	Summarizes the number of spots still legal and effective at the end of each year.
Output$^{(DI)}$: Service revenue from dining (SRDI)	Y_{jt}^{SRDI}	Revenue statistic is limited to the dining service.
Carry-over$^{(DI)}$: Number of restaurants (NR)	$C_{j(t-1,t)}^{NR}$	Income derived from the right of intellectual properties to another legal entity. Summarizes the number of restaurants still legal and effective at the end of each year.

Note: TA, TH, A, and DI are the symbols respectively denoting travel agency, hotel, the attraction, and dining services.

term T, which are independent decision-making units (DMUs), respectively, denoted by $DMU_{jt}(j = 1, 2, 3, ..., n; t = 1, ..., T)$. This study assumes a DMU first uses full-time tourism workers, X_{jt}^{TW}, as the separate input of four tourism service stages in time t: $\beta_{jt}^{EE(TA)}$, $\beta_{jt}^{EE(H)}$, $\beta_{jt}^{EE(A)}$, and $\beta_{jt}^{EE(DI)}$ (i.e., $X_{jt}^{EE} = \beta_{ji}^{EE(TA)} + \beta_{ji}^{EE(H)} + \beta_{ji}^{EE(A)} + \beta_{ji}^{EE(DI)}$). For the travel agency stage, each DMU also consumes one carry-over input, the number of travel agencies still operated in the previous period $t - 1$ ($C_{j(t-1,t)}^{NTA}$), to generate one intermediate output, the number of tourist visitors served $\left(Z_{jt}^{NT}\right)$, one desirable output, service revenue from the travel agency stage $\left(Y_{jt}^{SRTA}\right)$, as well as one carry-over output, the number of travel agencies still operating at the end of the current year ($C_{j(t,t+1)}^{NTA}$). The technology set of the travel agency stage in time t is represented by:

$$P_t^{TA} = \left\{ \beta_{jt}^{EE,TA}, C_{j(t-1,t)}^{TA}, Z_{jt}^{NT(TA-H,A,DI)}, C_{j(t,t+1)}^{TA}, Y_{jt}^{SRTA} \right\}$$

In the hotel stage, each DMU for time t uses one carry-over input, the number of hotels ($C_{j(t-1,t)}^{NH}$), and one intermediate input from the travel agency stage, the number of tourist visitors served ($Z_{jt}^{NT(TA-H)}$), to produce one desirable output, service revenue from the hotel stage $\left(Y_{jt}^{SRH}\right)$, as well as one carry-over output, the number of hotels existing at the end of the current year ($C_{j(t,t+1)}^{NH}$). The technology set of the hotel stage in time t is defined as follow:

$$P_t^H = \left\{ \beta_{jt}^{EE,H}, C_{j(t-1,t)}^H, Z_{jt}^{NT(TA-H)}, C_{j(t,t+1)}^H, Y_{jt}^{SRH} \right\}$$

In the attractions stage, each DMU for time t uses the carry-over input, the number of spots $\left(C_{j(t-1,t)}^{NS}\right)$, and one intermediate input from the travel agency stage, the number of tourist visitors served ($Z_{jt}^{NT(TA-A)}$), to generate one desirable output, service revenue from the attraction stage $\left(Y_{jt}^{SRA}\right)$, as well as one carry-over output, the number of spots existed in the end of the current year ($C_{j(t,t+1)}^{NS}$). The technology set of the attractions stage in time t is shown as:

$$P_t^A = \left\{ \beta_{jt}^{EE,A}, C_{j(t-1,t)}^{NS}, Z_{jt}^{NT(TA-A)}, C_{j(t,t+1)}^{NS}, Y_{jt}^{SRA} \right\}$$

For the dining stage, each DMU for time t uses the carry-over input, the number of restaurants ($C_{j(t-1,t)}^{NR}$), and one intermediate input from the travel agency stage, the number of tourist visitors served ($Z_{jt}^{NT(TA-DI)}$), to have one desirable output, revenue from the dining stage $\left(Y_{jt}^{SRDI}\right)$, as well as one carry-over output, the number of restaurants operating at the end of the current year ($C_{j(t,t+1)}^{NR}$). The technology set of the dining stage in time t is:

$$P_t^{DI} = \left\{ \beta_{jt}^{EE,DI}, C_{j(t-1,t)}^{NR}, Z_{jt}^{NT(TA-DI)}, C_{j(t,t+1)}^{NR}, Y_{jt}^{SRDI} \right\}$$

The relationships between stages, system, and overall performance measures based on the SBM-DNDEA model will be described in detail in Appendix A.

Weight setting for the SBM-DNDEA model. Given the parameter specification of the SBM-DNDEA model introduced by Tone and Tsutsui (2014), the weights for each time period and stage can be exogenously determined and should satisfy the conditions: $w^{2012} + w^{2013} + w^{2014} + w^{2015} + w^{2016} = 1$ and $w^{TA} + w^H + w^A + w^{DI} = 1$. The weight is used to represent the relative importance of these stages (periods) within a system

(research time scale). Regarding the choice of preferred weights for each time period, Tone and Tsutsui (2014) suggested that a reverse relationship between the magnitude of weight in each period and its chronological order - that is, the last period has the top-most priority and thus will be given the largest weight, while the first period will have the smallest weight. This study applies the sum-of-the-year's digits method to make the weight increases yearly. The weights assigned to the year during 2012 to 2016 are: $2012 = 0.067$, $2013 = 0.133$, $2014 = 0.200$, $2015 = 0.267$, and $2016 = 0.333$. Furthermore, both Yu et al. (2016) and Zhou et al. (2019) employed the same weights for each stage within the system efficiency evaluation when all stages are assumed equally important; likewise, this paper for simplicity defines the weight assigned to the four tourism service stages as being the same (0.25).

Spatial econometric model. This paper considers tourism development in relation to spatial distribution, which affects tourist flows (Leiper, 1979; Lohmann and Netto, 2016) and further pays attention to investigate the influencing factors of the operational efficiencies of China's regional tourism system by the econometric model. More specifically, the objective is to evaluate the impact of traffic development, urbanization level, and environment management on the operational efficiencies of four tourist service stages (travel agency, hotel, attraction, and dining) within a regional tourism system.

There are two points to be considered before building the econometric model. One is the restricted dependent variable. In the econometric model, the operational efficiency of each tourist stage estimated from the SBM-DNDEA model is taken as a dependent variable, separately, whose value ranges from 0 to 1. In contrast to the ordinary least square (OLS) model, the Tobit model is more suitably applied for coefficient estimation of the influencing factors on the censored dependent variable (Zhao et al. 2020).

The other point is spatial dependence (Tobler 1970), which assumes that the economic behaviour of a spatial unit (i.e., province-level administrative region in China) affects its neighbouring spatial unit via spatial interaction. This violates the assumption of independence in traditional econometric techniques. In other words, this may result in biased coefficient estimation if spatial dependence is ignored (Wu et al. 2017; Ma et al. 2022). Therefore, if the operational efficiency of each tourist stage of a regional tourism system has a remarkable spatial spillover effect, then the Tobit spatial model should be applicable instead of the general Tobit model.

If spatial dependence is not detected, then an ordinary panel Tobit would be suitable and constructed as follows.

$$\theta_{jt}^{TSS*} = \beta_i \sum_{i=1}^{5} X_{ijt-1} + \varepsilon_{ji} \tag{1}$$

Here, subscript jt represents the jth DMU (also the province-level sample) in year t; i represents there are five explanatory variables; θ_{jt}^{TSS*} denotes the operational efficiency obtained from the proposed SBM-DNDEA model for each tourist service stage (TSS), for the travel agency, the hotel, the attraction, and the dining within each regional tourism system (j); β_i denotes a vector of estimated coefficients; X_i is a vector of independent variables; and ε represents a random error term.

Global Moran's index. A spatial correlation test is generally necessary for spatial econometric modelling. The global Moran's index by Moran (1950) has been used extensively by a number of literature to confirm the existence of spatial dependence (Addae et al. 2022; Wan et al. 2023; Zhai and An, 2021), which is defined

as follows.

$$I_t = \frac{\sum_{j=1}^n \sum_{i=1}^n w_{ijt}(x_{it} - \bar{x}_t)(x_{jt} - \bar{x}_t)}{s^2 \sum_{j=1}^n \sum_{i=1}^n w_{ijt}} \qquad (2)$$

Here, w_{ij} denotes the spatial weight matrix. Following Wan et al. (2023), this paper constructs a spatial matrix based on geographical adjacency. If two spatial units are adjacent, their value is assigned to be 1 and zero otherwise. $x_{ijt}(\theta_{ijt}^{TSS^*})$ represents the operational efficiency of each tourist service stage within a regional tourism system in specific year t, and n denotes the number of spatial units (DMUs) in specific year t. The annual mean of operational efficiency in each tourist service stage is expressed by $\bar{x}_t(mean \quad \theta_t^{TSS^*})$, and the variance is defined by s^2.

Tobit spatial models. According to Zhao et al. (2020), if spatial dependence can be detected in the selected panel sample, then there are three kinds of spatial models - the panel Tobit spatial lag model (Tobit-SLM), the panel Tobit spatial error model (Tobit-SEM), and the panel Tobit spatial Dubin model (Tobit-SDM) - waiting for further identification, which one is more suitable. In this section the paper introduces them in turn as follows. First, if only spatial dependence can be found for a dependent variable among spatial units, then the Tobit-SLM model can be applied and is expressed as (Wan et al. 2023):

$$\theta_{jt}^{TSS^*} = \rho W \theta_{jt}^{TSS^*} + \beta_i \sum_{i=1}^5 X_{ijt-1} + \varepsilon_{ji} \qquad (3)$$

Here, $\theta_{jt}^{TSS^*}$ represents a dependent variable, and its definition is mentioned above; ρ stands for the spatial lag coefficient; W represents a spatial weight matrix; $W\theta_{jt}^{TSS^*}$ denotes its operational performance of each tourist service stage in the surrounding regions; and the other parameters are also the same as defined in Eq. (1).

Second, when the confirmed spatial dependence is caused by any omitted variables in the selected panel sample, the Tobit-SEM model can be applied and given by:

$$\theta_{jt}^{TSS^*} = \beta \sum_{i=1}^5 X_{ijt-1} + \varepsilon_{jt}; \quad \varepsilon_{jt} = \lambda W \varepsilon_{jt} + u_{jt} \qquad (4)$$

Here, λ represents the spatial error coefficient of the dependent variable; u denotes the random effort term of normal distribution; and all other variables and parameters have the same meaning and are defined in Eq. (3).

Third, the spatial Durbin model is used when it can be found that the dependent variable for a spatial unit is affected by the dependent and explanatory variables for its neighbouring spatial units (Zhao et al. 2020; Zhai and An, 2021). The Tobit-SDM model is described as:

$$\theta_{jt}^{TSS^*} = \rho W \theta_{jt}^{TSS^*} + \beta_i \sum_{i=1}^5 X_{ijt-1} + \varsigma W_i \sum_{r=1}^5 X_{ijt-1} + \varepsilon_{ji} \qquad (5)$$

Here, ς is a coefficients of the spatial lagged explanatory variables; $W_i X_{ijt-1}$ indicates the spatial lag of the spatial lagged independent variables. All other variables and parameters are also defined by the same meaning in Eqs. (3) and (4).

Selection and description of influencing factors. Traffic accessibility may play an important role in the development of a regional tourism system (Feng, 2023) because it increases tourist mobility, which provides a chance to increase the system's economic activity (Hou et al. 2021, Shu et al. 2023). The extant literature seems to focus on the impact of high-speed rail (HSR) connections in a tourism economy. This paper adopts a spatial perspective to analyse the influence of government transportation policy on a regional tourism system from a comprehensive view. Regional transportation policy is chosen as the main influencing factor (i.e., explanatory variable) on the operational efficiency of each tourist service stage within a regional tourism system. Three variables proxy for a regional transportation policy: regional government support (Rgs), regional rail infrastructure (Rrai), and regional road infrastructure (Rroi). Regional government support is measured by the ratio of the regional transportation budget to the fiscal budget (Wan et al. 2023). Regional rail infrastructure is expressed by the intensity of the railway length (kilometre) to the regional area (square kilometre) (Gao et al. 2019). Regional road infrastructure is measured by the intensity of road length (kilometre) to regional area (square kilometre) (Gao et al. 2019).

The study also controls for variables regarding the regional urbanization level (Rubl) and regional environmental protection investment (Repe), according to the regional external environment and economic growth theory. The regional urbanization level is the proportion of the urban population within the total regional population (Addae et al. 2022; Zhao et al. 2020). Regional environmental protection investment is expressed as total regional investment in controlling environmental pollution (Zhai and An, 2021).
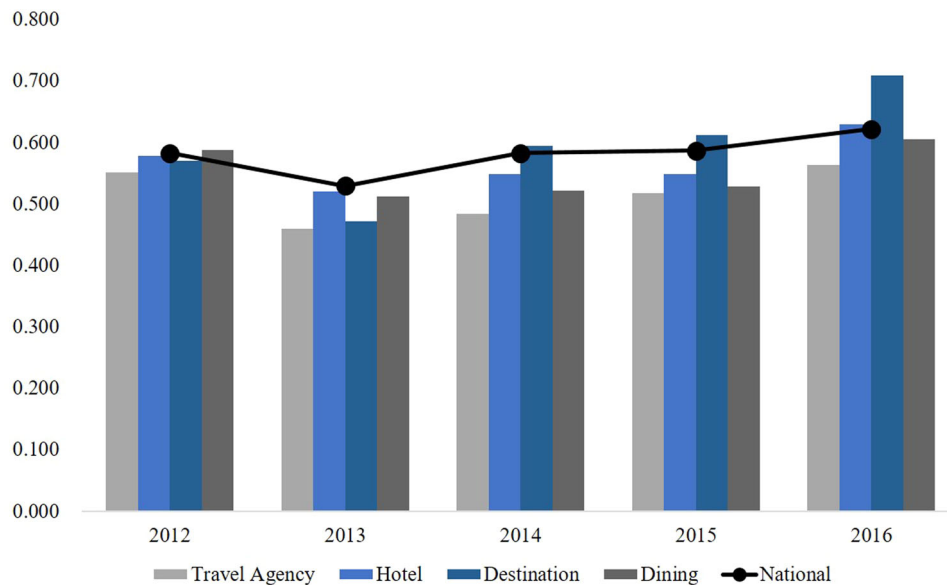
Empirical results
This section first shows the evaluation results of China's regional tourism system from the SBM-NDEA model and then examines whether spatial correlation exists where the Tobit and Tobit-SDM models are used.

Data collection and descriptive statistics. The main objective of this study is to construct a dynamic evaluation framework for a regional tourism system that includes interactions between stages and an intertemporal linkage. This study uses data from regional tourism systems in China, which comprises 34 provincial and special administrative regions that can be treated as DMUs. However, this study excludes Tibet, Macau, Hong Kong, and Taiwan due to a lack of data and different political systems, and only 30 provincial administrative regions (DMUs) are included in the selected cross-sectional sample to satisfy the homogeneous assumption of DEA specification. According to Chapter 19, Overall Strategies to Implement Regional Development of the Outline of the 11th Five-Year Plan (2006–2010) for National Economic and Social Development of the People's Republic of China, the nation is divided into four economic regions: northeast, east, central, and west. Hence, the selected 30 DMUs fall into these four economic zones based on their geographical locations, as listed in Table 3. To obtain a complete set of data, this study sets the starting point at 2012 and the end point at 2016. The

Table 3 The 30 regional tourism systems classified into the four economic blocks in China.

Economic block	Provinces
Northeast	Liaoning, Jilin, Heilongjiang
East	Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan
Central	Shanxi, Anhui, Jiangxi, Henan, Hubei, Hunan
West	Guangxi, Chongqing, Yunnan, Sichuan, Guizhou, Shaanxi, Ningxia, Gansu, Inner Mongolia, Qinghai, Xinjiang

Fig. 2 Operational performance movement. Operational performance trends of system and its tourist service stage have been gradually upward after 2013.

numbers of travel agencies (NTA), hotels (NH), spots (NS), and restaurants (NR) still operating at the end of 2011 are set as the initial values of the carry-over variables in each tourism service stage. The data for all the variables are from the *China Statistics Yearbook and the China Tourism Statistic 2013–2017*. To maintain consistency of the monetary terms, all monetary variables are adjusted to real RMB values in 2012.

Performance evaluation
Overall analysis at the national level. One of the advantages of the SBM-DNDEA model is that it can measure multiple-period performances for each evaluated unit and its subdivisions in a unified mathematical programming model through carry-over and intermediate variables. Accordingly, this approach can provide a common standard for intertemporal performance comparisons, which is also why it is superior to the static NDEA model (Yu et al. 2016). Hence, this paper investigates the trend of performance change for each regional tourism system and its stages from 2012 to 2016.

Figure 2 displays the average performance trend of China's regional tourism systems and their service stages obtained by the SBM-DNDEA model. From the national governance perspective and looking first at the average periodical performance score of 30 regional tourism systems, its value is 0.590 and ranges from 0.583 (2012) to 0.622 (2016). This indicates that the average regional tourist system performance score is increasing gradually, but in general, there is room for improvement of ~40% to reach the efficient frontier (i.e., a score equal to 1.000).
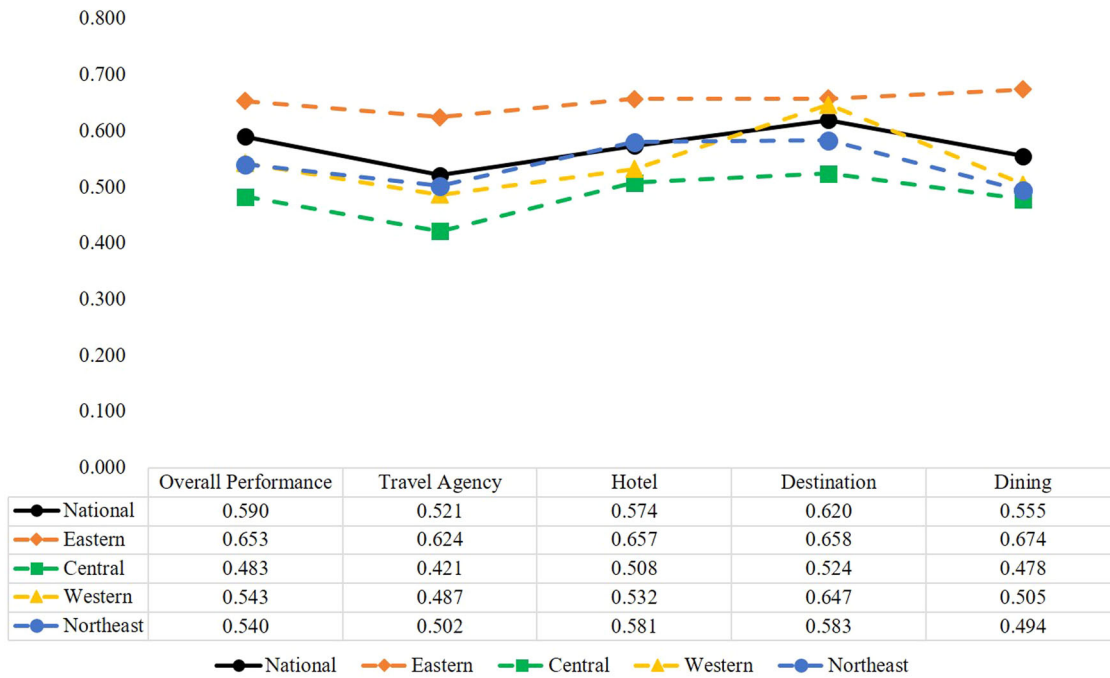
Since a region's system performance is measured by the weighted average performance of the travel agency, hotel, attraction, and dining service stages, this paper can determine the separate contributions of those to the whole tourist system. As shown in Fig. 2, the travel agency, tourist hotel, and dining service stages are always lower than the average of the regional tourism system over the assessment period, whereby the travel agency is the worst performer. This means that the primary reason why a regional tourist system still exhibits underperformance comes from the travel agency stage. On the other hand, the average performance of the attraction stage is obviously greater than that of other tourist stages.

In summary, during the study period (2012–2016), there was low efficiency in 2013, implying that underperformance in the travel agency stage may have had negative spillover effects on other stages. However, there were slight increases in the performances in all four stages after 2015. The performance fluctuations during this period may be due to the implementation of the China Tourism Law in 2013, which regulated the behaviour of various stakeholders within the tourism industry. As a result, the number of group tours declined sharply, and the number of independent tours began to grow. Traditional travel agencies clearly face a business transition (Ma et al. 2015).

Regional discrepancy analysis. Figure 3 shows the average regional tourism system and its tourist stage performance within four economic zones of China from 2012 to 2016. As shown in Fig. 3, the east region scored the highest in overall system performance, reaching 0.653, followed by the west (0.534), northeast (0.540), and central (0.483) regions, indicating an obvious imbalance among those economic zones except that the performances of the west and northeast regions are close to each other. Comparing the performances of all four tourist stages by economic zone, the difference in average overall system performance can be attributed to the dining, travel agency, and hotel tourist stages in sequence. The degrees of performance deviation for these three are obviously greater than those in the attraction service stage (also shown in the second line from the bottom of Table 4). In summary, an unbalanced economic development strategy, which can be traced to the reform and opening up since 1978, has played a crucial role in China's regional economies. The eastern economic zone received much of the nation's resources to realize a greater gross domestic product per capita, infrastructure, foreign direct investment, and urbanization. Such distinct economic resource segmentation results in relatively worse tourism performance in the northeast, western, and central economic zones.

The average overall system scores and rankings of each regional tourism system in China, as well as its scores and rankings for the travel agency, the hotel, the attraction, and the dining stages, are presented in Table 4. The overall system performance of the east region is 0.653 (see Fig. 3), which is higher than the national average level (see the last three rows in Table 4). Guangdong stood at the efficient frontier (score equal to

	Overall Performance	Travel Agency	Hotel	Destination	Dining
National	0.590	0.521	0.574	0.620	0.555
Eastern	0.653	0.624	0.657	0.658	0.674
Central	0.483	0.421	0.508	0.524	0.478
Western	0.543	0.487	0.532	0.647	0.505
Northeast	0.540	0.502	0.581	0.583	0.494

Fig. 3 Performance comparison of four economic zones. The average operational performance of the system and its four tourist service stages under the economic zone comparison is shown.

Table 4 Overall and stage economic performance scores of regional tourism systems in China.

No.	Economic zones	DMU	Overall Performance		Travel Agency		Hotel		Attractions		Dining	
			Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
1	East	Beijing	0.919	6	0.954	5	0.950	5	0.813	8	0.958	5
2		Tianjin	0.635	11	0.599	10	0.680	11	0.547	17	0.715	8
3		Hebei	0.248	29	0.222	26	0.208	29	0.426	25	0.135	30
9		Shanghai	0.987	3	1.000	1	1.000	1	0.948	4	1.000	1
10		Jiangsu	0.564	13	0.572	12	0.439	18	0.627	12	0.617	12
11		Zhejiang	0.529	16	0.451	17	0.620	12	0.554	16	0.492	17
13		Fujian	0.563	14	0.508	15	0.466	16	0.619	13	0.658	10
15		Shandong	0.324	27	0.313	21	0.259	28	0.235	30	0.490	18
19		Guangdong	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1
21		Hainan	0.766	8	0.626	9	0.949	6	0.813	9	0.676	9
4	Central	Shanxi	0.451	17	0.377	18	0.492	15	0.568	15	0.366	21
12		Anhui	0.350	23	0.305	22	0.323	25	0.502	20	0.273	25
14		Jiangxi	0.920	5	0.870	6	0.929	7	0.990	3	0.892	6
16		Henan	0.446	18	0.220	27	0.575	13	0.483	23	0.507	16
17		Hubei	0.354	22	0.304	23	0.313	27	0.348	27	0.452	19
18		Hunan	0.376	19	0.452	16	0.417	19	0.255	29	0.380	20
5	West	Inner Mongolia	0.228	30	0.152	30	0.201	30	0.272	28	0.286	24
20		Guangxi	0.357	21	0.353	19	0.342	22	0.522	19	0.211	27
22		Chongqing	0.784	7	0.755	7	0.775	9	0.722	11	0.883	7
23		Sichuan	0.556	15	0.509	14	0.529	14	0.587	14	0.597	13
24		Guizhou	0.700	9	0.687	8	0.783	8	0.763	10	0.568	14
25		Yunnan	0.620	12	0.523	13	0.441	17	0.869	7	0.646	11
26		Shaanxi	0.350	23	0.291	24	0.317	26	0.446	24	0.346	22
27		Gansu	0.317	28	0.188	29	0.332	24	0.490	21	0.260	26
28		Qinghai	0.696	10	0.580	11	0.733	10	0.912	5	0.558	15
29		Ningxia	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1
30		Xinjiang	0.363	20	0.318	20	0.402	21	0.530	18	0.204	28
6	Northeast	Liaoning	0.968	4	1.000	1	0.997	4	0.877	6	1.000	1
7		Jilin	0.326	25	0.217	28	0.413	20	0.385	26	0.290	23
8		Heilongjiang	0.326	25	0.291	25	0.332	23	0.489	22	0.192	29
	Mean		0.590		0.521		0.574		0.620		0.555	
	Std. Dev.		0.246		0.275		0.271		0.231		0.277	
	Efficient DMU	2			4		3		2		4	

Table 5 Differential rate of input, intermediate, and carry-over variables of four service stages in 2016.

No.	DMU	Travel agency			Hotel		Attractions		Dining	
		EE	NTA	NT	EE	NH	EE	NS	EE	NR
1	Beijing	0.00	7.71	−0.02	0.00	0.01	0.00	0.00	−0.04	0.20
2	Tianjin	−1.60	−43.04	−13.56	0.00	−21.96	0.00	21.31	−16.33	36.54
3	Hebei	0.00	−69.04	51.02	−49.10	−38.07	0.00	−15.49	−50.92	−43.19
4	Shanxi	−37.89	−43.50	−5.30	0.00	−11.58	−14.23	7.34	−28.07	5.02
5	Inner Mongolia	0.00	−59.60	7.69	−34.71	−40.28	0.00	−45.69	−23.07	−5.56
6	Liaoning	0.00	0.00	0.00	0.00	0.00	0.00	12.70	0.00	0.00
7	Jilin	0.00	−60.32	−60.69	0.00	−1.63	0.00	−41.30	0.00	−28.91
8	Heilongjiang	0.00	−57.33	−30.80	−18.19	−25.43	0.00	−39.53	0.00	−17.83
9	Shanghai	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	Jiangsu	−33.16	−58.05	−8.79	−40.88	−18.24	−2.17	−51.59	−25.40	−23.43
11	Zhejiang	0.00	−37.94	0.53	−2.72	−2.51	0.00	−24.59	−15.62	−29.54
12	Anhui	0.00	−48.66	87.54	−10.46	−28.85	−18.77	−57.30	−35.23	−55.59
13	Fujian	−38.60	−26.31	−79.82	−36.44	−47.93	0.00	8.18	−9.15	−21.13
14	Jiangxi	0.00	1.52	0.00	−2.09	−1.37	0.00	0.00	0.00	−7.32
15	Shandong	0.00	−49.58	−71.99	−42.10	−25.24	−55.42	−70.68	−6.80	−25.74
16	Henan	0.00	−53.14	16.57	−26.03	−68.93	0.00	−31.15	−14.46	−42.11
17	Hubei	0.00	−27.35	−33.72	−25.42	−49.66	−33.86	−23.20	−10.18	−19.53
18	Hunan	0.00	−27.28	−65.64	−30.98	−25.66	−59.19	−6.66	−17.85	−27.76
19	Guangdong	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	Guangxi	−35.92	−43.13	−49.40	−43.98	−34.75	0.00	−31.81	−46.04	−34.63
21	Hainan	−24.73	−27.73	0.00	0.00	0.00	0.00	244.94	0.00	0.00
22	Chongqing	−5.31	−25.50	0.00	−3.64	−21.30	0.00	4.33	0.00	0.00
23	Sichuan	0.00	0.78	−40.07	−14.55	−48.94	−27.77	−35.15	−23.63	−12.78
24	Guizhou	0.00	−10.46	0.00	0.00	−56.23	0.00	0.00	−25.37	−59.98
25	Yunnan	−38.81	−52.09	69.04	−56.65	−52.60	0.00	32.53	−29.79	−47.38
26	Shaanxi	0.00	−34.60	−82.70	−33.15	−62.00	0.00	−20.61	−29.27	−37.86
27	Gansu	0.00	−50.71	106.67	−45.12	−36.14	0.00	−25.87	−34.85	−41.22
28	Qinghai	−14.70	−45.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	Ningxia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	Xinjiang	0.00	−40.69	255.37	−10.63	10.31	0.00	−45.28	−18.71	−9.81
	Average	−7.69	−32.71	1.73	−17.56	−23.63	−7.05	−7.82	−15.36	−18.32

Note: EE is the number of full-time employees; NTA is the number of travel agencies operating at the end of the year; NT is the number of tourists received from the travel agency; NH is the number of hotels operating at the end of the year; NS is the number of spots operating at the end of the year; and NR is the number of restaurants operating at the end of the year.

1) from 2012–2016 and has become a benchmark for other provinces (DMUs) in the eastern economic zone to learn how to promote their tourist service. It is not surprising to see that Guangdong is an efficient DMU since it belongs to the Guangdong-Hong Kong-Macao Greater Bay Area and is an international gateway to southern China. The worst performer in the east region is Hebei (0.248). This might be because the economic and cultural development of Beijing and Tianjin is better than that of Hebei, which may decrease the attraction of native and foreign tourists. If a DMU is not evaluated as efficient, then it has room for improvement in its tourist service stages. From Table 3, for instance, Shanghai is efficient in 3 stages (travel agency, hotel, and dining service) and only lags slightly behind Guangdong in the attraction service stage. This means that Shanghai tourism could improve its overall performance by improving its attraction services.

For the performance results of individual service stages, Table 4 shows that in the travel agency stage and the hotel stage, Shanghai, Guangdong, and Ningxia are the top three performers. Nevertheless, Inner Mongolia, Gansu, and Jilin are the bottom three in the travel agency stage, and Inner Mongolia, Hebei, and Shandong are the bottom three in the hotel stage (e.g., Inner Mongolia is also the worst overall performer of the two stages above). In the attraction stage, Jiangxi was one of the top 3 performers, along with Guangdong and Ningxia. Inner Mongolia, Shandong, and Hunan are the bottom three provinces. In the dining service stage, Shanghai, Guangdong, and Ningxia still held their top positions, while Hebei, Xinjiang and Heilongjiang were

the 3 worst underperformers. Overall, the best (worst) performing provincial administrative regions (DMUs) are more likely to maintain their positions in all stages.

The way to become an efficient frontier. To design a better policy for performance enhancement, the (efficient) frontier projection from the DEA model is another important managerial tool that provides useful information to decision-makers in addition to performance evaluation. By measuring the difference in each variable with respect to the corresponding efficient frontier, the DEA model can reveal information on changes in variables in each stage to obtain an efficient DMU. This study uses data from 2016 to demonstrate these effects. Table 5 summarizes the differences in each variable with respect to the projected EF. A positive value indicates that the specific variable should be increased in percentage terms based on its actual value, whereas a negative value indicates that the specific variable should be decreased likewise.

According to the results in Table 5, because Guangdong, Ningxia, and Shanghai were ranked first in 2016, there were no changes in the variables in any stage. At the national level (in the last row of Table 5), several planning suggestions can be made to increase the performance of tourism systems. For instance, if the growth rate of the number of tourists can further increase to at least 1.73%, then the travel agency service, on a national average, could be ranked as efficient. In the hotel stage, if the number of employees could be reduced by 17.56% and the number of hotels could be reduced by 23.63%, then the hotel stage, on average,

Table 6 Estimation results of the panel random-effect Tobit/Tobit spatial Dubin Models.

Variable	Travel agency performance Model 1 (Tobit)	Hotel performance Model 2 (SDM)	Attraction performance Model 3 (SDM)	Dinning performance Model 4 (Tobit)
Rgs	0.889	−0.109	−0.174	0.703
	(0.738)	(0.649)	(0.710)	(0.689)
Ln(Rrai)	0.064	0.021	−0.005	0.129*
	(0.077)	(0.062)	(0.064)	(0.078)
Ln(Rroi)	0.072	0.111*	0.127**	0.141*
	(0.074)	(0.062)	(0.066)	(0.073)
Rubl	0.480***	0.341***	0.276**	0.515***
	(0.182)	(0.091)	(0.115)	(0.223)
Ln(Repe)	0.036	−0.004	0.014	0.031
	(0.023)	(0.016)	(0.018)	(0.022)
W*Rgs		−0.414	−0.660**	
		(0.312)	(0.319)	
W*Ln(Rrai)		−0.021	−0.066**	
		(0.026)	(0.031)	
W*Ln(Rroi)		−0.017	−0.059**	
		(0.020)	(0.025)	
W*Rubl		0.123***	0.055	
		(0.036)	(0.043)	
W*Ln(Repe)		0.005	−0.023**	
		(0.009)	(0.011)	
Rho		−0.084***	0.043*	
Moran's I	0.103**	0.153***	0.122**	0.138**
Wald SLM/SDM	6.05	13.62**	16.83***	9.34*
Wald SEM/SDM	6.30	15.49***	17.94***	10.15*
LR SLM/SDM	5.72	12.97**	15.75***	8.99
LR SEM/SDM	5.98	14.29**	16.69***	10.05*
LR Random	23.71***			47.76***
LR SAR vs OLS		9.783***	2.973*	
LR WX's		26.271***	20.563***	
F		34.315***	20.960***	
Observations	150	150	150	150

Note: All the determinants of operational performance for 4 tourist stages are lagged by 1 year; Robust-standard error of each independent variable is reported in parentheses; *, **, and *** indicate significance at the 10%, 5%, and 1%, respectively.

could also rank in the efficient frontier. These results also suggest that overcompetition and overemployment issues exist in the hotel, attraction, and dining stages.

From the viewpoint of an individual regional tourism system, it is important to expand the demand for tourism services; that is, increasing the number of tourists could imply greater consumption potential. The provinces ranked in the bottom ten in Table 4, such as Hebei, Anhui, Gansu, and Xinjiang, could benefit from measures to attract more tourists. In addition, most tourism service stages seem to encounter the problem of overcompetition. Measures for market restructuring, such as exit strategy consultation or merger mechanisms, could help to alleviate overcrowding. For the tourist destination service stage, Tianjin, Hainan, and Yunnan can consider the unique characteristics of their own tourism resources as the direction for development.

Tobit spatial model estimation results
Spatial correlation test. Spatial autocorrelation analysis is used to identify whether a spatial distribution of China's regional tourism system performance exists. Table 6 lists the Global Moran's I indices of the overall system's and each tourist service stage's performances. All the values of the index are positively significant at the 5% level, indicating that the overall system's and each tourist service stage's operational performances may have spatial clustering situations rather than just random distributions. Hence, it may be necessary to consider the panel spatial Tobit model to

analyse the influencing factors of the operational performance of China's regional tourism system and its tourist service stages.

Estimation of Tobit and Tobit-SDM. Table 6 reports the regression results of the ordinary panel Tobit and panel Tobit Durbin models on the operational performance of the four tourist stages within China's regional tourism system. To determine whether the panel Tobit spatial Durbin model (Tobit-SDM) needs to be used, either the Wald test (SLM/SDM and SEM/SDM) or the LR test (SLM/SDM and SEM/SDM) can be applied. The test results in Table 6 indicate that the Tobit-SDM may be an appropriate model for estimating the coefficients of influencing factors in the hotel, attraction, and dining service stages. In addition, if the Tobit-SDM model is applied for the then travel agency stage (Model 1) or the dining stage (Model 4), the results show that the spatial coefficient (Rho) of Model 1 and Model 4 is not significant. Hence, the ordinary panel Tobit model is selected to investigate the effect of influencing factors on the operational performance of the travel agency stage and the dining stage.

The ordinary Tobit models can be divided into three types: hybrid, random effects, and fixed effects. However, the fixed effect of the panel Tobit model does not present a consistent result from the unrestricted condition (Greene, 2004). To select an appropriate form of the panel Tobit model, both the LR tests (hybrid vs. random) of Model 1 and Model 4 reject the null hypothesis at the 1% level, indicating that the panel Tobit model with random effects is better than the hybrid model.

In the travel agency stage, Model 1 of Table 6 shows that, under a panel Tobit model with random effects, the coefficients of the three types of government transportation policies are positive but not statistically significant. The influence of Rubl is positively significant, which shows that an increase in the urbanization level in a local region can lead to an improvement in the operational performance of the travel agency stage.

In the hotel service stage, in Model 2 of Table 6, the coefficient of road infrastructure intensity (Rroi) is significantly positive. This shows that an increase in regional road infrastructure intensity effectively facilitates the operational performance of hotel services within a regional tourism system. The coefficients of Rubl and W*Rubl are significantly positive, meaning that a rise in the urbanization level in the local (neighbour) region can enhance the operating conditions of the hotel service stage located in two adjacent regions.

In the attraction stage, in Model 3 of Table 6, the coefficient of Rroi is significantly positive, implying that an increase in regional road infrastructure intensity remarkably facilitates traffic convenience for native and foreign tourists who are willing to visit any local attractions. This approach will greatly benefit the operational performance of the attraction service stage within a regional tourism system. The spatial coefficients of W*Rgs, W*Rrai, and W*Rroi are significantly negative, meaning that an increase in the ratio of transportation expenditure to the fiscal budget, railway infrastructure intensity, and road infrastructure intensity in the neighbouring region inhibits the operational performance of the attraction stage in the local region. This means that an adjacent region with more convenient traffic creates a siphon effect, and it is possible that the number of tourists arriving at a local attraction decreases.

In the dining service stage, in Model 4 of Table 6, the coefficients of Rrai and Rroi are significantly positive, which also has a probable siphon effect on the operational performance of the dining stage. Relatively complete rail and road traffic infrastructures can bring tourists who come from a far or neighbour region with great mobility. In addition, the purchasing power of people living in local regions for eating out increases when the urbanization level increases. This indicates that the dining service can possibly be effectively transformed into greater service revenue, thus benefiting the operational performance of the dining service stage within a regional tourism system.

Conclusion

This study proposes a performance evaluation framework for China's regional tourism system, which focuses on travel agencies and their cooperation with other tourist service stages, to identify all the operational performances of each regional tourism system and its tourist stages in each period and throughout the whole research period. The feature of this framework is that the intermediate linkage between service stages and the carryover variables of each stage between consecutive periods are included to provide appropriate measures of performance. The operational process of regional tourism systems comprises four tourism service stages: travel agency, hotel, attraction, and dining.

Using panel data from 30 provincial-administrative regions for China's tourism industry from 2012–2016, the operating performance of each regional tourism system and its tourist stages are measured by the SBM-DNDEA model (Tone and Tsutsui, 2014). Furthermore, the spatial effect of regional tourism system operational performance and its influencing factors (e.g., urbanization level, degree of environmental management, and level of traffic development) are investigated via the Tobit-SDM model. The main findings are as follows.

First, for most regional tourism systems, operational performance remained relatively low during the period 2012–2016, likely due to the low utilization of input resources. In addition, there are distinct differences in the average operational performance of China's regional tourism system among the four economic zones. The east region is the best performing region and has more considerable benefits from opening-up policies. This result is in accordance with the extant literature (Chaabouni, 2019).

Second, the attraction stage outperforms the other three tourism service stages and exerts a positive agglomeration effect. The government intends to provide fiscal support for attraction-related investment and construction through tourism development policies. Different types of attractions are created by combining the characteristics of tourism resources in different places to increase tourists' attraction choices and meet their needs. This means that government support for the construction of attractions significantly promotes the operational performance of the regional attraction service stage and has a spillover effect from the local region to the surrounding region. In addition, traffic conditions and environmental management are not conducive to enhancing the tourism performance of adjacent attractions. This study concludes that the performance of attractions depends not only on the characteristics of their own tourism resources but also on other complementary measures (e.g., transportation and transfer, internet services) that together provide a good tourism environment. Therefore, the better the transportation conditions and environment management are, the less tourists may visit adjacent attractions based on attractive choices. This argument is similar to that of Li et al. (2022), who concluded that an increase in tourism service facilities is not useful in resolving the management pressure of overpopulated attractions. This also highlights the importance of the systematic integration and allocation of resources for tourism development.

Third, the performance of the travel agency is the worst among the four tourism service stages, indicating that it is also the main source of inefficiency for a regional (national) tourism system. In other words, the travel agency stage does not live up to its full potential as an intermediator in a regional tourism system. The literature has implied that when digital technology becomes ubiquitous, it also affects tourism in major ways. Not only does it change the way the various stages of the tourism system operate, but it also reshapes tourist behaviour (Chiappa, 2013; Sharma et al. 2020), leading to decentralization of the products offered by travel agents (Huang et al. 2020). This result also reminds travel agents to change their business practices in response to the digital era to be more competitive.

Fourth, the estimation results of the Tobit-SDM model indicate that the degree of urbanization will lead to better performance of hotels in adjacent areas. This may be due to the increase in the urban population, which will lead to an increase in travellers travelling to and from the city and thus increase the demand for accommodation. In other words, accommodation facilities satisfy the needs of tourists, and the needs of businesses are also an important segment, especially when tourists provide services that meet the needs of different target segments to increase hotels' revenue.

The following policy and management implications are proposed according to the results of the tourism performance and spatial analysis. First, the ability of travel agents to collaborate online in other stages has become a major competitive model (Chiappa, 2013; Sharma et al. 2020). Several scholars have found that various groups (e.g., elderly individuals) and product types (e.g., high-risk tourists) still rely on travel agents to provide services (Chiappa, 2013; Kim and Kim, 2004). Travel agencies should combine their strengths (such as professional service advisors or product packaging capabilities) with those of other departments to provide personalized products, forming a professional cooperation

model that meets "high tourism quality" and "specific needs", strengthening their role in the tourism system and thus improving the performance of the tourism industry.

Second, there is a correlation between tourism performance and spatial characteristics. Providing comprehensive upgrading of industries, facilities, or services in a region through the tourism system is a way to promote coordinated regional development. This result confirms the concept of promoting the "all-for-one tourism" policy. However, when upgrading the quality of tourism holistically, it is worthwhile to consider creating tourism products with local features and in-depth experience to avoid homogeneous and shallow tourism.

The tourism system involves many stages, and the results of this study are limited in interpretability because the data available from the input/output indices and the research framework do not allow more stages to be included in this study of tourism performance. In addition, considering the wide coverage of the tourism industry, environmental protection investment is not categorized by tourism stage or element. Future studies could explore this issue and enhance the explanatory power of the impact of the macro level environment on tourism performance.

Data availability
The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation. All research data can be open-shared free in Dataverse (https://doi.org/10.7910/DVN/GHYB8I).

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Author contributions

SH: Conceptualization, methodology, writing- original draft preparation. TY: Data curation, investigation, software, writing- reviewing and editing. WC: Conceptualization, validation, supervision, writing- reviewing and editing.

Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

Informed consent

This article does not contain any studies with human participants performed by any of the authors.

Competing interests

The authors declare no competing interests.

Additional information