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Spatiotemporal analysis of regional tourism development: A semiparametric Geographically Weighted Regression model approach

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ABSTRACT

Tourism development is an important topic within tourism and regional studies. However, previous studies have lacked focus regarding the coexistence of spatial and temporal effects, where the mixed analysis of global and local influencing factors has been limited. This paper employs a semiparametric GWR model to explore the spatiotemporal relationships between regional tourism economy and influencing variables. Results indicate that in the areas of better tourism economic development, spatiotemporal lag factors play a key promotion role, while in the areas of lower tourism economic development, spatiotemporal lag factors play a restraining role. In comparison with traditional analysis methods, semiparametric GWR was found to be superior in analyzing regional tourism economies as it accounts for spatiotemporal relationship at both global and local scales.

1. Introduction

As society continues to develop, tourism has become a key industry in the global economy (Yao & Fotheringham, 2016). The development of tourism is dependent on the economic level of a nation, which in turn can be promoted (directly or indirectly) by increased levels of tourism (Pratt, 2015). The economic and social benefits of tourism include the effective promotion to adjust and optimize industrial infrastructure, increased employment opportunities and improvements to quality of life (Jin, Cheng, Xu, & Huang, 2018).

Concerning these economic and social benefits, existing literature has paid attention to the development of regional tourism. This has included a focus on the influencing factors of tourism development such as tourist attractions, international trade, economic expansion, infrastructure, and globalization (Yang & Fik, 2014; Rutty, Gössling, Scott, & Hall, 2015; Luo, Qiu, & Lam, 2016), as well as the impact of tourism on regional economic growth and urbanization (Khadaroo & Seetanah, 2007; Qian, Feng, & Zhu, 2012; Chen & Haynes, 2015; Albalate & Fageda, 2016; Samimi & Sadeghi, 2017). Concerns regarding the social and environmental impacts of tourism development have also been highlighted (Cárdenas-García, Sánchez-Rivero, & Pulido-Fernández, 2015; Pratt, 2015).

The development of a regional tourism economy takes place within a complex system (Jin, Huang, Xu, & Gu, 2013), and thus, spatial and temporal issues cannot be ignored. Indeed, more attention is increasingly being paid to the development of tourism from a spatiotemporal perspective (see Section 2). Here, the primary interests concern space-time analysis (both cross-sectional and pooled), specifically spatial dependence and spatial heterogeneity. Spatial dependence can be caused by various spatial spill-over effects, while heterogeneity can result from inherent differences between spatial units and from contextual variation over space (Anselin, 1988).

Further consideration of spatial heterogeneity and spatial dependence of tourism development should address two aspects; the spatial heterogeneity of influencing factors and the relationship between spatial dependence and spatiotemporal lag. Previous analysis of, influencing factors concluded that they were stationary, and so global regression models were used to explore these influences. However, due to spatial heterogeneity, discussion of tourism development is needed at a local level. To explain local variables, models such as the Geographically Weighted Regression (GWR) model (Fotheringham, Brunsdon, & Charlton, 2002) and Spatial Autoregressive Local Estimation (SALE) model (Pace, LeSage, 2004) have been suggested. Indeed, these two models have been used in tourism analysis where all factors were considered to be non-stationary (Jin et al., 2018; Deller, 2010). However, analysis can still be limited when influencing factors are considered as either stationary or non-stationary (Yao & Fotheringham, 2016). Thus, studying regional tourism development from a mixed

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perspective that incorporates both local and global aspects, rather than separating global and local aspects for isolated analysis, is recommended.

Regional tourism development is not only affected by influencing factors, but also by spatial dependence which can be represented by levels of tourism development in neighboring areas (Pike, Rodríguez-Pose, & Tomaney, 2017). Thus, it is required to discuss the temporal lag in the neighborhood space, taking a spatiotemporal perspective to build the lag variable. Furthermore, where the spatiotemporal lag is spatially non-stationary, it can be used as basis to analyze spatial heterogeneity, and thereby to discuss the influence of spatiotemporal lag on regional tourism development over time.

Tourism has become a strategic pillar industry of economic development for the national economy, with rapid urbanization and increased disposable income stimulating the travel demands of residents (Huang & Chen, 2016). However, rapid development has also brought inequality (Li, Chen, Li, & Goh, 2016; Yang, 2012), where spatial heterogeneity is observed in regional tourism growth (Yang & Fik, 2014), socioeconomic status (Jiang, 2009) and inbound tourism (Zhang, Lan, Qi, & Wu, 2017). Considering the spatial heterogeneity of tourism development, the Jiangsu Province of China has been identified as an example to explore the spatiotemporal model of regional tourism development due to the rapid development of its tourism industry.

The main contribution of this paper is to explore spatiotemporal heterogeneity within factors that influence regional tourism development and to consider the inclusion of spatiotemporal lag within a semiparametric GWR model when a mixed, global and local, perspective is taken. Using this mixed perspective, semiparametric GWR analysis has been used in studies concerning housing price (Yao & Fotheringham, 2016), hotel price (Latinopoulos, 2018) and population distribution (Huang, Zhao, Song, Chen, & Li, 2018). This paper is structured as follows, a literature review first introduces the use of spatiotemporal analysis and its application to tourism development, the research area is then introduced followed by data collection and analysis methods. Next, a semiparametric GWR model is used to discuss the spatiotemporal heterogeneity of relevant variables that influence regional tourism development. To conclude, the main findings and important contributions of this paper are then summarized.

2. Literature review: spatiotemporal analysis of tourism

Dimensions of time and space create a basic framework upon which understanding of social, cultural, political and economic activities are based (Hall, 2005). Tourism development is no exception, where regional tourism economy often develops within a complex system and thus requires the inclusion of spatial and temporal dimensions.

In terms of spatial dimensions, the tourism industry, and thus tourism activities, are dependent on the area in which they are based (Jin et al., 2013), and so tourism development not only varies between areas, but is also influenced by surrounding areas. This highlights the importance of spatial heterogeneity as a key research focus. Spatial heterogeneity of tourism includes the following aspects; tourism economy (Yang & Fik, 2014), tourism development efficiency (Zha & Li, 2017), inequality between tourism development and residents' income (Sarrión-Gavilán, Benítez-Márquez, & Mora-Rangel, 2015) and tourism supply (Incera & Fernández, 2015). Attempts have been made to explore spatial agglomeration characteristics to analyze the spillover effect of tourism development (Lazzeretti & Capone, 2009; Ma, Hong, & Zhang, 2015), including the agglomeration effect and its relationship with neighboring regions in regional tourism development (Majewska, 2015; Karmanova, Podsevalova, Zikirova, Silaeva, & Leonova, 2015). In terms of spatial influence, previous studies have employed the Spatial Lag Model (SLM) and Spatial Error Model (SEM) (Anselin, 1988) to analyze spatial influence of tourism (e.g., Capone & Boix, 2008; Marcouiller, Kim, & Deller, 2004).

In terms of temporal dimension, economic development has always influenced by the regional economic basis (Li & Wei, 2010; Pike et al., 2017), where the same can be said for the development of the tourism economy. Understanding history and background is therefore conductive in understanding current and future tourism development (Saarinen, Rogerson, & Hall, 2017). The dominant evolution model regarding destination is the Tourist Area Life Cycle (TALC) model (Butler, 1980), which analyzes of tourism development processes from the perspective of time. Likewise, time series data is used to analyze tourism development and its contribution to economic growth (e.g. Brida, Carrera, & Risso, 2008; Dritsakis, 2004; Tang, 2011), and panel data has been used to analyze regional tourism development (e.g. Brida, Punzo, & Risso, 2011; Fayissa, Nsiah, & Tadesse, 2008; Lee & Chang, 2008). The inclusion of temporal lag within dimension analysis has been used to analyze the impact of historical basis on the development of tourism economy in models such as Autoregressive Distributed Lag (ADL) model (Li, Park, & Seo, 2011) and Time Varying Parameter Error Correction Model (TVP-ECM) (Li, Wong, Song, & Witt, 2006).

Based on spatial and temporal analysis, attempts have been made to conduct more in-depth analysis from the perspective of combining the spatial and temporal aspects of tourism, particularly focusing on the spatiotemporal heterogeneity of tourism development. Spatiotemporal analyses have including inbound tourism development (Wang, Yi, & Wang, 2015), reducing income inequality (Li et al., 2016), relationship between hotel industry and transportation (Li, Fang, Huang, & Goh, 2015) and sustainable tourism development (Sijtsma, Broersma, Daams, Hoekstra, & Werner, 2015).

Previous studies concerning the spatiotemporal analysis of tourism have found that heterogeneity is common within many aspects of tourism development including attraction distribution, tourism economy and tourist flow (Jiang, 2009; Jin et al., 2018; Zhang, 2009). However, with a focus on the development of tourism itself, these studies have often neglected to discuss the heterogeneity of influencing factors. Furthermore, where heterogeneity analysis has been complete, often spatiotemporal lag is overlooked. By addressing these shortcomings, this study provides a new perspective to understand the impact of influencing factors to tourism economy development through heterogeneity analysis.

3. Methodology

3.1. Study area

Jiangsu Province, located in the east of China, covers an area of 102.6 thousand km^2 (Fig. 1). Encompassing 63 counties and cities, Jiangsu is often divided into three areas; Northern (29 counties), Central (16 counties), and Southern (18 counties), which when compared, demonstrate massive variations in economic development. In 2014, Jiangsu's Gross Domestic Product (GDP) was 6.51 trillion yuan RMB (JBS, 2015) making it one of the most important economies in China. The contribution of the tourism industry in Jiangsu was 5.5% GDP in 2014 (JBS, 2015) making it a pillar industry in the Province. In fact, the tourism industry has increasingly played an important role in overall national economic development, making Jiangsu Province an ideal and typical study area for this topic.

3.2. Data collection

As incomes has increased over China, the domestic travel demands of residents has also increased. This increase in domestic tourism has played an increasingly important role in the development of China's tourism industry. For example, in Jiangsu Province income from domestic tourism contributed 97.69% of the total tourism income in 2014 (JBS, 2015).

To discuss regional tourism development, this paper utilizes domestic tourism revenue data for each county in Jiangsu between 2010 and 2014, published in the *Tourism Development Report of Jiangsu*

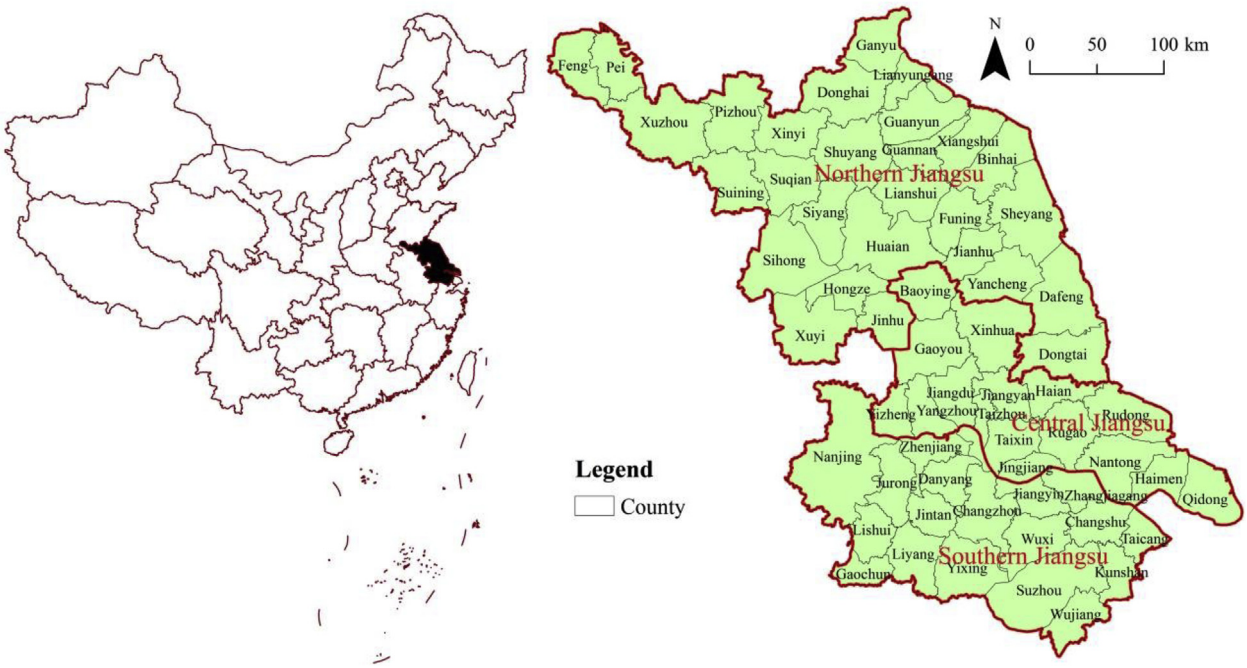

Fig. 1. Study area.

Province 2014 (JPTB, 2015). Furthermore, to discuss the impact of influencing factors (primarily spatial and socio-economic aspects) of regional tourism development, this paper also utilizes data related to spatial distance, such as the distance between counties, where data was obtained through Baidu map (https://map.baidu.com/), and socio-economic statistical data, where data was obtained at the county level from the *Jiangsu Statistical Yearbook 2014* (JBS, 2015).

3.3. Methods

3.3.1. Semiparametric GWR

This study employed semiparametric GWR to analyze the spatial relationship between regional tourism economic development and related factors at both global and local levels. The semiparametric GWR model is an extension of a traditional GWR model, which is a technique to model spatial aspects at a local level (Fotheringham et al., 2002; Nakaya, Fotheringham, Brunsdon, & Charlton, 2005). The traditional GWR model is based on a global regression model of regional tourism development and expressed by Equation (1):

$$T_i = \sum_j \beta_j X_{ij} + \varepsilon_i \tag{1}$$

where i and j are index of observations and covariates; T represents tourism income; X represents the covariate; β represents the parameter of various covariates; and ε is the error term. All data within Equation (1) are considered global, with the obtained parameter estimate assumed to be stationary in space. As previously noted, to capture the complexities of the tourism economy, non-stationary spatial aspects should be included and so a more flexible spatial model is required. GWR is a local modelling technique that can capture spatial variations in processes (Fotheringham et al., 2002) and is expressed by Equation (2):

$$T_i = \sum_j \beta_{ij}(u_i, v_i) X_{ij} + \varepsilon_i \tag{2}$$

where (u_i, v_i) represents the geographic location of the i-th observation in space and the parameter β_k (u_i, v_i) is a function of (u_i, v_i) of i-th observation. Reasonable neighborhood quantity is selected by optimizing bandwidth (distance or number of nearest neighbors) (Fotheringham et al., 2002). Such local parameters are often estimated by using neighborhood data and are weighted in accordance with Gaussian or bisquare models. The traditional GWR model focuses only on analyzing the differences between spatial effects of different influencing factors and assumes that all factors are non-stationary. However, the development of regional tourism is affected by complex factors that often have global and local significances, and so comprehensive consideration of both aspects is required. Semiparametric GWR model can effectively meet this requirement as it allows some parameters to be fixed over space and other parameters to vary across space, thus representing spatially stationary and spatially non-stationary relationships and processes simultaneously (Yao & Fotheringham, 2016). Semiparametric GWR model is expressed by Equation (3):

$$T_i = \sum_k \gamma_k X_{ik} + \sum_j \beta_{ij}(u_i, v_i) X_{ij} + \varepsilon_i \tag{3}$$

where k denotes an index of global covariates with a relationship to tourism income and j denotes an index of covariates that have a local relationship with tourism income.

This paper used Equation (3) to analyze the influencing factors of regional tourism development, where the bisquare kernel model was used to define the weight matrix. When considering global and local variable selection and bandwidth optimization, a model is usually calibrated through an iterative procedure where global and local parameters are estimated in turn, until satisfactory convergence of conditions is achieved. Here, selection of optimal bandwidth size and variables (global and local) were based on the corrected Akaike information criterion (Akaike, 1974), where the smallest the value was achieved, thus indicating that the model had a better fit. The weight matrix setting, bandwidth optimization, variable selection and parameter estimate in Equation (3) can all be implemented in GWR 4 software.

In traditional analysis models, choice of influence factors is often focused on three elements; destination resources, tourist market and the distance between origin and destination (Leiper, 1990). In addition to these three elements, this study also includes spatiotemporal lag to consider the influence of neighborhood tourism development. With respect to destination resources, data pertaining to permanent resident population, GDP, fixed asset investment, total retail sales of consumer

goods and attractions were selected. Likewise, data pertaining to the tourist market and distance between origin and destination were taken into account to construct weighted averages of economic distance and population distance. Finally, spatiotemporal lag was constructed to reflect the spatiotemporal dependence on the neighborhood. A collinearity test was performed in SPSS on all factors, where variables with a Variance Inflation Factor (VIF) greater than 10 were eliminated. From this, four factors; GDP, attraction value, weighted average economic distance and spatiotemporal lag were selected for further analysis. It is noted that to facilitate comparisons between different variables where parameters are estimated, each variable was subject to standard deviation standardization.

With respect to the four analytical variables, X_1 is GDP of an observation unit and shows the influence of economic development on a unit of tourism development. X_2 is the attraction value and represents the tourism attraction ability of a unit. This is obtained through a weighted summation calculated from the quantity and grade of A-level attractions in a unit (attraction is divided into five grades, of which 5A grade is the highest, and 1A grade is the lowest). Here, the weights of 1A - 5A are set to 1, 2, 3, 4 and 5 respectively (Huang, Cao, Jin, Yu, & Huang, 2017). X_3 is the weighted average economic distance and measures potential market access. This reflects the potential tourism market for a destination unit considering all origin units in the region. The calculation for determining X_3 is shown by Equation (4):

$$WD_i = \sum_j E_j d_{ij}/n \tag{4}$$

where, WD_i is the weighted average economic distance, E_j is the GDP of the i-th observation unit, and d_{ij} is the shortest road distance (calculated using Baidu map) between the capitals of two county units. X_4 is the spatiotemporal lag factor and indicates the spatiotemporal dependence of region tourism economy development on neighborhood tourism development. Where, spatiotemporal lag is defined by the average domestic tourism income of neighboring units in the previous year.

3.3.2. Moran's I

To calculate spatial dependence, Moran's I (a statistical method that measures spatial autocorrelation) was employed. For details concerning the Moran's I method, see Anselin (1995). In this study, a global Moran's I was used to examine the reduction of spatial auto-correlation in the residuals of global and local models of tourism development. Where adjacent regions were given the value of $w_{ij} = 1$ within the spatial weight matrix, and non-adjacent regions were given the value of $w_{ij} = 0$.

4. Results

4.1. Spatial distributions of tourism income and variables

Fig. 2 shows the domestic tourism income for Jiangsu counties in 2014. Tourism revenues were found to reach a maximum of 137.678 billion yuan in Nanjing urban area, and a minimum of 145 million yuan in Fengxian in 2014. This spatial differentiation highlights spatial inequality amongst counties. Here, counties with a high tourism income were found to be mainly distributed within southern Jiangsu, whilst tourism income in northern region was generally low. High-value and low-value agglomeration characteristics were more obvious. Table 1 presents descriptive statistics (maximum, minimum, average and standard deviation) for domestic tourism income across the Jiangsu Province over five years. Overall, tourism income has achieved a steady growth, and all indicators showing significant increases (Table 1), highlighting that the tourism industry has played an increasingly important role in the national economy of Jiangsu.

Fig. 3 shows the spatial distribution of the four variables in 2014. With respect to GDP, spatial differentiation was shown between counties, where counties in southern Jiangsu presented good economic development and counties in northern Jiangsu presented relatively poorer economic development. Likewise, when attraction value was considered, differences in internal features between counties were found to be significant, where some counties in south Jiangsu were found to have better developed attractions, and most counties in Jiangsu north lacked important tourist attractions, thus achieving a low score of attraction. With respect to weighted economic distance, the central region of southern Jiangsu was found to have the smallest value, indicating a greater location advantage and proximity to the tourist market. In northern Jiangsu the weighted economic distance was found to be large, thus limiting the potential of the tourist market. Differences between north and south Jiangsu were also indicated by the spatial lag calculation results, where the value of spatial lag factor in southern region was significantly higher than that of the northern region.

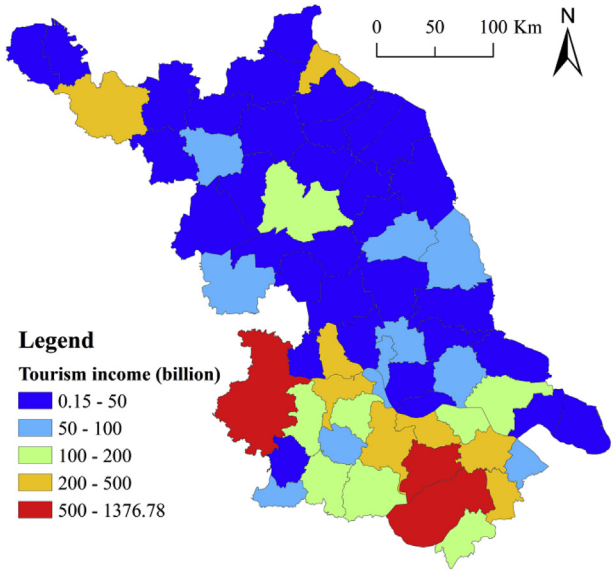

Fig. 2. Spatial distributions of tourism income in 2014.

Table 1
Descriptive statistics of tourism income.

Year	Tourism income (billion yuan)			SD
	max	min	Mean	
2010	83.022	0.046	7.876	147.144
2011	96.192	0.051	9.413	172.852
2012	109.811	0.071	11.010	201.167
2013	123.453	0.106	12.499	217.248
2014	137.678	0.145	13.588	235.469

4.2. Global analysis

A comparative analysis, comparing the calculation results of the global model, GWR model and semiparametric GWR model, was used to identify suitability in interpreting the influencing factors of regional tourism development. First, the relationship between regional tourism development and influencing factors was calculated using the global model. Due to the lack of spatiotemporal lag data in 2010, the OLS method was employed in lieu of a spatiotemporal lag analysis to estimate four regression models from 2011 to 2014. Table 2 presents the parameter estimation results from the global model.

The estimated results show an adjusted R^2 value of around 0.8 for all four years, indicating that the global model can adequately explain regional tourism development. The results also indicate that GDP (β_1), attraction value (β_2) and spatiotemporal lag (β_4) have a significant influence on regional tourism income. With respect to weighted economic

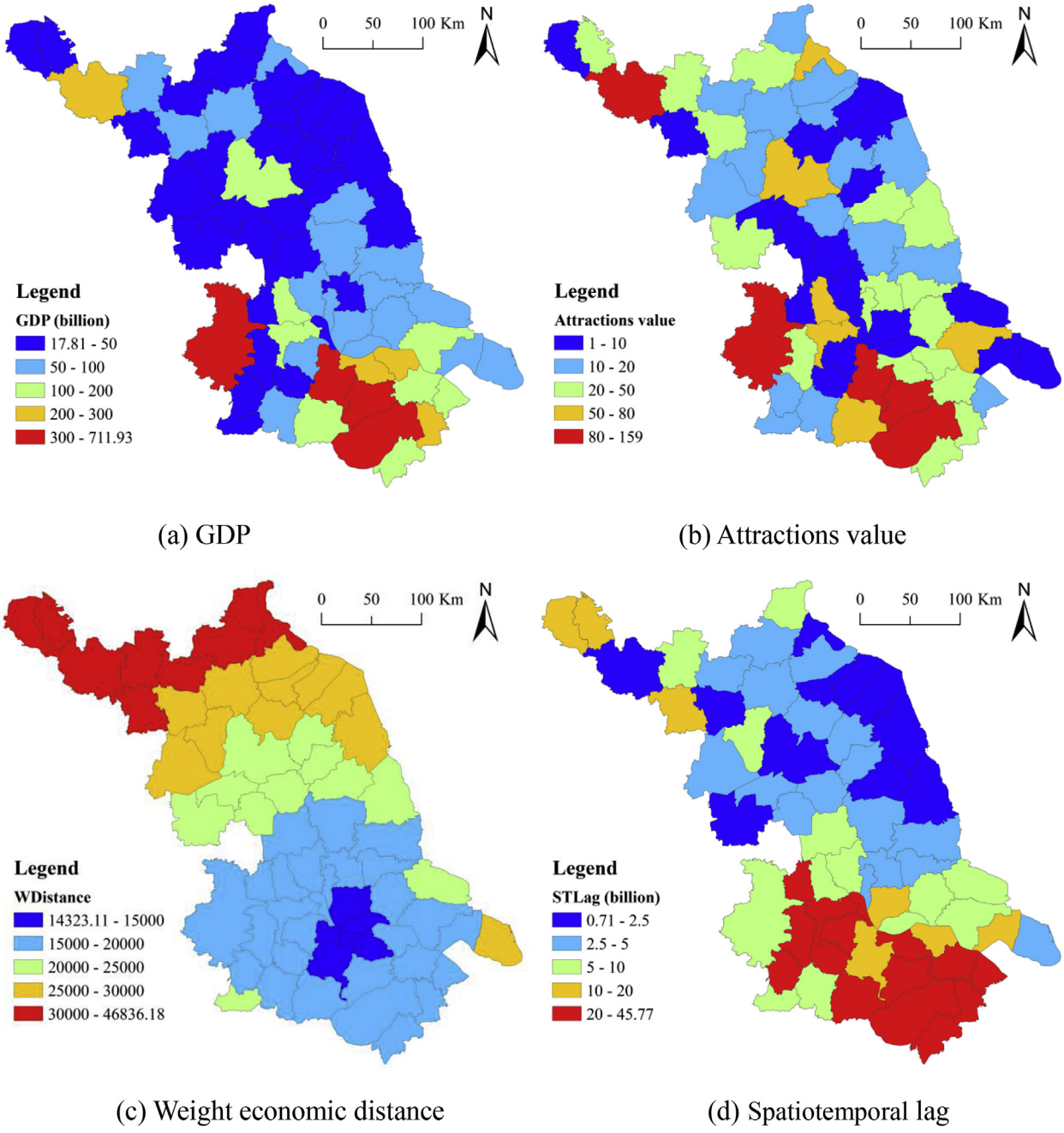

Fig. 3. Spatial distributions of variables in 2014.

Table 2
Parameter estimates for the global model.

Year	Constant	β_1	β_2	β_3	β_4	Adjusted R^2
2011	95.323*	74.314*	83.729*	−4.944	−1.333*	0.788
2012	111.290*	80.942*	82.723*	−19.682	−14.523*	0.783
2013	127.430*	119.938*	90.652*	−18.878	−16.908*	0.790
2014	126.715*	135.917*	86.277*	−8.610*	−3.420*	0.810

*$p < 0.05$.

distance (β_3), only results from 2014 were found to be significant. As seen from estimate coefficient, economic development level (GDP) and attraction development level were both found to present a significant positive correlation to regional tourism development. Here, regional economic development was shown to support, and continually enhance, regional tourism development. Likewise, the construction of attractions was also shown to significantly contribute to regional tourism development. In comparison, weighted economic distance and spatiotemporal lag factor were found to be negatively correlated to the development of tourism economy, and thus could limit regional tourism development.

4.3. Semiparametric GWR analysis

4.3.1. Model comparison

To complete the semiparametric GWR, the first step was to determine whether the four influencing factors were spatially stationary with global significance or spatially non-stationary with local significance. The values of factors deemed spatially stationary were then fixed. For those deemed spatially non-stationary, values were subjected to optimization and correction models so that all possible combinations of influencing factors in each year could be compared. Here, the

Table 3
Local parameters test in semiparametric geographically weighted regression models.

Year	Constant	β_1	β_2	β_3	β_4	Bandwidth
2011	√	√	F	F	√	7
2012	√	√	F	√	√	18
2013	F	√	F	F	√	13
2014	√	√	F	√	√	7

Note: F means fixed variable, √ means local variable.

optimal semiparametric model was chosen by comparing the size of AICc values, where the correction model with the lowest AICc value was selected as optimal.

Table 3 summarizes step one of the semiparametric GWR, highlighting whether parameters were fixed or stationary and noting bandwidth values for the years 2011–2014. Here, it is shown that both GDP and spatiotemporal lag parameters are spatially non-stationary in four years, and thus require local parameter estimation. In contrast, attraction value was found consistently to be a parameter with global significance, thus requiring values to be fixed as a global variable. With respect to the weighted economic distance, this parameter was found to be of a global significance in 2011 and 2013, but a local significance in 2012 and 2014. Bandwidth, which reflects scaling effects, was found to be greatest in 2012 with a value of 18.

Table 4 presents AICc, adjusted R^2 and Moran's I values for the three models. Here, it is noted that no comparative significance was found when the AICc values of each model was compared across the four years, however when a comparison was made between the different models for the same year, values were found to be comparative. Amongst the models, semiparametric GWR was found to have the smallest AICc value, which is significant as a lower AICc value indicates a better fitting model (Akaike, 1974). The semiparametric GWR was also shown to the largest R^2 value when compared with the global model and GWR model. In 2011, the AICc value reported for the semiparametric GWR model was found to be 47.274 and 48.064 less than the values reported for the global model and GWR model respectively. This lower value indicates that the semiparametric GWR model is significantly superior to the other models, and is repeated for the remaining three years. With respect to Moran's I values, all three models reported values greater than 0 that passed the significant test, indicating the existence of spatial autocorrelation within all three models. Moran's I values were found to be lower for semiparametric GWR when compared with the other two models, indicating that semiparametric GWR is better at reducing spatial autocorrelation. In summary, the semiparametric GWR model with comprehensive considerations of global and local variables was found to be superior to the global model, which only considers factors that are spatially stationary, and traditional GWR, which only considers factors that are spatially non-stationary. In light of this, semiparametric GWR can be argued to be superior for explaining the regional tourism economy.

4.3.2. Local parameter estimation analysis

As shown by Table 3, GDP and spatiotemporal lag were found to show significant local characteristics across all four years, and thus will be discussed further. Specifically, the parameter estimates of the two variables and their spatial heterogeneity will be explored. To describe the impact of such parameters on the development of regional tourism, 63 local parameter estimates were obtained for each year. The significance of the parameter estimates for each year and the spatial distribution of the two variables were then considered further. Here, t value was used to test the significance of parameter estimates against a hypothesis (Byrne, Charlton, & Fotheringham, 2009), where a significance level of 0.05 was selected.

Fig. 4 shows the spatial distribution of GDP local parameter estimates between 2011 and 2014. Differences in parameter estimate results indicate the existence of spatial differences, where the influence GDP on tourism development can be shown to differ between units. In 2011, 43 units were found to pass the significance test at the level of 0.05, with most units reporting good significance. Of the units that failed the significance test, most were located in northern Jiangsu. Parameter estimates were found to be higher in the northwest, and lower in the southeast, with only two units (near the north) reporting a negative correlation. For example, the GDP of Nanjing City and its surrounding areas (northwest) was found to strongly promote tourism development, while Nantong City and its surrounding areas (southeast) was found not to promote the tourism economy. In 2012, a similar pattern emerged where 38 units were found to pass the significance test of 0.05, with failing units mainly distributed in northern Jiangsu. Here, several county units in southeastern Jiangsu were found to be not significant. The parameter estimate of only one unit in the north was found be negative, while in the other units, GDP showed a positive influence, with a high-value area of estimate coefficient located in the northeast. In 2013, 40 units were found to pass the significance test, and GDP was shown to have a positive impact for tourism economy in all units. Again, the high-value area of estimate coefficient was located in the northeast region. In 2014, the number of units passing the significance test was found to reach a study high of 47, where all units reported a positive correlation between GDP and tourism economy. Units in the northwest Jiangsu were found to report enhanced estimated results in 2014, where the high-value area of estimate coefficient was also located in the northwest.

In summary, units reporting negative values were only found for the data years 2011 and 2012, indicating that GDP plays an important role in promoting tourism economic development for the vast majority of units. Furthermore, promotion effects were found to be most powerful in northern Jiangsu, which had been shown to report lower levels of economic and tourism development. In this region, where tourism is relatively limited due to a poor tourism economy foundation, economic development can not only enhance the near-distance tourism capacity of local residents, but also increase the development and construction ability of tourism resources. A consequence of the latter would be to attract foreign tourists, which is likely to promote the development of local tourism industry further.

Fig. 5 shows the spatial distribution of local parameter estimates for spatiotemporal lag between 2011 and 2014. Large differences were reported in parameter estimates between different units, indicating that each unit has a different dependence on spatiotemporal lag. In 2011, 35

Table 4
Fitting results of different models.

Year	Global Model			GWR			Semiparametric GWR		
	AICc	Adjusted R^2	Moran's I	AICc	Adjusted R^2	Moran's I	AICc	Adjusted R^2	Moran's I
2011	737.568	0.788	0.356*	738.358	0.801*	0.214*	690.294	0.959	0.142*
2012	758.045	0.783	0.363*	756.241	0.785*	0.234*	742.020	0.942	0.157*
2013	771.301	0.790	0.327*	743.351	0.960*	0.205*	691.132	0.962	0.123*
2014	718.285	0.810	0.301*	672.622	0.968*	0.198*	657.146	0.972	0.118*

*$p < 0.01$.

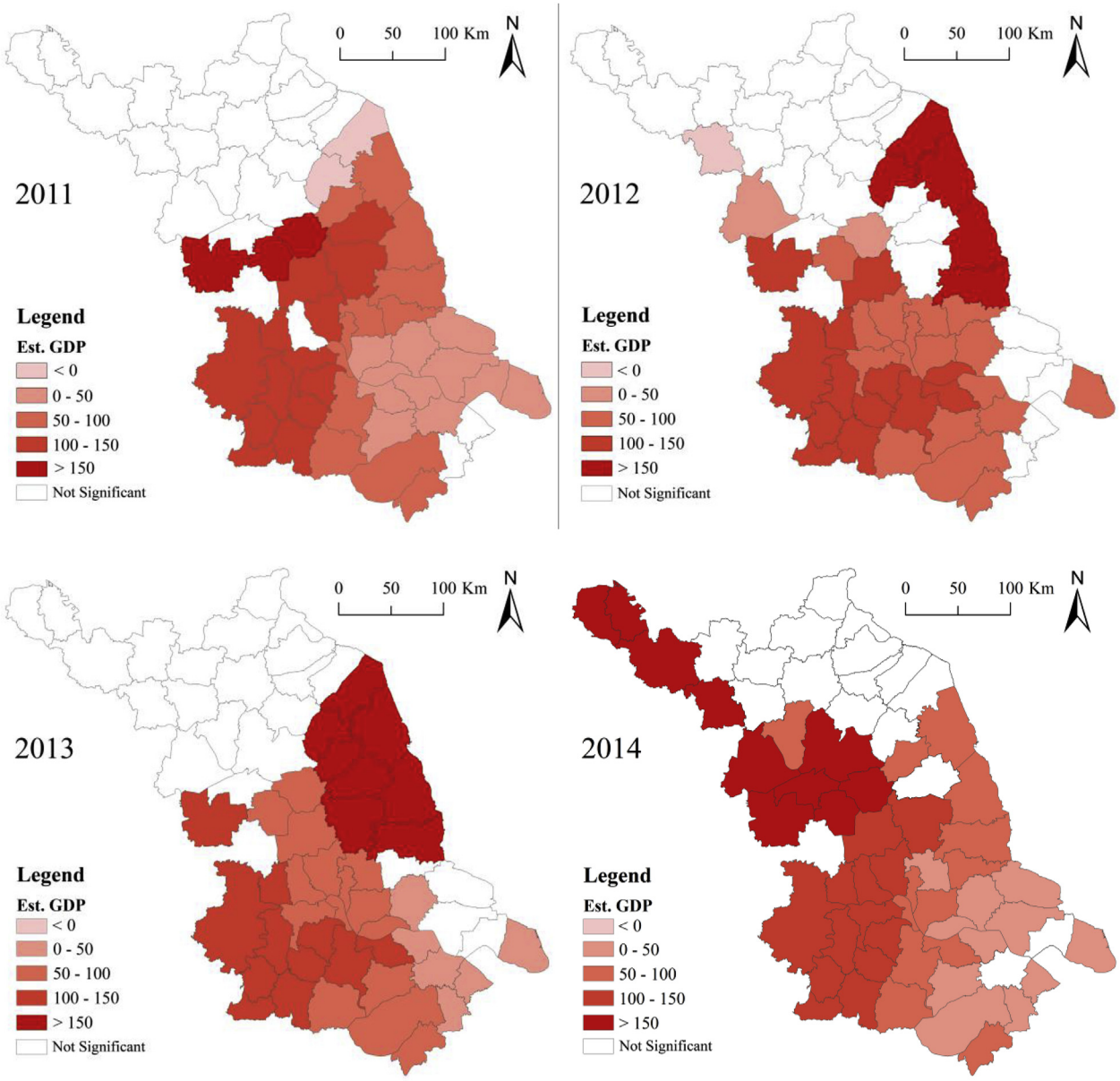

Fig. 4. Spatial variations in significant local parameter estimates of GDP.

units passed the 5 significance test at a level of 0.05 and were mainly located in central and southern Jiangsu. A significant negative correlation was found in the central Jiangsu, while a positive correlation was found in the southern region. In 2012, 40 units passed the significance test, and negative correlation was found for Yancheng and its surrounding area in central Jiangsu, while positive correlations were found in the southern and northern areas. In 2013, 47 units passed the significance test, and positive correlation was found in a vast area of northern Jiangsu. In 2014, 41 units passed the significance test. Here, the negative correlation area was found to expand into the eastern region, while areas of positive correlation were concentrated in the southwest region. When the four data years were compared, each reported a significant pattern of the coexistence between positive and negative effects. In southern Jiangsu, especially in the surrounding areas of Nanjing, the parameter estimates of spatiotemporal lag over the 4 years were found to be significantly positive. Thus, indicating that development of each regional unit was driven by its neighbors and positive agglomeration effects. Southern Jiangsu was found to be the most developed area of tourism industry, with a high level of natural and cultural tourism resources. Indeed, Nanjing, Suzhou, Wuxi and other units were found to attract a large number of tourists, and effectively promote the tourism development of neighboring areas. Furthermore, where regional economy was found to be relatively developed, tourists were found to have a stronger willingness to travel. In central Jiangsu, the parameter estimates of spatial lag between 2011 and 2014 were found to be negative. Furthermore, the tourism industry of one county was also found to have influenced by the development level of neighboring areas, where larger differences between counties of tourism development may inhibit tourism development of lesser developed units. Indeed, units reported to have a higher level of development were found to have a first-mover advantage, taking advantage of governmental support of capital for publicity and tourism resource development, thereby increasing tourism revenues. Whereas, neighbors to these first-movers that have a less developed tourism industry, could be inhibited by a lack of equivalent governmental support, thus making tourism development more difficult.

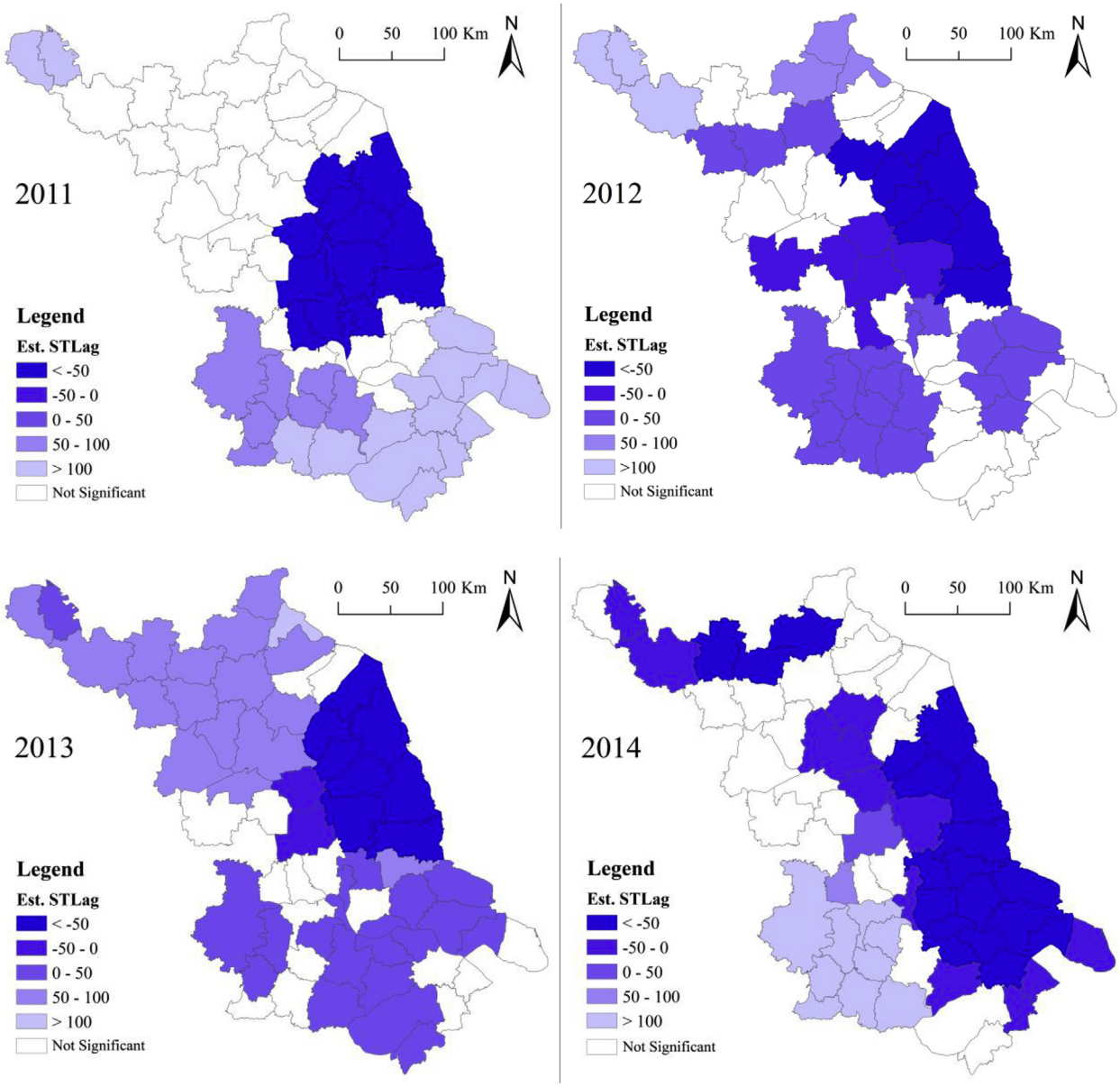

Fig. 5. Spatial variations in significant local parameter estimates of spatiotemporal lag.

5. Discussions and conclusions

This study employed semiparametric GWR to explain the spatial effects of regional tourism economies. Specifically, the effects of spatiotemporal differences between neighborhoods (i.e. spatial dependence) on the influencing factors of regional tourism development was studied. Results show that semiparametric GWR, which incorporates both global and local spatial relations, is superior to previous models. By achieving a significantly lower AICc value than the global model and traditional GWR model, results from the semiparametric GWR were found to have a more optimal fit, and the parameter estimates of influencing variables were found to be more accurate.

The most important contribution of this study was to expound relationship between regional tourism development and associated variables at global and local levels, exploring variations over space and time. While spatiotemporal lag has been widely applied in regional studies to explain the neighborhood effect in regional development (Pace & LeSage, 2004; Ramajo, Marquez, & Hewings, 2017; Tu, Yu, & Sun, 2004), such analysis are generally completed using the global model and often conclude that the neighborhood effect is spatially stationary. Here it is argued that spatiotemporal lag is spatially non-stationary, where its role in regional development is different in various regions. This study took an innovative approach, whereby spatiotemporal lag was taken as local variable in analysis, and concluded that positive neighborhood effects were only prominent in southern Jiangsu. Indeed, in some areas, such as central Jiangsu, tourism development was found to be inhibited by neighborhood effects.

Furthermore, this study quantified the spatial effect of GDP on the development of regional tourism. Overall, GDP was found to play an important role in promoting regional tourism development (Massidda & Mattana, 2013; Po & Huang, 2008). However, spatial differences were found in this promotion role during this study, where the promotion role in more economically developed areas such as southern Jiangsu was found to be stronger than in less economically developed areas such as northern Jiangsu.

Limitations of this study concern the duration of data used and spatial scale of the study. To study four years of regional tourism development, five years of tourism income data was used. Such a short study period could make it difficult to make conclusions that understand the evolutionary processes of influencing factors that have

variable roles in regional tourism economic development. Concerning spatial scale, previous studies of tourism economies have been carried out at a nation-wide scale (e.g. Wen & Tisdell, 1996; Tang, Selvanathan, & Selvanathan, 2007; Zhang, Xu, & Zhuang, 2011). On the other hand, this study, discusses spatiotemporal heterogeneity at a regional scale. Furthermore, the results of statistical hypothesis tests may be impacted by the Modifiable Areal Unit Problem (MAUP) and model accuracy could be impacted by boundary effects. Future studies could overcome these limitations by using long-term data and carrying out analysis at a different spatial scale. Nevertheless, the data and scale used by this study provides key insights into the use of semiparametric GWR analysis, highlighting it usefulness in performing spatiotemporal pattern analysis on regional tourism development.

In conclusion, the tourism industry is one of the most important industries within the national economy, an important part of the macroeconomy and is linked to quality of life. Many qualitative and quantitative perspectives and research methods have been employed to research the development of tourism. Based on the spatial analysis of Geographic Information System (GIS), in particular spatial statistics, this study presents a tool, semiparametric GWR, to study the development of regional tourism economy, which explicitly considers spatial dependence and heterogeneity. Furthermore, this study has demonstrated that the advantages of using a mixed model method include the incorporation of spatial effects alongside global and local factors that influence regional tourism development. Indeed, semiparametric GWR can provide a comprehensive spatial analysis method to model tourism economies in other regions and to model the development of other industries. It does this by capturing spatial stationary and non-stationary processes and by providing an analytical framework to estimate local parameters for calculating spatiotemporal lag.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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