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REGULAR PAPER

THE SPATIOTEMPORAL CHARACTERISTICS AND FLOW PATTERN OF INBOUND TOURIST FLOW BASED ON UGC DATA: A CASE STUDY OF SOUTHERN JIANGSU

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Annotation. Flowability characterises the internal relation of tourism regional system elements and is the primitive core expression of changes in the complex tourism network relation. By using data process, social network technology, P-DBSCAN density clustering, and Markov transition probability based on Flickr's geotagged photo data, this paper reveals the spatio-temporal characteristics of tourist flow from two dimensions of time and space with a case example of Suzhou, Wuxi, and Changzhou; further, this study analyses the types of spatial hot zones and flow patterns. The results show that the time sequence period of tourist flow has obvious fluctuation characteristics, and travel time distribution tends to be balanced. The flows and connections inside the Suzhou nodes are relatively high; the cross-city flow characteristics are gradually strengthened. The constraint of flow and distance affect and control the scale and direction of tourist flow, which shows the radioactive characteristics of Suzhou Gusu district as the core to the periphery and Wuxi and Changzhou. The tourist hot spots are divided into central hot zones, sub-central hot zones, general hot zones, and borderline hot zones. The hot zones for tourists' one-day trips are mainly concentrated in 1-4 AOI; one or two AOIs within one day become the main trajectory pattern.

Keywords: UGC data, tourism flow, spatiotemporal characteristics, flow pattern, Suzhou, Wuxi, and Changzhou area.

JEL classification: C33, C34. L83, Z3.

Introduction

The "big data" affects social economics fields, changing the traditional consumption pattern and accelerating social transformation. Recently, more users have shared their original content, thus, creating the notion of "user-generated content (UGC)" (Chen, Hong, 2015). Meanwhile, tourists share

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their travel information on social networks. Therefore, relevant UGC platforms have become the key channel that affects their decision-making and behaviour choices (Deng *et al.*, 2018). Pictures have become one of the notable carriers of UGC information transmission due to their intuitive transmission method and precise coordinate positioning. With the rise in current Internet big data and a deeper comprehension of geospatial, researchers expand the attributes and connotations of geospatial. Given the “Internet paradigm’s” transformation and the increasing scientific cognition of “flow space”, tourism destinations are no longer confined to a particular city, but the characterisation and analysis of network system and its internal relationship that comes from “flow data” are emphasised (Shih, 2006; Lee, Kim, 2018; Cai *et al.*, 2018). The growth of the tourist flow network system further interprets present social flow characteristics, which are changing in the form of flow. It constantly changes the characteristics, functions, structures, and relations of the destination network system (Birenboim *et al.*, 2013; Vu *et al.*, 2015). With the increasing urban agglomeration, the connections between scenic spots have become closer and more complex, forming a non-linear complex network relationship, which brings a far-reaching spatial impact on focusing the scenic spots with different natures, levels, and scales in different spatiotemporal scales within the areas, performing their functions and values under the impact from space of flows. The increasing flow of capital, objects, people, and information is transforming “social society” into a “flowing society” (Sun *et al.*, 2016). The focus of geography changes from the horizontal expansion and dynamic evolution of space to spatiotemporal structures to explain spatial flow (Jiang, 2017).

Prominently, tourist information search is one of the essential fields of tourism studies. An increasing number of tourists search for information on the Internet as it extends a wide range of diverse information to tourists (Bulhalis, Law, 2008). Further, digital technologies also play a pivotal role in tourists’ decision-making by offering almost all sorts of information. For instance, 57% of individuals in China utilise digital technologies to explore tourism information (Liu *et al.*, 2019). As a typical kind of human mobility, the tourists’ movement over spaces is reported to play a noticeable role in forming the cultural, economic, and ecological landscape of the global society (Cohen, Cohen, 2012). Therefore, various studies from diverse perspectives are attracted by the analysis of tourist movement across different scales to effectively comprehend the spatiotemporal behaviour of tourists, manage different types of tourism influences, and extend practical insights on destination marketing and tourism planning (Xu *et al.*, 2022). A growing number of studies examine the flow trajectory of tourists by employing different big data sources from sensors such as GPS tracking, Wi-Fi, and cellophane roaming (Pan, Yang, 2017). Along with the increasing penetration of IT-oriented communication, the Internet has transformed into a participation-interaction-forum from a publishing-browsing-forum (Xiang *et al.*, 2015). As a result, researchers use online data to predict tourist flows, realise tourist destination experiences, and monitor tourist flows across various destinations (Zhou *et al.*, 2017).

Using the spatiotemporal scale, the tourism flow studies develop the basic paradigm from background analysis, data extraction and processing, and practical/theoretical implications (Lian, Xie, 2024). Besides the micro-scale, tourism flow studies are often reflected on the macro-scale among countries, provinces, and regions. The tourist flow between scenic spots in the city and between attractions in scenic spots has garnered substantial attention (Becker, 2015; Xingzhu *et al.*, 2014). Though these studies depict the flow characteristics of tourism flow within the study scope, assuming the administrative boundaries of the study area, the tourist points of interest, flow law, and trajectory patterns are not revealed within the interest points (Caldeira, Kastenholz, 2020; Liu *et al.*, 2017). Meanwhile, the in-depth analysis of change characteristics of tourist flow on the spatiotemporal scale and the flow law and pattern in the tourist hot zone is lacking in the extant literature (Zhang *et al*., 2023; Wu *et al*., 2021). To fill this gap, the tourist flow analysis in this study acts as a prerequisite for realising precise tracks of tourists based on the spatial organisation of the internal scale of the city and the primary expression of the regional scale, deepening the geospatial expression and flow-spatial analysis in the Chinese context. Simultaneously, in this study, the change from the flow phenomenon to the analysis of time and space of tourist flow and the shift from the analysis of flow characteristics to the effective exploration of flow mechanism and pattern have triggered a novel round of comprehension of the "flow space". This offers a decision-making reference for optimising urban tourism space layout and precise marketing of tourist destinations.

This paper aims to examine the spatiotemporal characteristics of inbound tourist flow in Suzhou, Wuxi, and Changzhou using data mining and the Flickr API interface to obtain geo-tagged photo data for the period ranging from 2010 to 2018 based on the social network analysis, density clustering (P-DBSCAN) analysis, GIS spatial analysis, and spatial hot zone identification to uncover the spatial flow law and flow pattern of inbound tourist in China's tourism hot zones.

1. Literature Review

Foreign and domestic scholars extensively study tourism flow. Western scholars' focus on tourism flow has driven the continuous innovation of China's tourism flow, especially in relation to the spatial characteristics of tourist flow. However, the temporal characteristics of tourist flow are often ignored. Tourism activities are sensitive to time elements, leading to a universal imbalance in the time distribution of tourist flows. Based on the analysis of inter-annual and annual variation, the time-scale tourism studies analyse the change law of tourist flow over a more extended period from a macro-scale, and its prediction of tourist flow at tourist destinations has become mainstream. (Sun, 2000; Song, 2006; Yu *et al*., 2012). Seasonal and monthly changes reflect the periodic behaviour of tourists, characterising the seasonal shift in tourist flow. Given that tourism seasonality significantly impacts tourism development, the causes and effects of tourism seasonality, manifestations and characteristics, spatial differences and measures, and mechanisms and countermeasures are extensively studied (Lim, 2004; Cuccia, 2010). Furthermore, the short-term and small-scale studies on special periods such as day, week, and holiday have been gradually increasing, offering a complete perspective for the continuous deepening of tourism flows on the time scale (Liu *et al*., 2010; He *et al*., 2011; Wu *et al*., 2016).

Prior studies on tourists' spatial behaviour are undertaken in economics, behavioural science, social psychology, and other fields. Since the late 1960s, geographers began to study tourists' spatial activities from a regional spatial perspective, emphasising theoretical models and empirical analysis (Liu *et al*., 2010; Song *et al*., 2013; Zhu & Wei, 2019). Presently, studies assert theoretical frameworks, behavioural models, and affecting factors, deepening the connotation of the tourism flow's spatial nature. Given the new geographic technologies and effective combination of temporal geography and spatial behaviour, the spatiotemporal 2-dimensionality of tourism flow has formed the key research contents, including flow characteristics and patterns, spatial structure and effect, and formation mechanism. Tourism flow analysis based on the combination of portable GPS and questionnaire data is a case of flow-spatiotemporal analysis (East *et al*., 2017).

The IT evolution has triggered the physical sciences' revolution. The traditional "human-land relationship" theory has developed from the traditional relationship between humans and objective geospatial space to the relationship between humans and the composite space formed by geospatial and cyberspace. (Liu *et al*., 2010). The Internet data such as photos, texts, videos and mobile network data such as Bluetooth and text messages are introduced into the tourism flow research, which constitutes the mainstream of

UGC data, including the analysis of tourists' spatiotemporal behaviour characteristics based on Weibo data mining (Wang, 2018; Jingqing, 2018); analysis of tourists' flow network based on travel strategy and online big data (Xiaoli, 2017; Cheng, 2016); analysis of tourist behaviour patterns based on mobile data (Ruan, 2016; Luo, 2010). The innovation of tourism flow research is effectively promoted in this period, comprehensively integrating different analyses.

2. Data Sources and Methodology

2.1 Study Area

Su-Xi-Chang area means Suzhou, Wuxi, and Changzhou city; it is located in the south of Jiangsu Province, which is the traditional sense of southern Jiangsu, and the region with the fastest growing tourism industry in the Yangtze River Delta.

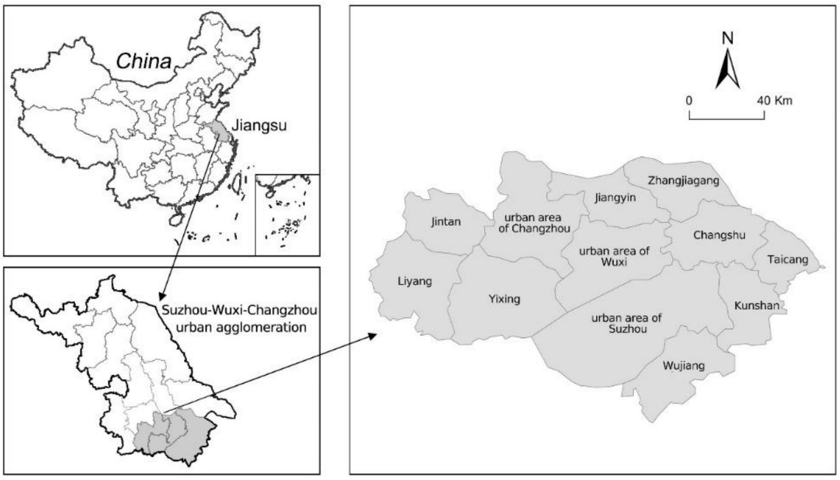

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Figure 1. **Geographical Location of Southern Jiangsu**

With its distinct resources and economic foundation, intercity high-speed railways, and transport network between cities, it has become a notable global tourist destination. The Su-xi-Chang area has also accelerated its tourism investment. 4A-level scenic spots and above occupy a large portion of the entire Yangtze River Delta region, promoting Su-Xi-Chang as the key tourist destination in Jiangsu Province (*Figure 1*).

2.2 Data Sources

Su-Xi-Chang includes 95 key tourist attractions in Suzhou, Wuxi, and Changzhou, containing the famous scenic spots in the Su-Xi-Chang area such as Humble Administrator's Garden, Guanqian Street, Pingjiang Historic District, Jinji Lake, Lingshan Scenic, Turtle Head Park, Spring and Autumn Herind of Yancheng. Notably, non-traditional destinations such as Suzhou University, Jiangnan University, Wuxi 1912 Street Bar, Suzhou High Railway Station, Suzhou Centre and Wuxi Railway Station have also become tourists' traditional choices.

Data collection and data processing: Grasping the geo-tagged photo data within Jiangsu Province (116.3°E~121.95°E,30.75°N~35.33°N) using the API interface on Flickr (www.flickr.com/services/api), refining the related information including photo ID, owner ID, owner name, date taken, title, longitude, latitude, user nationality. Since limited latitude and longitude ranges show rectangles when data is captured, there is also some irrelevant data. Hence, the vector base of Suzhou, Wuxi, and Changzhou should be superimposed, and the point data that does not fall into the scope should be eliminated to ensure preliminary cleaning. A total of 31,242 data records are obtained. Finally, a series of data screening criteria with the user ID, shooting time, latitude, and longitude as identifying objects, removing missing data, wrong number, and unrelated data such as the same user's photo data at the same time point but different coordinates; the same user with the exact coordinates but different shooting time (error data); multiple photos of the same user with the same shooting time and coordinates (duplicate data); the user record with continuous photo recording interval longer than one month (non-tourist data). All such data, including the data that is unrelated to tourism, is deleted.

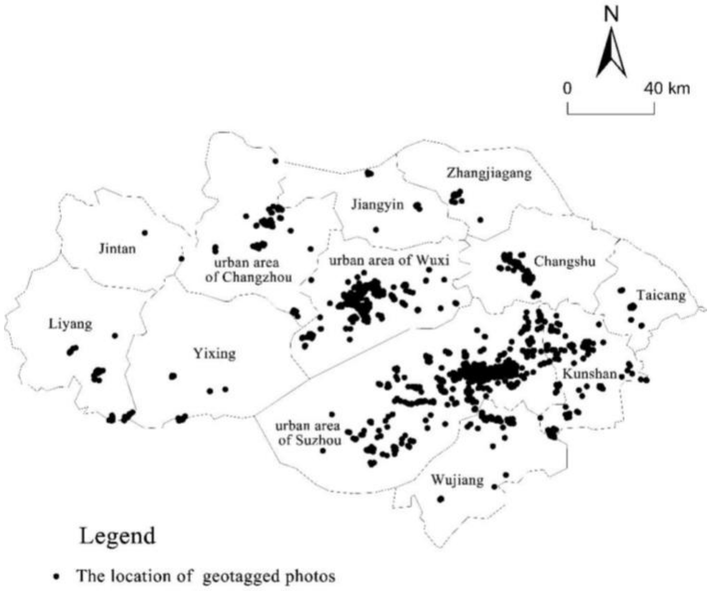

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Figure 2. **The Location of Geotagged Photos**

There are 16,945 geo-tagged photo data and 1,769 tourists, constituting the database of tourist flows in Su-Xi-Chang and then it is spatialised (*Figure 2*).

2.3 Methodology

1) **Seasonal index**

Seasonal intensity index and seasonal variation index are introduced to study the seasonal variation law of attractions' visiting frequency of inbound tourists as follows:

$$R = \sqrt{\sum_{i=1}^{12}(x_i - 8.33)^2 / 12} \quad (1)$$

In Formula (1), R is the seasonal intensity index; xi is the ratio of inbound tourists visiting frequency for the whole year; the closer R is to 0, the more uniform the time distribution of inbound tourists; the more significant the R-value, the more pronounced the difference between busy and off-season.

$$Q_i = \frac{\frac{1}{n}\sum_{j=1}^{n} x_{ji}}{\frac{1}{12}\sum_{i=1}^{12}\frac{1}{n}\sum_{j=1}^{n} x_{ji}} \times 100\% \quad (2)$$

In Formula (2), Q_i is the seasonal variation index, and x_{ji} is the frequency of visiting nodes for inbound tourists in *i* month *of* the year *j*. *j*=2010, 2011, ...2018, *i*=1,2,...,12, Q_i reflects the monthly mean change of visiting frequency for inbound tourists (Bao, Chu, 1999; Luo, 2010).

2) **Hodrich-Prescott filter**

This method filters out the low-frequency trend components and retains the high-frequency periodic components by processing time series data. $\{M_t\}$ is a time series that contains fluctuation- and trend components, $\{M_t^c\}$ and $\{M_t^T\}$ are, respectively, the fluctuation- and trend components.

$$M_t = M_t^c + M_t^T$$

The essence of the HP filter is to separate M_t^T from $\{M_t\}$. Generally, the trend $\{M_t^T\}$that cannot observed in time series $\{M_t\}$ is defined as a minimum loss function:

$$\min \sum_{t=1}^{T} \{(M_t - M_t^T)^2 + \lambda \sum_{t=2}^{T-1} [(M_{t+1}^T - M_t^T) - (M_t^T - M_{t-1}^T)]^2\} \quad (3)$$

Adjustable parameter λ is crucial for the HP filter. According to experience, yearly data λ=100; Seasonal data λ=1600; Monthly data λ=14400. The HP filter analysis method is used to find the overall laws of choosing tourist nodes for inbound tourists. (Hodrick, Prescott, 1980).

3) **The identification method of spatial hot zones**

The kernel density method is used for the identification of tourist hot zones (Wu *et al.*, 2015; Yang *et al.*, 2011; Zhu *et al.*, 2016). The cold and hot spots of kernel density reflect the regional status, but kernel density reveals the general trend within the hot zones; it cannot precisely measure the tourists' trajectory. Although the accounting method based on DBSCAN reflects the characteristics of tourist trajectory, this method of representing the tourists' number by the number of photos is not reasonable since a tourist probably takes many photos in a certain area, it magnifies the density cluster of tourists' number. Therefore, this paper identifies tourism AOI based on the calculation of P-DBSCAN. P-DBSCAN calculation identifies the so-called "core record" with a neighbourhood radius and a threshold for the number of tourists. Supposing D is a collection of geotagged photos, the latitude and longitude coordinates of photo *p are* (x_p, y_p). The distance between photo *p* and *q* is defined as *Dist*(*p*, *q*). The neighbourhood photo collection $N_\theta(p)$ for photo *p* is:

$$N_\theta(p) = (q \in D,\ Owner(q) \neq Owner(p) | Dist(p, q) \leq \theta) \quad (4)$$

θ is the neighbourhood search radius; *Owner*(*q*) is the user attribute functions of photo *q*. If the users of photo *q* and photo *p* are different, and their distance is between θ, photo *q* is the neighbourhood photo of photo p. NumOwner(p) is defined as the total number of neighbourhood photo aggregation $N_\theta(p)$. δ is the threshold of the user amount. If *NumOwner*(*p*) is more than δ, photo p is the "core records". The spatial distribution of the core record also indicates the hot zones' spatial distribution. The number 12 is used as the value of tourists' amount threshold δ to make hot spots in the suburbs that have relatively small tourist amounts can be effectively identified. The value of neighbourhood radius θ is decided by the spatial distribution characteristics of photos in different zones. After all the hot zones are identified, only the records within the hot zones are used to analyse the tourism flows' law.

3. Analysis of Results

3.1 Time Series Characteristics of Inbound Tourist Flow

3.1.1 Seasonal Fluctuation Characteristics

To analyse the variation characteristics of the frequency of inbound tourists visiting destinations, the seasonal index was used to scale the seasonal intensity index and seasonal variation index (Figure 3 and Figure 4).

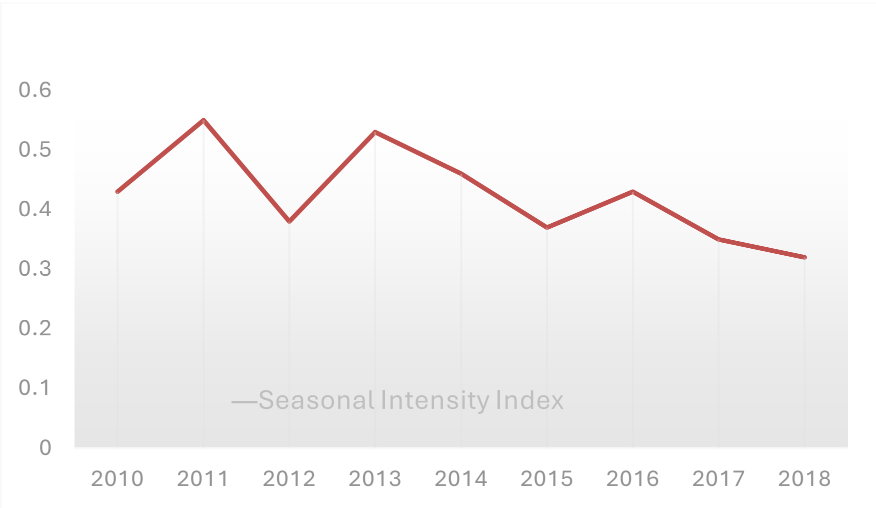

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Figure 3. **Seasonal Intensity Index of Inbound Tourist Flows**

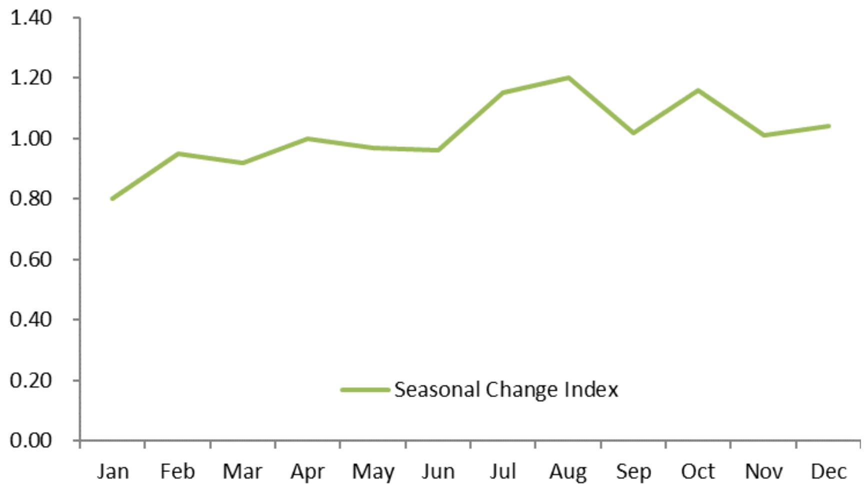

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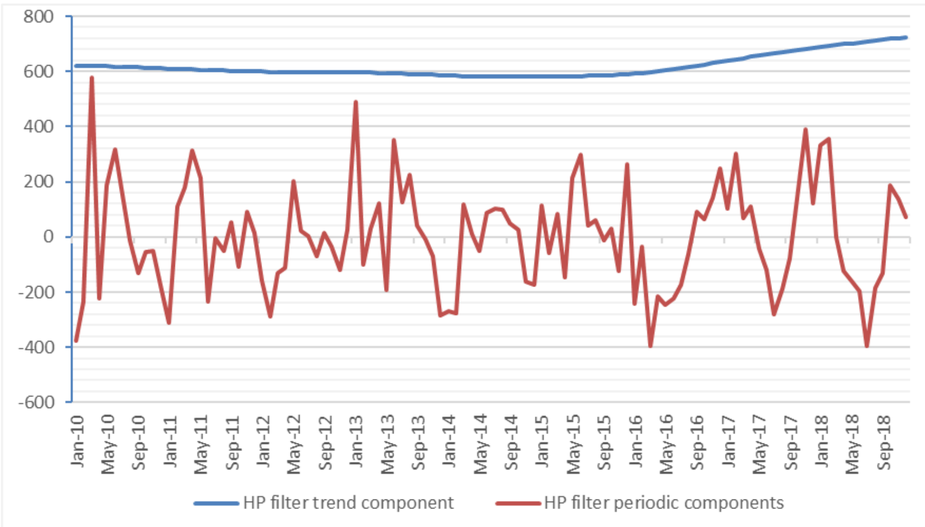
Figure 4. **Seasonal Change Index of Inbound Tourist Flows**

There is an apparent variance between the seasonal intensity index and seasonal variation index in the Su-xi-Chang, but the overall variation trends are consistent. The former index shows a notable declining trend. This infers that the time distribution of frequency for visiting destinations of inbound tourists changes toward a relatively balanced direction, especially since 2014. The variation ranges from 2010 to 2014, changing toward a relatively stable phase after 2014, depicting the relatively stable timing of inbound tourists in domestic tourism. Hence, the state and firms are emphasising the international tourism market, therefore tourism development has become more orderly. From the seasonal variation index, the variation is relatively steady in the Su-xi-Chang, basically hovering around 1.0. However, fluctuation curves show a relatively high peak travel period for inbound tourists in August and October and relatively low troughs (low period) in January and February, which matches the above analysis of fluctuation peaks and troughs. It is aligned with the travel time of domestic tourists as the Su-xi-Chang area is located in the Yangtze River Delta region with obvious high and low seasons. There is a consistency in the travel time for domestic tourists.

3.1.2 The Analysis of HP Filter Characteristics

The seasonal fluctuation reflects the temporal characteristics of peak and trough periods, but it is often disturbed by irregular factors that mask the development rules and hide certain information. Hence, the processing of the above results should be refined, and the interference caused by seasonal changes should be deleted to accurately analyse the periodic frequency of destination visits for inbound tourists. This study uses the additive models in the moving average ratio to adjust the monthly original time series, eliminating the effects of individual singular values and irregularities on periodic factors to obtain the periodic fluctuation of inbound tourists. 4 HP filter methods are used to report the periodicity of nodes' visiting frequency for inbound tourists. Though there are differences in the filter analysis' periodicity of Su-xi Chang, the BP filter's outcomes are more apparent, depicting the periodic fluctuation characteristics and specific peak and trough values (*Figure 5*).



Source: created by the authors.

Figure 5. **HP Filter Analysis of Inbound Tourist Flows**

The overall trend has transitioned from a relatively balanced to a slowly rising stage, which means that the periodicity of inbound tourists has risen steadily, with a relatively stable trend in the inbound tourist market in Su-Xi-Chang. HP filter periodicity is considerably obvious from January 2013 to January 2016, reflecting that the inbound tourists' stability in this period is higher than at other times.

3.2 The Spatial Characteristics of Inbound Tourist Flow

3.2.1 The Analysis of Spatial Characteristics of Su-XI-Chang Tourists Flow Constrained by Flow

The above analysis elaborates on the temporal variation of inbound tourist flow. The spatial analytical tool GIS is used to analyse the spatial characteristics of tourist flow. The amount of traffic between scenic spots in the Su-xi-Chang area depicts that the scenic spots consist of 4 levels, $I_{ij}>0$, $I_{ij}\geq10$, $I_{ij}\geq20$, $I_{ij}\geq50$, and the flow network under these thresholds is tracked by GIS (*Figure 6* and *Figure 7; Appendix 1*). The Ucinet analysis and social network analysis measure network indicators under different flow thresholds (*Table 1*).

Table 1. The Flow-Constrained Network Indicators of Tourist Flow

Region/Year	Flow threshold	Network density	Outward degree central potential	Inward degree central potential	Intermediate centre potential
SuXiChang/2010	$I_{ij}>0$	0.278	0.458	0.182	0.203
	$I_{ij}\geq10$	0.256	0.470	0.195	0.218
	$I_{ij}\geq20$	0.233	0.349	0.173	0.192
	$I_{ij}\geq50$	0.239	0.355	0.167	0.218
SuXiChang/2018	$I_{ij}>0$	0.293	0.482	0.193	0.241
	$I_{ij}\geq10$	0.277	0.493	0.196	0.246
	$I_{ij}\geq20$	0.241	0.421	0.179	0.203
	$I_{ij}\geq50$	0.259	0.437	0.186	0.197

Source: own calculations.

Under the flow constraints, the complexity of the flow network in the Su-Xi-Chang area is obvious in the chart. With the rise in threshold flow, the network density and central potential greatly changed, as compared to 2010 and 2018. The change in network density is more obvious, from 0.278 (2010) to 0.293 (2018). The numerical change reflects that the development process of the tourist flow network has improved, promoting scenic spots' tourism development. As a regional network across cities, as flow networks mature, nodes change their roles into a larger scale regional network, affecting the core and surrounding nodes, as well as the flow of scenic spot nodes in Suzhou's original internal scale. The flow change between scenic spots across cities is weaker than inside the city. As depicted in the typical Suzhou Humble Administrator's Garden and Guanqian Street, their flows are always more than 30. However, the flows of Suzhou Humble Administrator's Garden and Wuxi Lingshan scenic spot, Wuxi Turtle Head Park, and Wuxi Huishan Ancient Town are not always in a high-value flow state. The across-regional flow between scenic nodes is rising, but the flow between urban scenic spot nodes is always dominant. The core nodes inside Suzhou City control the whole flow network of Su-Xi-Chang. It is crucial to boost the linkage between core nodes in different cities and the regional tourism networks' development.

For node route levels, when flow threshold *Iij* is higher than 0, including all scenic spots in the region, the flow network is most complex, outward degree- and inward degree central potentials are relatively low, and the core position of scenic spots is not obvious, weakening the external communication ability of key scenic spots. When the flow threshold *Iij* is more than or equal to 10, the number of nodes and routes begins to decline. However, the network density and central potential at the moment are at the maximum state. The core position of central scenic spot nodes is better reflected. The primary and secondary relationships of the nodes are relatively explicit, and the network nodes occupy 82.73% of the total nodes, better reflecting the shape and spatial characteristics of the general network. When flow threshold *Iij* is more than or equal to 20, the number of nodes and routes constantly decline, the network density and central potential decrease, the nodes' impact in the central scenic area is reduced, and the primary-secondary relationship of the network nodes cannot be represented well. When the flow threshold *Iij* is more than or equal to 50, the number of nodes and routes is minimal. The network density and central potential increase, but the value of the outward and inward degrees of central potential is not numerically dominant. The expression of core nodes and primary-secondary relationship is insufficient, and the central potential is relatively low. Fewer nodes remain with intermediary connections belonging to the underdeveloped flow network. The network structure is optimal when the flow threshold *Iij* is more than or equal to 10. The scenic spots at this point have a clear primary-secondary relationship and structural characteristics in space. It is centred on the key core nodes in Suzhou city, continuously making and establishing contact with surrounding urban scenic spots.

3.2.2 The Spatial Characteristics of Distance-Constrained Tourist Flow in SuXiChang

The nodes and routes of the flow network inevitably change with the change in distance. The actual distance of scenic spots in Su-Xi-Chang highlights that the distance is divided into 4 levels, 0-10km,10-30km,30-50km,≥50km, to distinguish the spatial characteristics of tourist flow in Su-Xi-Chang under the constraint of distance (*Figure 8* and *Figure 9; Appendix 2*), processing the flow network under the constraints of different distance in Su-Xi-Chang based on the expression. The related indicators of the inbound tourists' flow network are attained (*Table 2*).

Under different distances, the tourist flow in Su-Xi-Chang shows different spatial characteristics than in 2010 and 2018. When a distance *dis*＞0km covers all scenic spots, the network structure is the most complex at this point. The number of nodes and routes is maximum, but the benefit of core nodes is not exceptional. The network relationship between primary and secondary nodes is too complex. When *dis* is between 0km to 10km, the nodes with the larger flow are basically retained, but the secondary nodes are eliminated while the spatial characteristics of the flow network are not obvious. When *dis* is between 10km and 30km, some nodes with larger flows are eliminated, but some concurrently remain. The network structure is formed whereas the outward degree- and inward degree central potential has also increased.

Table 2. The Distance-Constrained Network Indicators of Tourist Flow

Area/ Year	Distance threshold	Network density	Outward degree central potential	Inward degree central potential	Intermediate centre potential
SuXiChang/2010	＞0km	0.278	0.458	0.182	0.203
	0-10km	0.157	0.392	0.156	0.167
	10-30km	0.134	0.413	0.163	0.173
	30-50km	0.146	0.387	0.155	0.158
	≥50km	0.153	0.373	0.143	0.151
SuXiChang/2018	＞0km	0.293	0.482	0.193	0.241
	0-10km	0.166	0.405	0.163	0.183
	10-30km	0.143	0.417	0.179	0.195
	30-50km	0.158	0.402	0.161	0.176
	≥50km	0.175	0.392	0.158	0.163

Source: own calculations.

Thus, the centre node's control force to the surrounding nodes under this distance constraint is better reflected. When distance dis is between 30km to 50km, the network density increases, but the centre potential is relatively low, reflecting a decline in the external connection of central scenic spots and imperfection in the flow network. When distance dis is greater than or equal to 50km, the network structure is relatively perfect, but there is a decline in both network density and central potential. The connections between scenic spots of different cities in the Su-Xi-Chang area are relatively weak. Relative to 2010 and 2018, with a rise in distance scale, the effect of distance on nodes, flow, and the network is substantially deepened, especially for the across-cities regional network, this effect is more pronounced. Since the nodes were constrained by distance, the nodes show diverse flow space under the constraint of different scale distances, reflecting the flow and position/value of core nodes in diverse flow networks within distinct distances.

3.3 The Analysis of Flow Patterns

3.3.1 The Identification of Spatial Hot Zones

The spatial hot zone clusters in the study area are analysed to discover tourists' interests, behaviour law, and flow patterns. There are 26 hot zones in the Su-Xi-Chang area, mainly distributed in Suzhou, occupying 60%; followed by Wuxi and Changzhou, respectively occupying 20% and 20%. There are numerous tourists in the main or central areas, and many tourist hot zones are gathered, showing a continuous space extension. Most of those hot zones with relatively small areas in space and clear borderlines are single tourist attractions, causing spatial isolation. However, these zones show a larger spatial agglomeration and a lower spatial dispersion. Generally, the hot zones take the high-level tourist attractions as the main body, leaning towards modern city functional areas. Since each hot zone probably contains single or multiple tourist attractions to reflect the critical role, the names of tourist attractions that appear mostly in different hot zones are used as the representative names of the entire hot zone (*Table 3A, Appendix 3*).

Inbound tourists prefer leisure tourist attractions, such as Humble Administrator's Garden area, ShanTang Street area, Hanshan Temple area, and Huqiu Scenic Area, representing a typical culture of Suzhou; historical/cultural hot spots also occupy a high ratio, such as Zhou Zhuang area, Tongli Ancient Town area, Shajiabin area, and Qingmingqiao Ancient Canal area. Such a zone often has a long history and profound culture. The hot zones of modern business and shopping also occupy a particular proportion, gathering a core area in the city. Besides, the attractions with good reputations, like Spring and Autumn Herind of Yancheng and Wuxi Movie and Television City area, occupy a relatively small proportion, showing few connections with other hot zones affected by the distance and relatively isolated in space. Such a hot zone mainly concentrated in Changzhou, also reveals that the appeal of Suzhou's international tourism market is higher than in Wuxi and Changzhou. The clustering analysis shows that hot zones must be further classified to show the characteristics of tourist flow in different hot zones.

Table 4. The Grade and Centrality of Tourism Hot Zones

Item	Names	Inflow	Outflow	Centrality	Properties
1	HumbleAdministrator's Garden area	304	272	576	(A) Central hot zone
2	ShanTang Street area	148	139	287	(A) Central hot zone
3	Jinji Lake	118	112	230	(A) Central hot zone
4	The Turtle Head Park area	52	72	124	(B) sub-central hot zone
5	Zhou Zhuang area	63	59	122	(B) sub-central hot zone
6	Qingmingqiao Ancient Canal area	56	62	118	(B) sub-central hot zone

Table 4 (*continuation*). The Grade and Centrality of Tourism Hot Zones

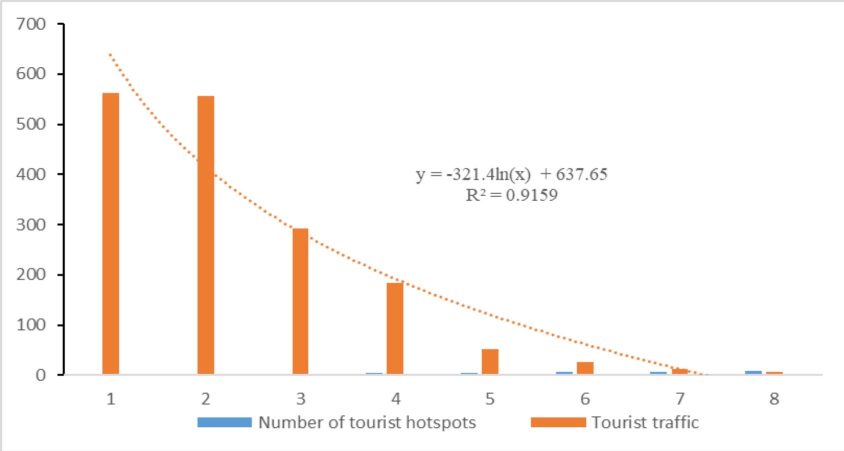
Item	Names	Inflow	Outflow	Centrality	Properties
7	Hanshan Temple area	55	62	117	(B) sub-central hot zone
8	Huqiu Scenic Area	51	52	103	(B) sub-central hot zone
9	Panmen Scenic Area	48	47	95	(B) sub-central hot zone
10	Lingshan Scenic Area	47	43	90	(B) sub-central hot zone
11	Tongli Ancient Town area	43	40	83	(B) sub-central hot zone
12	Xihui Park area	37	28	65	(C) General hot zone:
13	Dongshan Area	26	30	56	(C) General hot zone:
14	Yangcheng Lake area	25	30	55	(C) General hot zone:
15	Taihu Lake area	25	29	54	(C) General hot zone:
16	South Street area	21	31	52	(C) General hot zone:
17	Wuxi Movie and Television City area	19	22	41	(C) General hot zone:
18	Spring and Autumn Herind Of Yancheng	23	10	33	(C) General hot zone:
19	Changzhou Universal Dinosaur City	19	14	33	(C) General hot zone:
20	Shajiabin YuShanghu Scenic Area	11	20	31	(C) General hot zone:
21	Tianmu Lake	9	20	29	(D) Borderline hot zone
22	Luzhi Ancient Town	11	14	25	(D) Borderline hot zone
23	Stone lake Scenic Area	10	11	21	(D) Borderline hot zone
24	Suzhou Amusement Land	10	10	20	(D) Borderline hot zone
25	Qiandeng Ancient Town	6	7	13	(D) Borderline hot zone
26	Universal Animation Joyland	2	3	5	(D) Borderline hot zone

Source: created by the authors.

The centrality index of hot zones reveals that 26 hot zones are divided into four levels: ①(A) Central hot zone: the centrality index is more than 200, including Humble Administrator's Garden area, ShanTang Street area, and Jinji Lake. These hot zones are in a core position in the tourists' spatial flow. The inflow and outflow are at a high level, while the ability to gather and diverge is strong. They dominate and affect the connection pattern of the tourist hot zones in Suzhou, Wuxi, and Changzhou, and they establish tourists' connections between hot zones in the area. ②(B) Sub-central hot zone: the centrality index is between 80-200, including the Turtle Head Park area, Zhou Zhuang area, Qingmingqiao Ancient Canal area, Hanshan Temple area, and Lingshan Scenic Area. They are important hot zones with a closer connection to other hot zones. The difference between inflow and outflow is more obvious, and the tourists tend to saturate or diffuse in a single direction. ③(C) General hot zone: the centrality index is between 30-80, its benefit is not obvious, and the tourists' visiting frequency is relatively low. There is little interaction with other hot zones, including the Xihui Park area, the Taihu Lake area, the South Street area, the Wuxi Movie and Television City area, and Spring and Autumn Herind of Yancheng. ④(D) Borderline hot zone: the centrality index is less than 30, including Tianmu Lake, Luzhi Ancient Town, and Qiandeng Ancient Town. These hot zones are on the edge, often becoming isolated hot zones (*Table 4*).

3.3.2 Flow Trajectory Pattern

The statistics on tourist one-day trips depict that hot zones for tourist one-day trips mainly concentrate on 1-4 hot zones (*Figure 10*).



Source: created by the authors.

Figure 10. **Statistics of popular tourist areas of one - day tour**

Table 5. The Flow Trajectory Pattern of Tourists' Single AOI

Item	Name	Numbers of tourists	Item	Name	Numbers of tourists
1	Humble Administrator's Garden area	73	20	Shajiabin YuShanghu Scenic Area	11
3	Jinji Lake	48	6	Qingmingqiao Ancient Canal area	11
5	Zhou Zhuang area	35	18	Spring and Autumn Herind Of Yancheng	10
11	Tongli Ancient Town area	23	12	Xihui Park area	8
2	ShanTang Street area	21	19	Changzhou universal dino-saur City	13
4	The Turtle Head Park area	18	10	Lingshan Scenic Area	12
16	South Street area	14	21	Tianmu Lake	2

Source: created by the authors.

The ratio of visiting 1 or 2 AOIs is close, which is the largest proportion. Accordingly, tourists often choose 1-2 hot zones within a day. However, the ratio of selecting 5-8 hot zones is the smallest. The number of tourists is less, making it unfeasible to count the characteristics. Thus, this paper analyses the pattern of 1-4 hot zones for tourists on one-day trips. The analysis of the visiting trajectory of choosing a single AOI (*Table 5*) confirms that tourists mostly choose the historical and cultural scenic spots, with the highest ratio of AOIs in Suzhou as the highest.

Further, Jinji Lake has become a key choice for tourists. The top-ranked and relatively low-ranked AOIs often become the core choices for a single attraction route, and this result is related to the location, scale, and nature of AOI. The top-ranked areas, such as Jinji Lake, have a reputation for fully meeting the cultural experience needs of tourists. Zhou Zhuang area and Tongli Ancient Town are impacted by the distance. Further, the locations of 2 AOIs are not dominant. Although, these AOIs can thoroughly reflect the distinct artistic characteristics of the ancient town of Jiangnan (China). The multiple functions of sightseeing, cultural experience, and shopping are also gathered.

Table 6. The Tourists' Flow Trajectory Patterns of Multiple AOIs （n=2, n=3）

Path type	Track line	Path type	Track line
	N=2		N=3
A-A	HumbleAdministrator's Garden area↔ShanTang Street area HumbleAdministrator's Garden area ↔ Jinji Lake	A-A	HumbleAdministrator's Garden area→ShanTang Street area→HumbleAdministrator's Garden area HumbleAdministrator's Garden area→Jinji Lake→HumbleAdministrator's Garden area HumbleAdministrator's Garden area→ShanTang Street area→Jinji Lake
A-B	HumbleAdministrator's Garden area→Hanshan Temple area HumbleAdministrator's Garden area→Zhou Zhuang area ShanTang Street area→Hanshan Temple area	A-B	HumbleAdministrator's Garden area→Hanshan Temple area→ShanTang Street area HumbleAdministrator's Garden area→ShanTang Street area→Huqiu Scenic Area HumbleAdministrator's Garden area→Hanshan Temple area→Jinji Lake Zhou Zhuang area→HumbleAdministrator's Garden area→ShanTang Street area
A-C	HumbleAdministrator's Garden area→Taiping Mountain aera HumbleAdministrator's Garden area→Taihu Lake area Jinji Lake→Shajiabin YuShanghu Scenic Area	A-C	Jinji Lake→Taihu Lake area→Taiping Mountain aera HumbleAdministrator's Garden area→Jinji Lake→Taihu Lake area HumbleAdministrator's Garden area→Taihu Lake area→Dongshan Area
B-B	The Turtle Head Park area ↔ Lingshan Scenic Area Qingmingqiao Ancient Canal area ↔ The Turtle Head Park area Lingshan Scenic Area→Qingmingqiao Ancient Canal area	A-D	HumbleAdministrator's Garden area→Jinji Lake→Qiandeng Ancient Town
B-C	Qingmingqiao Ancient Canal area ↔Xihui Park area Xihui Park area→The Turtle Head Park area Qingmingqiao Ancient Canal area→Wuxi Movie and Television City area	A-B-C	ShanTang Street area→Panmen Scenic Area→Dongshan Area HumbleAdministrator's Garden area→Dongshan Area→Zhou Zhuang area

Source: created by the authors.

Besides the inbound tourists choosing a single AOI, there are still several tourists who choose 2 or more AOIs for their tours, especially the ratio of 2-4 AOIs is larger (*Table 6*), which constitutes the flow patterns of inbound tourists' spatial behaviour. Choosing 2-4 AOI mainly comprises central- and central hot zones, central- and sub-central hot zones, central- and general hot zones, sub-central- and central hot zones, namely, the types of A-A,A-B,A-C,B-A,A-B-A, indicating the effect of central hot zones on other hot zones. Tourists prefer the central hot zones with higher reputation, thereby assuming other non-central hot zones. Meanwhile, the central hot zones have more connections to sub-central and general hot zones and fewer connections to borderline hot zones. The borderline hot zones are often isolated. However, the scenic spots in the borderline hot zone also have relatively complete service functions.

Under the single AOI pattern and based on tourists' trajectory routes and patterns, tourists often directly visit their destination with a clear goal, and no longer attend other AOI activities; under the 2 AOIs pattern, they except for high-frequency mutual flows in some central hot zones while other hot zones are prone to simple-level, straight-chain, or ring-type flow, exhibiting the flow pattern of the inbound tourists' trajectory in Su-Xi-Chang.

4. Discussion

This section carries out a detailed discussion of the study results. The key discussions are as follows: firstly, the time series characteristics analysis of inbound tourist flow shows its periodic fluctuation characteristics. There is a consistency in the overall change trend of the seasonal intensity index and the seasonal change index. Also, the distribution of tourist travel time tends to be balanced, showing a relatively stable development trend in the inbound tourism market. In terms of HP and BK filters, the BK filter verifies the HP filter's stability, with significance from January 2013 to January 2016. The stability of the inbound tourist market at this stage was relatively higher. Further, spatial characteristics of tourist flow suggest that the flow and connection between nodes in Suzhou are relatively high, the cross-city characteristics of scenic spots are gradually reinforced, and the distance affects the core dominant position of the internal nodes of the city. Therefore, the flow from the nodes in Suzhou to Wuxi and Changzhou does not increase, while the constraints of flow and distance impact the scale and direction of tourist flow. However, internal core node positions in Suzhou always remain the same. The higher flow between nodes is still distributed inside Suzhou City. This phenomenon harms the tourism industry's balanced development in Suzhou, Wuxi, and Changzhou, triggering the dilemma of inbound development in Suzhou and relatively insufficient inbound tourism development in Wuxi and Changzhou. The continuous improvement shall optimise the transportation network system and tourism industry in Wuxi and Changzhou. Conversely, the current flow characteristics show that it still shows the radioactive characteristics radiating to the periphery, Wuxi, and Changzhou, with Suzhou Gusu District as the core, which also has the spatial structural characteristics of tourist flow in Su-Xi-Chang.

Secondly, the tourist hot zone identification and flow patterns show that numerous tourists exist in the main or central area. Many tourist hot zones are gathered, depicting a continuous extension in space, occupying an absolute dominant position. Most of those hot zones with relatively small areas in space and clear borderlines are single tourist attractions. The hot zones present the characteristics of taking high-level tourist attractions as the key body, leaning towards modern city functional areas, relying on urban transportation clustering, and overlapping with urban historical and cultural spaces. The centrality index shows that the 26 hot zones are divided into four levels: central, sub-central, general, and borderline hot zones. The tourist hot zones for 1-day trips are concentrated in 1-4 AOIs per tourist flow trajectory. From the tourist flow trajectory and pattern, under the single AOI pattern, tourists mostly go straight to their destination and no longer attend other AOI activities; under the above 2 AOIs pattern, except for high-frequency mutual flows in some central hot zones, other hot zones are prone to simple-level flow, straight-chain, or ring-type flow.

Thirdly, the analysis of inbound tourist flows based on UGC data shows the spatiotemporal characteristics and flow laws of inbound tourist flow and the excavate flow law of tourists in hot zones through the behaviour choice of inbound tourist' destinations. Based on the entire flow analysis, time and space have become two key dimensions for analysing the flow characteristics. Using flow analysis on a spatiotemporal scale effectively grasps the control of flow resources, bringing the spatial transfer and accumulation of social and cultural capital and accelerating the transformation from geographical to social flow. This is not only the physical space change in the body but also the depiction of tourists' main flow in the social structure. The increased flow also supplements the tourism reach. Under the new paradigm of flow, tourism flow includes the spatial flow of individual tourists (tourism flow) in traditional tourism geography research and the following active system composed of diverse resources, relationships, power, and social, economic, and cultural relations (Sun *et al*., 2016). This expands the connotation of tourism and comprehends the tourism flow's characteristics and its interaction with local, spatial, and social flow.

Conclusions

The main conclusions drawn in this study are as follows: the time sequence period of tourist flow demonstrates prominent fluctuation characteristics, whereas travel time distribution tends to be balanced. Inside the Suzhou nodes, the flows and connections are comparatively high, with the cross-city flow characteristics gradually strengthening. The constraint of flow and distance control impact the scale and direction of tourist flow, which exhibits the radioactive characteristics of Suzhou Gusu district as the core to the periphery, Wuxi, and Changzhou. Additionally, the tourist hot spots are classified into general-, central-, sub-central- and borderline hot zones. Lastly, the hot zones for one-day trips of tourists are predominantly concentrated in 1-4 AOIs; one or two AOIs within one day become the key trajectory pattern.

This study also has specific theoretical and research implications. Primarily, this study offers valuable evidence for the IT application in flow space and is deepening in theory by refining the tourist flow trajectory patterns in tourist hot zones of China. Furthermore, the spatiotemporal flow and its law also hold specific practical implications for Chinese practitioners and researchers to understand the cross-border tourism of foreign tourists, offering practical value for strengthening the cultural structure, brand formation, and marketing strategies of the tourism industry. By comprehending the spatiotemporal law of inbound tourist flow, such analysis explores the characterisation of the tourist flow process. It reviews the network, structure, and spatial interactions formed by the flow elements. As a result, this offers a novel theoretical direction for the spatial expression of the geographical flow of tourists. The diversified flow situation and the complex scene space derived from cross-border tourism must also become a notable link in future studies. Based on the inbound tourist flow and the spatio-temporal characteristics, the behaviour choice of inbound tourists related to travel destinations in hot zones extends a valuable implication for tourist destinations to explore and expand foreign tourism markets.

This study also has certain limitations. For instance, this study used a small sample of only three cities in one province of China. Future studies should be undertaken with a relatively larger sample from different Chinese provinces to derive generalised outcomes. Furthermore, because the COVID - 19 pandemic led to a drastic decline in tourist flow, the study period is confined to the years 2010–2018. Hence, further studies might consider performing related research with an extended and updated period. Lastly, from the global perspective, though the chosen cities are rich in tourism resources and activities, the study sample lacks international generalizability. In the future, different cities from prominent tourism economies can be included in the study sample to enhance their global acceptability.

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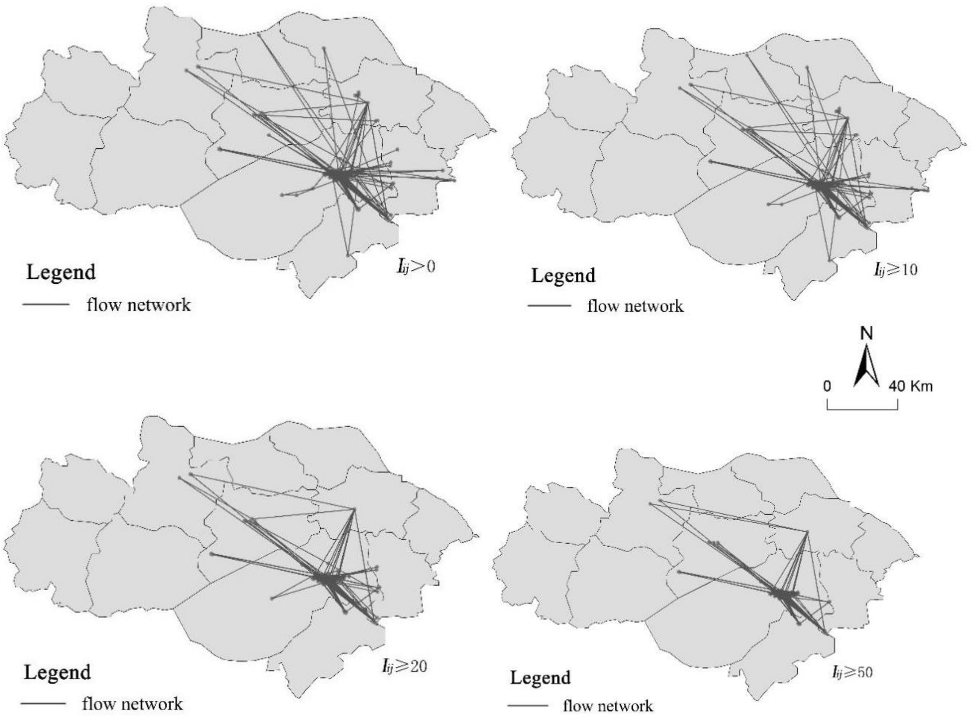
VARTOTOJŲ SUKURTO TURINIO VERTINIMAS – ERDVĖLAIKIO CHARAKTERISTIKOS IR ĮVAŽIUOJANČIŲ TURISTŲ SRAUTŲ MODELIS: PIETŲ JIANGSU ATVEJIS

Santrauka. Turistų srautų dinamika ne tik atspindi vidinius turizmo regioninės sistemos elementų tarpusavio ryšius, bet ir yra pagrindinė sudėtingo turizmo tinklo pokyčių išraiška. Šiame tyrime, pasitelkus duomenų apdorojimo metodus, socialinių tinklų analizę, P-DBSCAN tankio grupavimą ir Markovo perėjimo tikimybių modelį, remiantis „Flickr" nuotraukų su vietos koordinačių duomenimis, atskleidžiamos turistų srautų erdvėlaikio charakteristikos laiko ir erdvės dimensijose Suzhou, Wuxi ir Changzhou vietovėse. Taip pat nagrinėjami erdvinių karštųjų zonų tipai ir turistų srautų modeliai. Tyrimo rezultatai atskleidė, kad turistų srautų laiko seka pasižymi ryškiais svyravimais, o kelionių trukmės pasiskirstymas tampa vis tolygesnis. Suzhou vietovės mazguose turistų srautų intensyvumas išlieka aukštas, o tarpvietoviškų srautų ryšiai palaipsniui stiprėja. Turistiniai karštieji taškai klasifikuojami į centrines, subcentrines, bendrąsias ir ribines karštąsias zonas.

Reikšminiai žodžiai: vartotojų sukurtas turinys; turizmo srautai; erdvėlaikio charakteristikos; srautų modelis; Suzhou, Wuxi ir Changzhou vietovės.

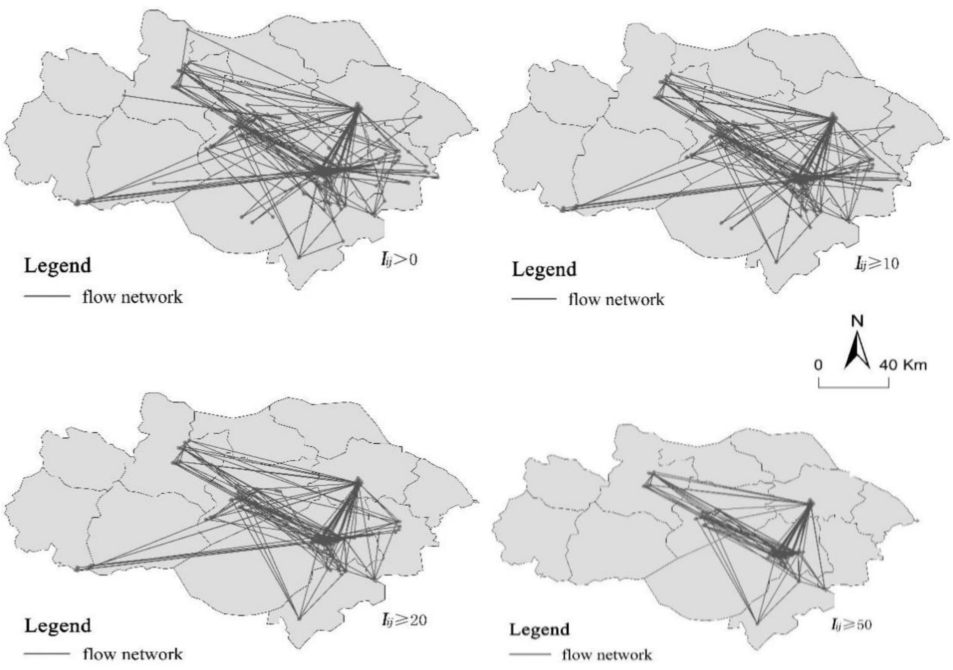
Appendexes

Appendix 1



Source: created by the authors.

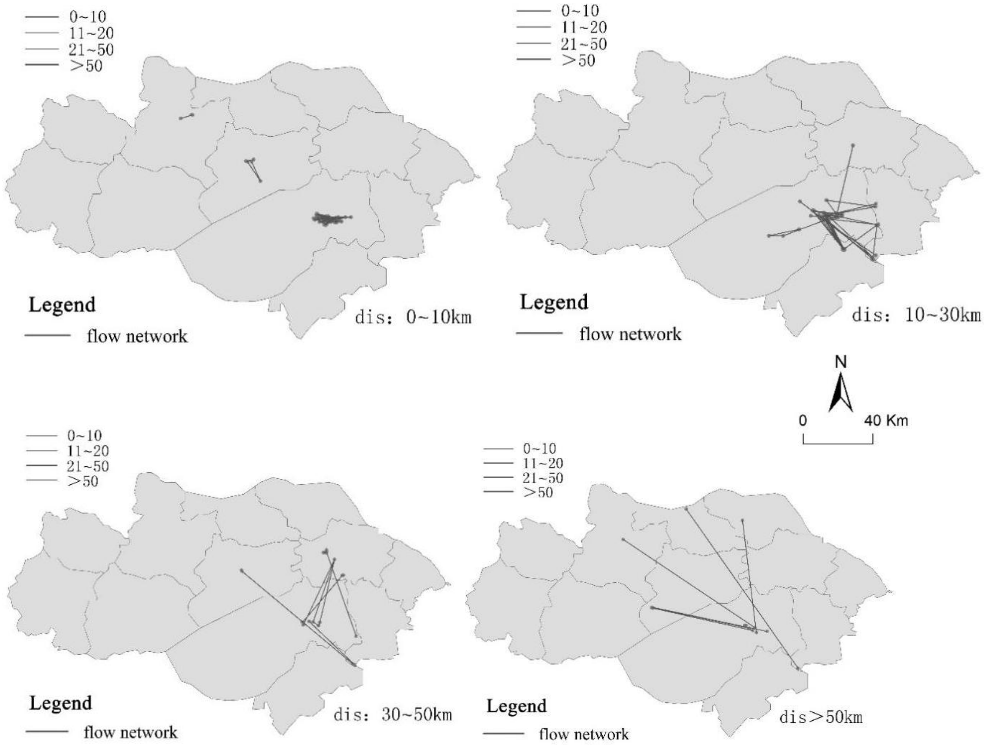
Figure 6. ***The Flow-Constrained Spatial characteristics of Tourist Flow （2010）***



Source: created by the authors.

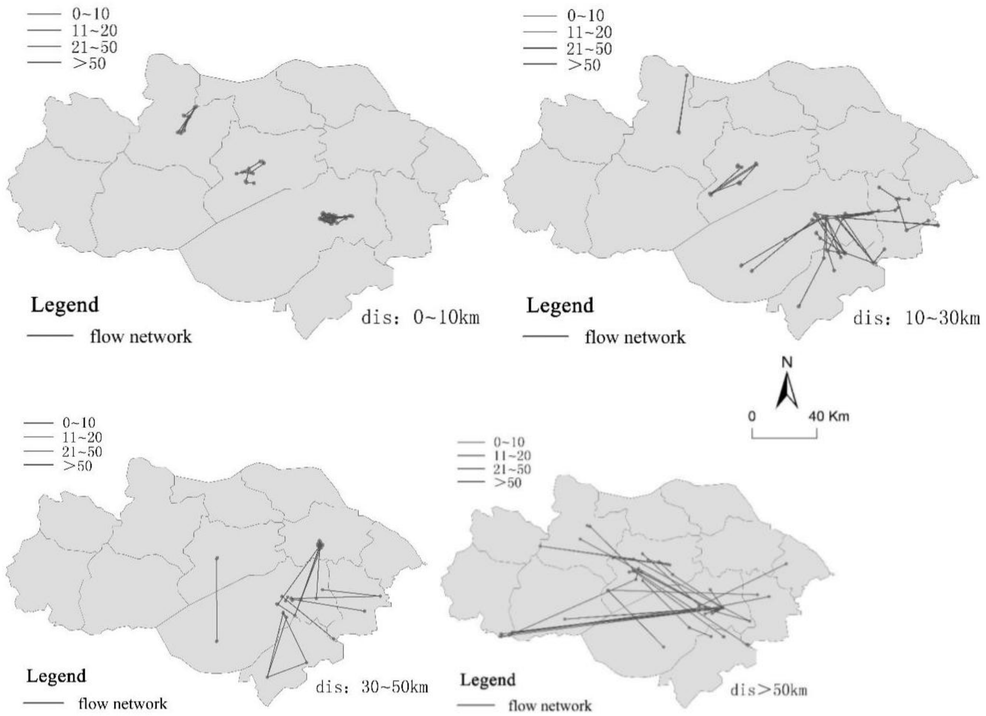
Figure 7. ***The Flow-Constrained Spatial characteristics of Tourist Flow （2018）***

Appendix 2



Source: created by the authors.

Figure 8 The Distance-Constrained Spatial characteristics of Tourist Flow （2010）



Source: created by the authors.

Figure 9. ***The Distance-Constrained Spatial characteristics of Tourist Flow （2018）***

Appendix 3

Table 3A. Tourism Hot Zones and Constitute Elements

Item	Number of photos	Hot zones and the names of attractions
1	4130	HumbleAdministrator’s Garden area；Humble Administrator’s Garden,Suzhou Museum,Lion Forest,Suzhou Silk Museum,Pagoda at Bao’en Temple in Suzhou,Pingjiang Historic District,East Garden,Xiangmen,Suzhou University,Guanqian Street,Garden of Harmony,Suzhou park,Shiquan Street,Master-of-Net’s Garden,Canglang PavilionCanglang Pavilion,Suzhou Embroidery Museum,Twin Towers,Suzhou Railway Station
2	1269	ShanTang Street area: Seven-mile Shantang, Shilu Pedestrian Street, Lingering Garden,Xiyuan Temple,Chang Men, The Garden if Cultivation
7	469	Hanshan Temple area：Hanshan Temple,Maple Bridge
8	500	Huqiu Scenic Area：Huqiu Scenic Spot, Set garden
9	534	Panmen Scenic Area：Panmen Scenic Spot,xū mén,
3	1566	Jinji Lake
24	228	Suzhou Amusement Land Area：Suzhou Amusement Land,Heshan park, Shishan Road
13	144	Dongshan Area：Dongshan Scenic Spot,Xishan Scenic Spot
15	139	Taihu Lake area：Suzhou Taihu National Tourism Vacation Zone,Qionglong Mountain Scenic Spot
22	318	Luzhi Ancient Town
11	563	Tongli Ancient Town area：Tongli Ancient Town ,Meditation garden
5	982	Zhou Zhuang area：Jinxi Ancient Town,Zhou Zhuang Ancient Town
25	59	Qiandeng Ancient Town
14	196	Yangcheng Lake area：Yangcheng Lake Vacation Zone ,Suzhou Yangchenghu Peninsula Tourist Resort,Yangcheng Lake Water Park,Bacheng Yangcheng Lake
20	398	Shajiabin YuShanghu Scenic Area：Shajiabin Scenic Spot,YuShang Shanghu Scenic spot,Square Tower Garden
23	79	Stone lake Scenic Area：Wang mountain scenic Spot,Shilake Scenic spot
4	384	The Turtle Head Park area：Wuxi The Turtle Head Park,Lihu,Li Garden ,Jiangnan University
6	567	Qingmingqiao Ancient Canal area：Qingmingqiao historical street,Chongan temple,NanChan Temple Pedestrian Street,former residence of XueChengfu,San Yang square,Donglin academy
10	223	Lingshan Scenic Area
17	176	Wuxi Movie and Television City area
12	283	Xihui Park area：Xihui Park,Huishan National Forest Park,Plum garden
16	419	South Street area：Changzhou South Stree ,Hongmei Park,Qingguo Lane historical street,Dongpo park,Tianning Temple
18	123	Spring and Autumn Herind Of Yancheng
19	110	Changzhou universal dinosaur City
21	56	Tianmu Lake
26	68	Universal Animation Joyland

Source: created by the authors.