Understanding the Local Sustainable Economic Development from New "3D" Perspective: Case of Hainan Island

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Abstract: This paper proposes a new T-3D measurement framework for calculating tourism economic space and as a tool able to assist in determining the sustainability of tourism development. The T-3D framework is described as a tourism-specific version of the Density, Distance, Division (3D) framework. Tourism economic concentration, level of integration and the degree of specialization are used to provide a touristic interpretation of density, distance and division. Taking Hainan Province as an example, this paper outlines the T-3D characteristics of tourism economic space. The results show that Hainan Province has large differences in the distribution of the tourism economy. In addition to the spatial division of the tourism economy, the spatial density and distance of the tourism economy are basically consistent in value. Further, the spatial density and division of the tourism economy exhibits a dual-core based on the cities of Sanya and Haikou, and the spatial distance of the tourism economy exhibits "core-peripheral" characteristics. The tourism economic space shows that the highest agglomeration based on T-3D characteristics occurs in the east followed by the west with the lowest agglomeration in the middle of the province. Using empirical analysis, the validity of the T-3D analysis system of the tourism economic space is verified and this is more conducive to improving the competitiveness of the tourism industry and promoting sustainable tourism development.

Keywords: tourism economy; sustainable development; spatial structure; T-3D; economic geography; Hainan Island

1. Introduction

Within political units such as regions, cities rarely develop independently and usually establish a range of linkages with other cities in their region based on the movement of people, goods and services. Tourism has a role to play in promoting connections of this type [1]. At city level, globalization and regional integration have encouraged agglomeration characterized by a free flow of tourism production factors between urban tourist destinations within regions [2]. These forces have enabled previously isolated tourist destinations to achieve greater levels of connectivity and cooperation.

In recent decades, the rapid growth of domestic tourism has led to an imbalance in regional tourism development in some Chinese provinces, generating interest in the study of the spatial structure of regional tourism economies. Tourism economy refers to the economic activity generated by tourism and includes first, second and subsequent rounds of expenditure, usually reported as tourism multipliers. First-round spending by tourists includes transportation, accommodation, food and beverage, shopping, other services (including travel agents and insurance firms) and visits to tourist

sites. Second and subsequent rounds of economic activity generated by tourism expenditure can be attributed to expenditure by the suppliers and their employees who support the tourism industry.

The spatial structure of tourism economies reflects the level of economic linkages between tourist destinations, and the influence and role of tourist destinations within these regions [3]. Understanding these processes can provide policy makers with data that will assist in selecting tourism-related infrastructure projects that are likely to provide the highest rate of return on funds invested with the least cost to the environment and resident social structures. For example, planners can determine if projects that strengthen competitive advantage through agglomeration will generate higher tourism flows than projects that provide faster transport links between core and distant periphery cities. Planners also will have access to data that can assist in determining impacts of tourism on the environment and local communities. The structure of tourism economic space also affects the efficiency and allocation of tourism economic elements in regions and determines the benefits that may accrue through external agglomeration.

Over the past 40 years, tourism theory has been greatly influenced by economic geography. In 2009, the World Bank [4] issued a report titled *Reshaping World Economic Geography*, which suggested the adoption of Krugman's *New Economic Geography* (NEG) structural system based on the 3D framework of Density, Distance and Division [5]. The 3D framework has become a useful tool for understanding changes in global economic patterns over geographic scales that include cities, regions and nations. According to the World Bank [4], high density, short distances and low segmentation are the basic conditions for successful economic development. Related studies in economic geography suggest that regional economic development is increasingly dependent on the competitive advantages offered by economic division (level of integration) and agglomeration [6]. Differences in economic density, the extent of economic distance and the strength of economic integration fundamentally affect the shape and strength of economic linkages between regions, and in turn affect the spatial distribution of regional economies [5,7]. On this basis, the World Bank report advocated a new approach termed the *new economic geography framework* to describe the evolutionary process of regional economic geography space. As with all economic sectors, the development of the tourism industry is also influenced by the division of labor and the level of agglomeration of businesses within the tourism industry. For this reason, the 3D framework theory can be used to understand changes in the patterns of tourism economic space. For the purposes of this paper, tourism economic space is defined as the spatial distribution of tourism economic development [8]. From this perspective, tourism economic space describes the spatial distribution and connection status of tourism economic units. The formation and evolution of tourism economic space is the outcome of geographical features, historical legacies, cultural traditions, environmental limitations, as well as the level of urban productivity, the economic strength of the city and level of tourism activity.

The NEGF identifies high density, short distance and low segmentation as the basic conditions for successful sustainable economic development. The difference in economic density, the size of economic distance, and the extent of economic integration fundamentally affect the "economic linkage" between regions, which in turn affects the spatial layout and opportunities for sustainable development of regional economies. The development of the tourism industry is affected by the economic density of the tourism space, the economic distance of the tourism space and the economic integration of the tourism space. The same "3D" feature is also applicable to judgments of what development elements of the tourism economy are sustainable. From a policy research perspective, the impacts of high-density, short-distance, and low-segmentation tourism development on the natural environment and local communities can be used as the basis for developing appropriate policy strategies.

The successful operation tourism industry is greatly influenced by the level of integration of the tourism economy and the level of agglomeration of tourism firms. From a theoretical perspective, very few studies have used the 3D framework to investigate these linkages. The purpose of this research is, therefore, to explore how high-density, short-distance, and low-segment distribution of the spatial economy is conducive to the success of the tourism economy using a modified version of

the 3D model. The approach taken is to demonstrate the application of "3D framework" theory to tourism economic space research is to propose and test a new "T-3D framework" (where T stands for tourism) and to identify the characteristics of the tourism economic spatial structure. The T-3D framework outlined in Table 1 introduces modifications in terminology to reflect its application in a tourism setting. Density is renamed as spatial density of the tourism economy, distance is renamed as the spatial distance of the tourism economy and division is refers to spatial integration of the tourism economy. Hainan Province was selected as a suitable site to analyze the spatial characteristics of the urban tourism economy based on the three dimensions of spatial density, spatial distance and tourism integration.

Table 1. Comparison of 3D and T-3D analysis system.

3D Framework				T-3D Framework			
Fact layer	Density	Distance	Division	**Feature layer**	Spatial density of tourism economy	Spatial distance of tourism economy	Spatial integration of tourism economy
Analysis layer	Agglomeration	Market distance	Non-distance barrier	**Implication layer**	Agglomeration of tourism economic space	Tourism market distance	Regional tourism integration
Policy layer	Urbanization	Regional development	Regional integration	**Index layer**	Geographical concentration	Space-time distance	Tourism connection

The results support the validity of the T-3D approach for understanding issues related to tourism economic space and identifies several issues that are of significance for tourism development planning policy formulation in urban tourism settings. The results also provide new insights which can be used by planning authorities wishing to promote sustainable economic development, which can be described as policies that meet human development goals while simultaneously supporting the ability of natural systems to provide the natural resources and ecosystem services on which the economy and society depend both in the present and in the future. From a theoretical perspective, 3D framework theory developed by Krugman can be adopted in a tourism context to enhance understanding of the role of spatial structures within the tourism economy [5].

2. Literature Review

2.1. Spatial Structure of Tourism Economy

The spatial structures of the tourism economy include economic activity as well as spatial attributes and the interrelationships of economic activities related to tourism [9]. Interest in the spatial structure of the tourism economy can be traced back to the 1960s, and includes research into the causes of regional differences, spatial differentiation characteristics and external effects of tourism economic development [10–12]. Lundgren [13] explored the relationship between recreational activities in geographical space while Pearce studied the distribution and function of tourism space as a means of maximizing urban tourism space [14]. Dredge, drawing on existing theories and models, conceptualized the core spatial structure of destinations as being single-node, multi-node and a chain node [15]. Since the 1980s, with the acceleration of urbanization, urban centers have gradually shifted from a single-core state to a multi-core model. There has been increasing interest by scholars on the role of economic linkages between cities, including the spatial linkages of the tourism economy, including theoretical and empirical research on the internal organization of urban tourism [16,17], research on tourism flows and spatial structure modes [18–20], identifying spatial patterns and the role of influencing factors on tourism economy [21–23].

Chinese scholars began to publish in this area in the 1980s and have generally focused on three aspects of tourism economic space development: the dynamic evolution of tourism spatial

structures; analysis of spatial differences between regional tourism economies; the spatial network structures of the tourism economy. Building on the concept of the dynamic evolution of tourism spatial structures, Shen et al. employed GIS technology to simulate the dynamic evolution process of tourism spatial structures in Anhui Province, China and found that the development of regional tourism was unbalanced [24]. On a national scale, Chen and Li used Exploratory Spatial Data Analysis (ESDA) spatial analysis to study the spatial distribution of tourism in China and found that there was strong positive spatial agglomeration in general [25], and an increasing trend towards further agglomeration.

Analysis of spatial differences in regional tourism economies was undertaken by Feng et al., who explored the dominant factors affecting spatial differentiation patterns in Xinjiang's tourism economy between 2003 and 2013 [26]. The results found that Xinjiang's tourism economy had a radial pattern emanating from a central core. Li et al., investigated spatial differences in Henan's urban tourism economy by measuring the income of foreign exchange earned from inbound tourism [27]. The results found that the spatial correlation of the tourism economy was positive over the four-year study period.

In an investigation of the role of spatial network structures in the tourism economy, Wang et al. analyzed the structural characteristics and influencing factors of the tourism economic network in the Wuhan metropolitan area and found that the overall connection density of the tourism economic network was low and the structure was immature [28]. Yan et al. used social network analysis to study the characteristics of tourism economic spatial networks in Hainan Province and found a network pattern where the density of the eastern sector of the province was greater than the western sector [29].

A number of scholars have examined issues related to tourist economic connection. For example, Ma et al., using Shanghai [30] and Beijing [31] as examples of inbound tourism flows, used the transition state index and tourism gravity model to conduct a coupling analysis of the spatial transfer of inbound flows and the strength of tourism economic linkages. Wu et al. analyzed the level of tourism economic connection between cities in the Yangtze River Delta and found an interactive response path between Shanghai's urban tourism and tourism in surrounding regions [32]. Dong et al. built a tourism economic flow intensity model using tourism economic connection and the evaluation index system of urban tourism competitiveness and found that spatial flow intensity is the external embodiment of the outward function of urban tourism and its influence of the tourism economy [33]. Using a modified gravity model, Zhang et al. conducted an empirical study of the tourism economic connections of 17 cities in Anhui Province, with the results showing that Anhui has four major tourism economic circles [34].

Compared to Chinese scholars, international scholars have mainly focused on identifying spatial connections within the tourism economy, including urban tourism internal organization theory, tourism flow and spatial structure modelling, tourism economic spatial patterns and influencing factors. Chinese scholars have paid more attention to urban space connections, with particular attention given to the evolutionary impacts of changes in space over time.

2.2. The 3D Structural Framework

Following its introduction, the 3D framework has generated considerable interest from scholars in China and elsewhere [5]. For example, Conroy et al., selected representative indicators for each "D" using regression analysis to investigate the welfare status of Latin American states [35]. Roberts et al. used a similar method to study productivity difference in Chongqing, China using least squares regression [36]. The results of both studies indicate that distance and spatial productivity distribution had a strong correlation. Shabani et al., used the 3D framework to analyze the impact of population density, economic distance and division of labor on regional economic growth and proposed a simple theoretical framework to study the impact of population density, economic distance and division on regional economic growth [37]. Their framework offered useful insights into the use of NEG models with endogenous growth and free capital mobility. Oh argued that urbanization processes undergo

three stages: the 1D stage of density concentration, the 2D stage of density concentration and distance reduction, and maturity in the 3D stage [38].

In China, Li and He used the 3D framework to analyze the economic space of the Beijing–Tianjin–Hebei metropolitan area, the Wuhan urban agglomeration and the Yangtze River Delta urban agglomeration and, based on their findings, put forward suggestions for optimizing regional economic space [39]. Chen, et al. studied the spatial evolution patterns of prefecture-level cities in Jiangsu Province from a 3D perspective using principal component analysis and the spatial autocorrelation method and were able to extend previous research on the Yangtze River Delta region [6,40]. At present, Chinese and international research using the 3D framework is limited to the field of new economic geography, with a focus on the economic space of urban agglomerations. The 3D framework has yet to be used to investigate tourism economic space.

In summary, the existing literature pays considerable attention to inter-regional economic relations and regional development differences and places greater emphasis on relational data rather than attribute data. However, little attention has been given to the evaluation and analysis of spatial structure characteristics of the tourism economy. To redress this research gap, this paper tests a tourism version of the 3D framework renamed as the T3D framework.

2.3. Spatial Density of the Tourism Economy

Density, defined as the intensity of economic activity per unit of land, is an import factor. Higher density allows for more effective use of production advantages accrued through aggregation [40]. Ciccone et al. found that in the United States an increase in employment density occurred as labor productivity and economic density increased [41]. Ciccone subsequently analyzed the density of tourism economic space in five European countries (France, Germany, Italy, Spain and the United Kingdom) and found that there was a significant positive correlation between population density and labor productivity [42]. The spatial density of the tourism economy is similar to that of the regional economy. As the spatial density of the tourism economy increases, the agglomeration effect on the tourism economy will also increase, leading to lower costs, thus promoting further growth in the regional tourism economy. The geographical concentration index is often used to measure the economic agglomeration of the whole region [40], and its equation is as follows

$$G = 100 \sqrt{\sum_{i=1}^{n} \left(\frac{A_i}{X}\right)^2} \tag{1}$$

where *G* is the index of geographical concentration, n is the number of cities, A_i is the tourism revenue of the first city and *X* is the total tourism revenue of the region. Considering that the geographic concentration index is suitable for measuring the agglomeration of whole regions, and that it is difficult to measure the situation of individual cities, this paper uses the tourism economic concentration index per unit area to measure the spatial density of the tourism economy (R_i). The calculation equation is

$$R_i = \frac{A_i / \sum_{i=1}^{n} A_i}{T_i / \sum_{i=1}^{n} T_i} \tag{2}$$

where R_i is the tourism economic density of city *i*, Ai is the tourism income of city *i* (100 million yuan), T_i is the territory area of city *i* (km^2), and n is the number of cities in the region.

2.4. Spatial Distance and the Tourism Economy

In NEG, distance is considered as a major dimension of the differences that develop between economically active and backward regions [43]. As the first law of geography outlines, convergence of the nearest and divergence of the distant explains the influence of distance [40]. To some extent, the micro-mechanism of distance can overlap with density, because high density itself means short

distances, which can lead to agglomeration. In a study of the NUTS3 region of the United Kingdom, Rice et al. found that productivity increases as distance between economic units declines [44]. In another study, Davis et al. examined the level of patent citation of American headquarters enterprises in a specific geographical area from the perspective of their economic agglomeration and found that the technology spillover effect of the small-scale region is greater than that of the large-scale region [45]. In NEG, distance generally refers to market distance, and spatial distance between cities, and is used as a measurement index. This paper holds that the spatial distance of the tourism economy can also refer to the distance from a specific tourism market, where spatial distance is used as a measurement index. The market distance of tourism refers to the distance from the tourist market to tourist attractions. The tourist market for tourists declines with increasing distance. Given that there are over 600 cities in China, we chose the top 20 tourist origin cities as measurement objects. We have revised the measurement equation, calculating the distances from in-land and off-land tourists of origin cities, and taken the proportion of tourists on the island and tourists outside the island as weight. Based on this relationship, the spatial distance measurement indicators of the tourism economy is:

$$Di = G\left(\frac{\sum\limits_{j=1}^{n} dij}{\sum\limits_{i=1}^{n}\sum\limits_{j=1}^{n} dij} \times \frac{n}{n+m} + \frac{\sum\limits_{k=1}^{n} dik}{\sum\limits_{i=1}^{n}\sum\limits_{k=1}^{n} dik} \times \frac{m}{n+m}\right) \quad (G=100) \tag{3}$$

where D_i is the distance between the tourism economic space of the city i, and d_{ij} is the shortest transportation distance between the city i and the in-island city j (km). d_{ik} is the shortest distance between the city i and the off-island city k. m is the amount of in-island tourists and n is the amount of off-island tourists (from 20 main cities). The more tourists, the closer the market is, so the reverse contribution is made. The original data were obtained by undertaking a Baidu Map Survey where the track longitude and latitude data were obtained according to the start point and end point. Baidu Maps provide users with intelligent route planning, intelligent precision navigation (driving, walking, cycling), real-time road conditions, and other travel-related services.

2.5. Spatial Integration (Division) and the Tourism Economy

Most NEG studies redefine Division as "integration" [6,39,40,46,47]. Integration emphasizes mutual exchanges, industrial linkages and removal of non-distance barriers. Liu and Wang put forward the view that the economic integration of urban areas includes the integration of the economic systems of urban agglomerations (industrial integration and market integration), the integration of economic support systems of urban agglomerations and the construction of regional coordination systems of urban agglomeration [48]. Chen et al. considered that improving the level of urban economic integration is the main strategy used to achieve the optimization of economic space [6]. In their study, they found that the level of coordination between regions was not as effective as it could be, in part as a result of economic obstacles (such as the governance system) in administrative regions that require more effective mechanisms for coordination between regions. As an approach to the measurement of integration indicators, Chen et al. used the intensity of urban flows to measure the integration intensity of various cities [6], while Li and He used the intensity of economic links within the urban agglomeration to measure the integration of regional economic space [26]. On this basis, combined with tourism, the intensity of tourism economic links was used to measure the integration of regional tourism economic space in the Yangtze River Delta region [47]. They found that strong tourism economic connections led to a higher degree of integration and smaller non-distance barriers.

The development of tourism is not only affected by spatial factors, but also by the operation of other industries and regional economic development policies. Given the relevance of the space economy and the difference between tourism economic spatial connections and urban economic spatial connections, this paper uses a modified gravity model to measure the economic linkages between

cities. Considering the connections between all cities in Hainan, this paper replaces the original index with the total number of tourists and total tourism income and introduces the relationship coefficient K_{ij}. The revised tourism attraction model is used to measure the connection strength of the tourism economy between cities. The calculation equations are as follows

$$C_i = \sum_{j=1}^{n} T_{ij} \qquad (4)$$

$$T_{ij} = K_{ij} \frac{\sqrt{P_i \times A_i} \times \sqrt{P_i \times A_i}}{d_{ij}^2}, \; (K_{ij} = \frac{A_i}{A_i + A_j}) \qquad (5)$$

where C_i is the integration of tourism economic space, T_{ij} is the value of tourism economic intensity between city i and city j, K_{ij} is the coefficient of gravitational relationship, P_i, P_j and A_i, A_j are the total number of tours received by city i and j (10,000 people) and total tourism income (100 million yuan), and d_{ij} is the shortest traffic distance between city i and j (km).

2.6. Comparison between T-3D Framework of Tourism Economic Space and the Standard 3D Framework

The proposed T-3D framework gives new meanings to density, distance and integration from a tourism perspective. A comparison between the 3D features of NEG and spatial pattern analysis system of the T-3D tourism economy is shown in Table 1.

The T-3D system outlined in this paper reflects the spatial agglomeration of the tourism economy, the distance to tourism markets, and the integration of regional tourism. Quantitative analysis is based on the levels of geographic concentration, spatial distance and tourism linkages.

Because the tourism industry is not an independent industry, its development is affected by the operation of many other industries. In addition to spatial distance, time distance and psychological distance should be taken into account in the development of tourism. Due to data limitations, the spatial measurement model constructed in this paper only considers spatial distance, and does not take into account the impact of related industries and regional policies.

3. Methods

Using a modified version of the 3D framework theory, this paper undertakes a T-3D analysis of the tourism economy of Hainan Province and outlines new directions for future investigation of the role of density, distance and division at the spatial level of the tourism economy. This paper employs ArcGis and NetDraw to analyze the T-3D characteristics of tourism economic spatial patterns. The natural fracture method of ARCGIS software is used to project the results of each city and county onto a map. NetDraw is used to analyze the strength of connections between cities.

Study Region: Hainan

Hainan Province is located off the southern coast of China and has the status of a special economic zone with a free trade port. The total land area of the province is 354,000 km^2, while the maritime area is approximately 2 million km^2. Following the 4 January 2010 proclamation of the State Council policy, Some Opinions of the State Council on Promoting the Construction and Development of Hainan International Tourism Island, Hainan has developed rapidly as an international tourism island. The province's tertiary sector is dominated by tourism, which is now recognized as the province's main economic driver. To further encourage tourism, large amounts of land have been set aside for future tourism development. Geographical location map of Hainan Province as illustrated in Figure 1.

In 2018, the value of Hainan's tourism industry was 39.282 billion yuan, an increase of 8.5% over 2017. By 2018, visitor numbers had grown to 76.3 million, an increase of 11.8% over 2017. The majority of visitors (63.3 million) overnighted, an increase of 11.7%. over the previous year. Total tourism

revenue was 95.0 billion yuan, an increase of 14.5% over the previous year. At the end of 2017, the province had 124 star-rated hotels including 26 five-star hotels, 38 four-star hotels and 54 three-star hotels and had become one of the largest tourist destinations in China. Total tourist numbers and tourism income for Hainan's eighteen cities (including their surrounding region) was sourced from the Hainan Statistical Yearbook [40]. The shortest distance between cities was measured using a Baidu Map. Sansha City established in 2012 is not included in this study because of problems with obtaining data. Table 2 outlines the status of the cities within the province from the perspective of their role in the tourism industry.
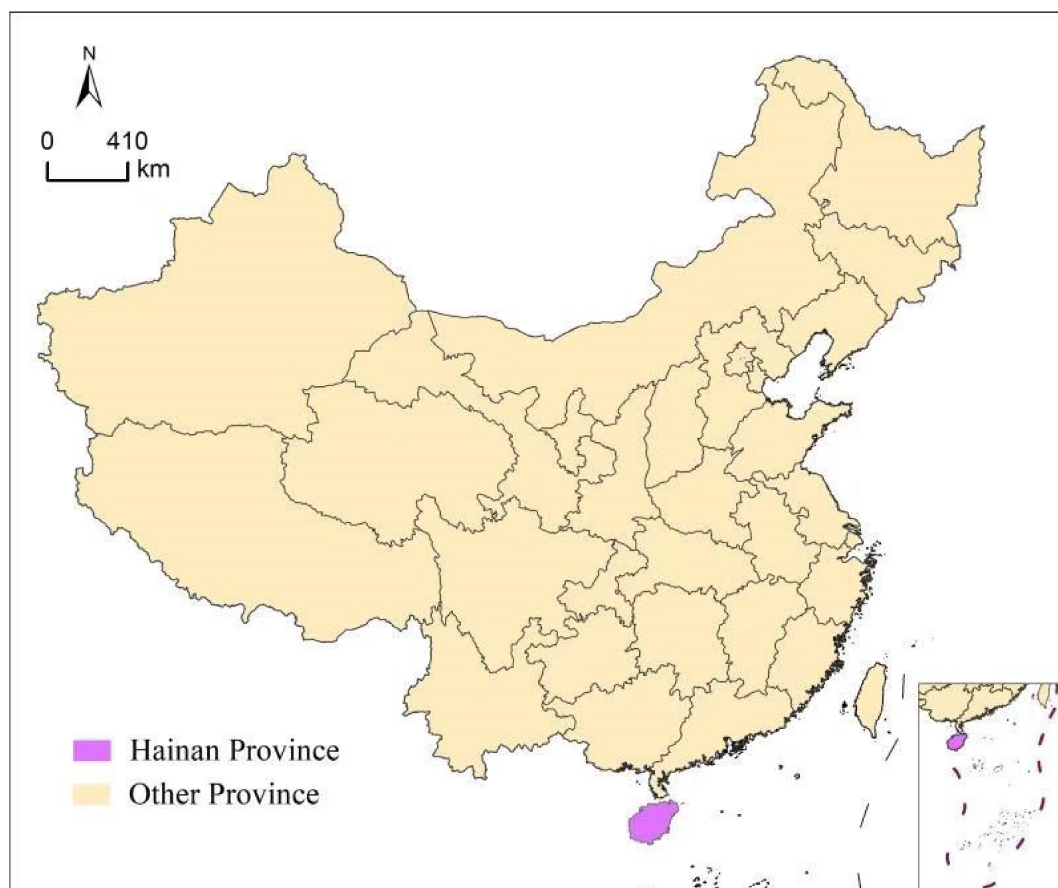

Figure 1. Geographical location map of Hainan Province.

Table 2. Tourism development in Hainan Province.

City	Area (km²)	Tourism Income (Billion)	Tourist Numbers (Ten Thousand Person Times)	4A- Class Scenic Area	City	Area (km²)	Tourism Income (Billion)	Tourist Numbers (Ten Thousand Person Times)	4A- Class Scenic Area
Haikou	3145.93	29.81	2077.68	11	Qiongzhong	2704.66	0.590	92.24	0
Sanya	1919.58	51.47	2232.69	19	Baoting	1166.60	1.660	171.31	2
Qionghai	1692.00	2.943	430.08	9	Baisha	2117.73	0.240	51.80	0
Wanning	4443.60	3.89	552.52	11	Danzhou	3400.00	1.727	301.72	3
Wenchang	2488.00	1.68	320.83	12	Dongfang	2266.62	0.668	127.65	0
Lingshui	1128.00	3.59	359.84	3	Chengmai	2072.00	1.284	214.45	3
Wuzhishan	1169.00	0.41	109.27	1	Lingao	1317.00	0.390	95.65	0
Dingan	1189.00	0.829	108.62	2	Ledong	2747.00	0.809	121.41	0
Tunchang	1231.50	0.29	71.15	0	Changjiang	1569.00	0.594	121.02	0

4. Findings

4.1. Tourism Economy Spatial Density

According to the geographic concentration index Equation (1), the total geographic concentration index G1 of Hainan province is 50.63. To facilitate a comparative study, we assume that the income of the economy tourism is evenly distributed between the 18 cities of the province. The geographic concentration index G2 was found to be 5.56, implying that the distributed geographic concentration index is far smaller than that of the realistic geographic concentration index; that is, G1 > G2, which shows an assembling condition in the provinces' tourism economy in Hainan.

Using domestic tourism income and urban territory area as indexes, Equation (2) was used to calculate the spatial density of the urban tourism economy (Table 3), as illustrated in Figure 2.
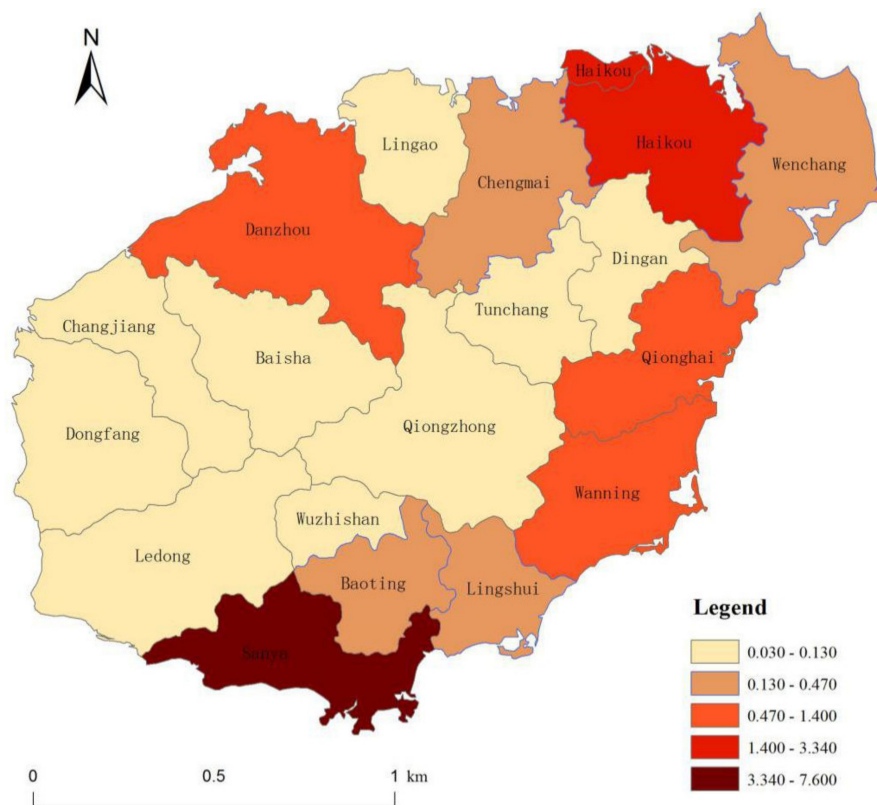

Figure 2. Spatial Density of the Tourism Economy in Hainan Province.

Table 3. Spatial Density of Urban Tourism Economy in Hainan Province.

Rank	City	Tourism Economy Spatial Density	Rank	City	Tourism Economy Spatial Density
1	Sanya	7.60	10	Changjiang	0.13
2	Haikou	3.34	11	Dingan	0.12
3	Qionghai	1.40	12	Wuzhishan	0.09
4	Danzhou	1.39	13	Dongfang	0.07
5	Wanning	0.90	14	Lingao	0.07
6	Lingshui	0.47	15	Tunchang	0.05
7	Chengmai	0.38	16	Ledong	0.04
8	Baoting	0.34	17	Qiongzhong	0.04
9	Wenchang	0.24	18	Baisha	0.03

These findings show that there are obvious differences in the spatial density of the urban tourism economy, ranging from a maximum of 7.60 in Sanya to 0.03 in Baisha, which had the lowest rank.

For the province as a whole, the range of spatial density is large, however, the level total spatial density of the urban tourism economy is comparatively low. Sanya (7.60) has the highest level of spatial density, while second-ranked Haikou (3.34) had a density less than half that of Sanya, effectively creating two tourism nucleuses. Both cities exhibit a high level of concentration in their tourism economy. While the spatial densities of the tourism economies of Qionghai (1.40), Danzhou (1.39) and Wanning (0.90) are smaller than Sanya and Haikou, they still surpass other cities, reflecting the role they currently play in the province's tourism economy. Based on the ranking of the density of tourism economy, all cities that ranked below Lingshui have a density less than 0.5. This result indicates there remains scope for improvement, particularly in middle-ranked cities such as Baisha, Qiongzhong and Tunchang. From a spatial distribution perspective, the distribution of density of the tourism economy is dispersed, with a noticeable spatial differentiation.

The spatial density reflects variations in the level of tourism development. Factors such as the level of natural factor endowment and transportation accessibility are key determinants of spatial density. Sanya and Haikou both have advanced local economies, more convenient transportation and significant tourism resources, which have collectively boosted the development of tourism. On the other hand, while western and middle cities (such as Chengmai, Danzhou, Changjiang, Dongfang, Ledong, Baisha, Qiongzhong, Tunchang) have a high level of natural resources and cultural attractions, their transportation facilities are backward, posing numerous difficulties for tourist development and leading to a lower geographic concentration of tourism.

4.2. Spatial Distance of the Urban Tourism Economy

Using the shortest distances (d_{ij}) between the 18 cities, as measured using a Baidu Map, Equation (2) was used to calculate spatial distance statistics for the urban tourism economy (D_{ij}), using ArcGis10.2 to simultaneously perform visual analysis. The measurement results are shown in Table 4.

Table 4. Spatial Distance of Urban Tourism Economy in Hainan.

Rank	City	Tourism Economy Spatial Distance	Rank	City	Tourism Economy Spatial Distance
1	Tunchang	7.37	10	Baoting	5.21
2	Baisha	7.25	11	Chengmai	5.17
3	Ledong	6.43	12	Lingshui	5.11
4	Qingzhong	6.12	13	Wanning	5.02
5	Dongfang	5.81	14	Wenchang	5.00
6	Dingan	5.80	15	Danzhou	4.93
7	Changjiang	5.54	16	Qionghai	4.85
8	Lingao	5.37	17	Haikou	4.77
9	Wuzhishan	5.29	18	Sanya	4.51

The spatial distance of the tourism economy represents the distance from tourism markets. The smaller the figure, the closer the destination is to its market economy, with most ranging from 4 to 7. Tuncang (7.37), Baisha (7.25) and Ledong (6.43) have high distance figures and are disadvantaged by their geographic location in the north-eastern and south-western parts of Hainan. Next on the spatial distance scale are Qiongzhong(6.12), Dongfang (5.81), Dingan (5.80), Cangjiang (5.54) and Lingao (5.37). These cities have figures above 5.30. Qionghai (4.85), Haikou (4.77) and Sanya (4.51), have the lowest figures (as illustrated in Figure 3).
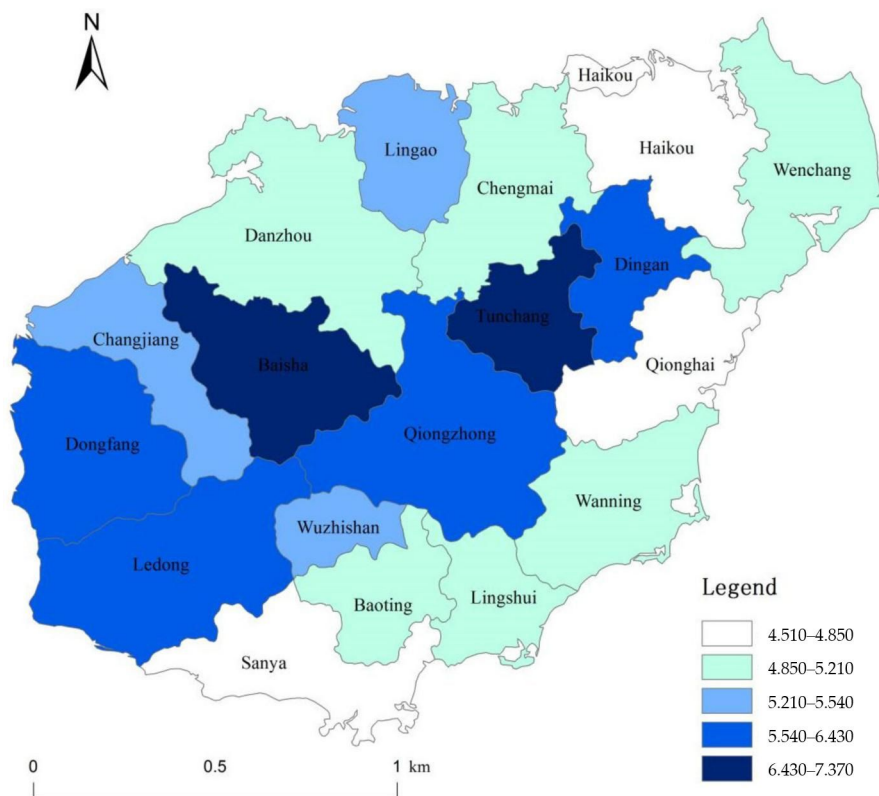
Figure 3. Spatial Distance of Urban Tourism Economy in Hainan Province.

This paper has suggested a measurement model that employs spatial distance, where geographic position is largely related to distance between cities. However, distance may be influenced by other factors, such as access to roads, airports, rail and virtual internet channels. For example, building new roads and railway lines could overcome current problems of access. A similar observation can be made about Internet and mobile communications.

4.3. Spatial Division of Tourism Economy

Using tourism income and number of tourists as base figures, Equations (3) and (4) are used to calculate the integrated figures of the tourism economy (see Table 5). Using Ucinet6.0, a grid structural diagram showing the spatial distances of the tourism economy was developed. The size of the panel points represents the degree of spatial division of the tourism economy and the thicknesses of lines represent the strength of intercity connection within the tourism economy.

Table 5. Spatial Division of Urban Tourism Economy in Hainan.

Rank	City	Spatial Division of Tourism Economy	Rank	City	Spatial Division of Tourism Economy
1	Sanya	21.99	10	Dingan	0.17
2	Haikou	19.83	11	Wuzhishan	0.13
3	Qionghai	5.30	12	Changjiang	0.11
4	Danzhou	3.83	13	Qiongzhong	0.08
5	Wanning	3.49	14	DongFang	0.06
6	Wenchang	1.05	15	TunChang	0.05
7	Chengmai	1.01	16	LingGao	0.04
8	Lingshui	0.79	17	LeDong	0.04
9	Baoting	0.49	18	BaiSha	0.02

The results outlined in Table 5 indicate significant differences in the spatial integration of the tourism economy ranging from 0.02 to 21.99. The division is low in 10 of the 18 cities (0.5 or less), reflecting the overall low-level spatial integration of the tourism economy as a whole. The results for Sanya (21.99) and Haikou (19.83) reflect their role as the core cities of the province's tourism economy and indicate their capacity to assist other cities develop their tourism sectors. Qionghai (5.30), Danzhou (3.83) and Wanning (3.49) play a secondary role which includes assisting cities on the periphery. Several cities with low scores including Wenchang (1.05) and Chengmai (1.01) are near to Haikou but have failed to take advantage of their location to develop their tourism economies. Cities with a very low score such as Baoting (0.49) and Wuzhishan (0.13) have generally failed to enter into collaboration with other cities in the core of the tourism economy.

From a spatial integration perspective, the eastern cities have developed close spatial connections with Haikou and Sanya. The western cities, along with Danzhou, Chengmai and Lingao, have developed strong spatial connections to Haikou, while cities on the south-west have generally failed to make use of their connection with Sanya, and as a consequence have weaker spatial integration in their tourism economy. The spatial integration of the middle cities is low even though the eastern and western parts of the island are connected by high-speed rail. The reasons include topography and technology constraints that have inhibited communication and collaboration with cities that have a high level of economic development.

The spatial integration of the urban tourism economy reflects the level of connection with the external tourism economy of Hainan Province and can be represented as a tourism economy grid (as illustrated in Figure 4).
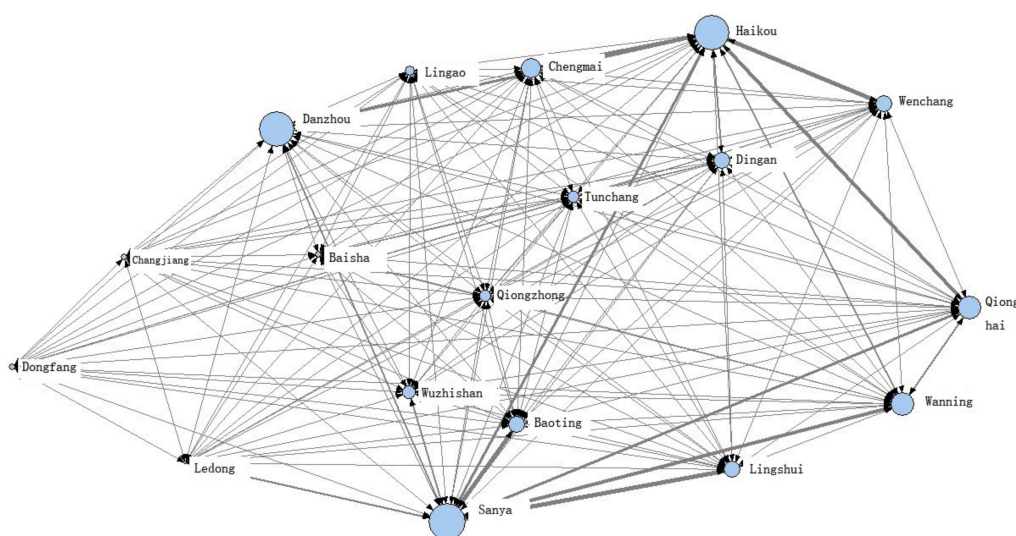

Figure 4. Spatial Division of Urban Tourism Economy in Hainan Province.

The level of spatial integration of the tourism economy depends on differences in the level of economic activity in individual cities, geographical location and transportation connectivity. Cities with developed tourism economies can achieve higher levels of spatial integration because they have the strength to emerge as the focal points for tourism activity and are able to draw on surrounding tourism resources to strengthen their competitive advantage in the tourism markets they service. Cities which are located close to core cities have some advantages over those that are more distant. Advantages include having access and the ability to draw on the resources of core cities' suite of resources such as communications, increased opportunities for cooperation and access to transport networks.

5. Discussion and Conclusion

5.1. Discussion

This aim of this research was to test the ability of the T-3D framework to investigate three spatial dimensions of Hainan's tourism economy: spatial density, spatial distance and spatial integration. Significant differences were found between the top ranked cities of Sanya, Haikou, Qionghai, Danzhou and Wanning, and the lowest ranked cities of Lingao, Ledong, Baisha, Qiongzhong and Tunchang. In terms of the spatial distance of the tourism economy, Qiongzhong, Tunchang and Wuzhishan have obvious distance advantages, while Haikou and Sanya rank fourth and sixth with lower distance advantages. It was apparent that, from a spatial density and integration perspective, tourism development in Hainan Province has led to the emergence of a pattern of primary and secondary core cities. The primary core cities for the province are Sanya in the south and Haikou in the north. Qionghai emerged as a secondary core in the east with good connections to both Sanya and Haikou. From a spatial perspective, the province's tourism economy can be described as having a dual-core structure based on Sanya and Haikou with a small number of secondary core cities. Collectively, the Province exhibits a core-periphery structure.

The eastern region has the most developed tourist economy, with the highest level of tourist economic density and integration. The western region has a lower level of integration, characterized by lower tourist economic density and a lower level of spatial integration of the tourist economy. Danzhou is the only secondary core city of the tourism economy located in the western region. The level of development of the tourism economy is the weakest in the central region, which lacks a core city and has the lowest density and lowest level of integration of the province's tourism economy. The development of tourism in the central region of Hainan is also characterized by a relatively low level of integration and agglomeration. These findings indicate that the ongoing integration of the regional tourism economy in the province as a whole is no longer a simple function of cooperation or competition but is now subject to a complex competition–cooperation relationship.

5.1.1. Theoretical Implications

The 3D framework has become a useful tool for understanding changes in global economic patterns over geographical scales, including urban and rural, regional and national. Adapting the standard 3D framework for application in a tourism setting gives tourism planners the ability to understand the implications of economic density, economic distance and economic integration in terms of the tourism economy. For example, high levels of economic density in the tourism economy facilitate agglomeration by encouraging firms to reduce their distance from economically dense areas. Relocating to economically dense regions enables firms to benefit from economic opportunities provided by higher levels of integration, leading to an increase in economic density. It is apparent that the level of tourism activity is influenced by the level of integration of the tourism economy and the patterns of agglomeration that are demonstrated by firms operating in the tourism economy. From this perspective, the 3-TD framework enables tourism scholars the opportunity to examine a range of spatial interactions within a region's tourism space and tourism economy. These insights can also be used to evaluate how development within the tourism economy, including integration and agglomeration, may affect the long-term sustainability of natural systems and local communities.

This research highlights aspects of the spatial problems experienced in Hainan during recent economic development, including those associated with the sustainability of tourism development.

5.1.2. Practical Implications

As the tourism industry in a region expands, it is able to benefit from the competitive advantages derived from economic integration (division) and agglomeration. Economic density, distance and integration provide a new framework to describe regional economic tourism space. From a planning perspective, the analysis of Hainan's tourism economy using the 3TD framework provides insights into

the drivers affecting the tourism economy and provides a tool for forecasting future levels of integration and agglomeration based on existing trends. These insights may also be used to understand potential impacts on the region's environmental asserts, such as protected areas, as well as the potential for unregulated development to adversely affect preexisting social structures. From a policy perspective, this understanding can be used in policy formation that seeks to determine what constitutes a desirable balance between development, the environment and social structures. It should be noted, however, that determination of the weighting between development, the environment and social structures is a function for government with the role of the 3TD framework restricted to providing information on trends.

5.2. Conclusions

According to the World Bank [4], high density, short distances and low segmentation are the basic conditions for successful economic development. Recent studies in economic geography support this view and contend that successful economic development in regional areas depends on fostering the competitive advantages provided by economic division (level of integration) and agglomeration [6]. From this perspective, differences in economic density at the regional level, the extent of economic distance and the strength of economic integration has a fundamental impact on the extent and strength of economic linkages between regions, which in turn affects the spatial distribution of regional economies. The findings of this paper support this view in a tourism context, highlighting the impact of spatial changes such as integration on the tourism economy. The findings also demonstrate the validity of T-3D framework as a tool for investigating these factors. From a sustainability perspective, the T-3D approach provides useful data on spatial trends in the tourism economy that may indicate the emergence of problems if patterns of agglomeration and integration begin to impact ecosystems and social structures.

However, given its case study setting, there remains a need to confirm if the spatial structure of the tourism economy has a universality in its application that applies in the countryside as well as in cities. For example, the ideal density of development needs to be considered. While a moderate density can take advantage of economic agglomeration, a high density may generate diseconomies of scale and generate unanticipated environmental problems. This raises the question of density having a critical value and how it should be measured.

The measurement of spatial distance also raises questions. For example, should indexes other than linear distance be considered? The level of integration (division) of the tourism economy also needs further analysis. While the level of tourism development has a direct impact on the development of related industries, the overall level of regional economy development can also affect the level of tourism development. The operation of these interrelated linkages and how they interact at industry and regional levels also needs further investigation.

Finally, there is scope to use the 3-TD framework to investigate how the development of Hainan's tourism economy has impacted the province's non-tourism economy, environment and social structures. Given that tourism development can increase economic density, strengthen economic integration and optimize economic distance, the impact of these changes and their impact on the environment and social structures needs further investigation.

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