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Article

Spatial Pattern and Drivers of China's Public Cultural Facilities between 2012 and 2020 Based on POI and Statistical Data

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Abstract: In the context of globalization and the intensification of international competition, the construction of public cultural facilities has long been not limited to meeting the cultural needs of the people but has become an important initiative to shape the competitiveness of cities. This paper collected POI and socio-economic statistics from 2012 to 2020 from 285 Chinese cities and employed the coefficient of variation (CV), Gini index (GI), ESDA, and GeoDetector to analyze the spatial patterns and driving mechanisms of public cultural facilities. Findings: (1) Public cultural facilities in Chinese cities were featured by evident regional gradient differences and uneven spatial distributions, with a CV greater than 1.3 and a GI greater than 0.5 in both years. They also showed signs of aggregation at weak levels, with a Moran I of 0.15 in both years and a cluster pattern of "hot in the east and cold in the west". (2) Different types of public cultural facilities had differences in their differentiation, aggregation, and change trends. The CV changed from 1.39~2.69 to 1.06~1.92, and the GI changed from 0.53~0.80 to 0.47~0.62, with the differentiation of libraries, museums, theaters, art galleries, and cultural centers decreasing gradually, while that of exhibition halls increased day by day. As the Moran I increased from 0.08~0.20 to 0.12~0.24, libraries, museums, art galleries, and cultural centers showed weak aggregation with an increasingly strong trend. Theaters and exhibition halls also showed weak aggregation but in a declining trend, with the Moran I changing from 0.15~1.19 to 0.09~0.1. (3) The five driving variables exhibit significant differences in their strength across time and across regions, with the economic and infrastructure factors being the strongest and the urbanization factor the weakest. There are significant differences in the strength of the driving forces among the factors, with the total retail sales of consumers, the number of subscribers to internet services, regular higher education institutions, and undergraduates in regular HEIs playing both direct and interactive roles as the core factors. (4) The 285 cities in China are divided into four policy zonings of star, cow, question, and dog cities. Star cities should maintain their status quo without involving too much policy intervention, whereas the core and important factors should be the focus of policy in dog cities and cow cities, and the auxiliary factors should be the focus of policy in question cities. This paper contributes to the in-depth knowledge of the development pattern of public cultural facilities and provides a more refined basis for the formulation of public cultural facility promotion policies in China and similar countries.

Keywords: spatial evolution; influencing mechanism; cultural service; POI; China

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1. Introduction

Public cultural facilities are places that provide cultural services to the public, including libraries, museums, cinemas, art galleries, concert halls, and cultural centers, serving as an important part of the public service system [1,2]. With the intensification of international competition in the context of globalization, the rise and development of public cultural facilities are no longer limited to a means of meeting the cultural needs of the people [3] but has become an important initiative to improve the cultural soft power of the country and the relevant city [4]. This is why the construction of public cultural facilities is receiving more and more attention from the government and the public, and related studies are beginning to attract academic attention. Spatial configuration is a core topic that needs to be discussed in all public service facilities. Due to historical development, economic conditions, cultural policies, and other reasons, there are differences in the development of public cultural facilities in different places [5–7], such as regional differences, urban-rural differences, and accessibility differences, which further attracts the academic field to explore the spatial pattern and optimization of public cultural facilities. The space is a unique perspective for geography and urban and rural planning to cognize the world. Studying the changing characteristics and driving mechanisms of public cultural facilities from a spatial perspective can help to gain a deeper insight into their development patterns and formulate more refined management policies.

According to international experience, the share of cultural consumption increases significantly when the per capita GDP of a country or region exceeds USD 3000 [8]. The per capita GDP in China, the world's second-largest economy, exceeded USD 3000 in 2008 and USD 12,500 by 2021 [9]. The central government has issued many documents in this context, such as the *Opinions on Accelerating the Construction of a Modern Public Culture Service System* (2015) and the *Public Cultural Service Guarantee Law of the People's Republic of China* (2016), which have effectively promoted the construction of public cultural facilities. By the end of 2021, China had built 3215 public libraries, 3316 cultural centers, 6183 museums, more than 40,000 township (subdistrict) cultural stations, and 570,000 village-level comprehensive cultural service centers [10], greatly satisfying residents' increasing demand for cultural consumption. However, in view of the fact that China is still a developing country with inherent differences between different regions, a low level of construction of public cultural facilities [5], and prominent uneven distribution [11,12], pushing the construction of public cultural facilities and their equalization remains a vital task for its cultural development in the long term. Therefore, it can be seen that China is a typical and exemplary country across the world for the study of the spatial patterns and influencing factors of public cultural facilities.

This paper focuses on the following questions: (1) What are the characteristics of spatial distribution, spatial differences, and spatial aggregation of public cultural facilities in Chinese cities? What is the pattern of their spatial changes? (2) What are the driving factors for public cultural facilities in China and in the eastern and western regions of the country? What are the manifestations of the interactions? What is the pattern of their changes? (3) Based on the perspective of spatial management, how can management conduct refined policy zoning and put forward differentiated suggestions for the development of public cultural facilities? By addressing the above issues, this paper attempts to reveal the spatial change patterns of public cultural facilities, clarify the driving mechanisms of their spatial differentiation, and propose differentiated development suggestions for public cultural facilities in different regions, with the aim of providing references for central and local governments to promote the construction and balanced development of public cultural facilities.

2. Literature Review

2.1. Data and Objects of Spatial Patterns Need to Be Expanded

The studies available have mainly explored the spatial pattern of public cultural facilities at both national and urban scales. At the national scale, Zhang, Li, and Ma et al. analyzed the spatial distribution of museums and libraries in China based on statistical data, arguing that, although both continue to increase in number, regional inequalities are expanding, with libraries showing a high distribution pattern in the east, low in the west [13], high in the south, and low in the north and museums showing a dense distribution pattern in the southeast and sparse in the northwest [7,14]. Ballatore, Kervankıran, and De Graaff et al. analyzed the geographical distribution of museums in the UK, Turkey, and the Netherlands based on statistical data and pointed out that museums in all three countries have a clear regional imbalance, with the museums in the UK clustered in the south and prominent north–south differences [15], and the museums in Turkey and the Netherlands clustered in the west, with prominent east–west differences [16,17]. Donnelly analyzed the geographic distribution of libraries in the US based on statistical information, noting that the number of libraries in the southern and western states is lower than that in the northeastern and midwestern states [18]. Li et al. analyzed the spatiotemporal characteristics of new physical bookstores in China based on enterprise data, stating that the number of new physical bookstores continues to increase, with significant unevenness and regional differentiation, with East China being the distribution hot spot [19].

At the urban scale, Wang, Nawa, Macintyre, and Ghasemi et al. analyzed the spatial inequality of public cultural facilities in Xi'an, Tshwane, Glasgow, and Tehran based on statistical data, noting that Xi'an and Tehran have prominent spatial inequality characteristics regarding public cultural facilities [6,20]; Tshwane showed great inequality between white and black and urban and rural public cultural facilities [21]; Glasgow has a higher density of museums and art galleries in affluent neighborhoods, while the libraries and cinemas show no clear pattern of deprivation [22]. Zhao, He, and Zhang et al. analyzed the spatial distribution of public cultural facilities in Zhengzhou, Beijing, and Tianjin based on POI data and pointed out that the aggregation characteristics of different types of public cultural facilities differed and were closely related to urban development characteristics [3,23,24]. Działek and Ayatac et al. analyzed the spatial characteristics of art museums and libraries in Krakow and Istanbul based on statistical data, holding that art museums in Krakow are highly concentrated in the historical and cultural areas of the city [25], while the libraries in Istanbul show a clear center-periphery structure [26].

Overall, it seems that there are still two limitations to the study of the spatial patterns of public cultural facilities. The first is about the research data; specifically, the studies that are available are mainly based on statistical data, which only covers the public cultural facilities constructed by the government rather than those spontaneously constructed by the market, leading to some defects in the accuracy and integrity of the data. Some of the studies are based on POI data, which compensates for the lack of statistical information. However, due to the difficulty of data acquisition, studies are limited to the static analysis of a single year, and there is no report on the findings of spatial dynamic analyses. The second is about the objects of study; specifically, the available studies have mainly analyzed the spatial patterns of public cultural facilities, such as museums, art galleries, libraries, and bookstores, but given that the types of public cultural facilities are diverse and that different types of facilities have different spatial change patterns, it is necessary to make further comparisons and summarize these.

2.2. Tool and Indicators of Driving Factors Need to Be Improved

The studies on the driving factors of public cultural facilities can be largely summarized as two main approaches: single factors and multiple factors. In the single-factor approach, the existing studies probe into the influence of population, economy, housing price, transportation, tourism, systems, and other factors on the distribution of public cultural facilities. For example, Donnelly pointed out (based on the OLS model) that population and household income have a large impact on the distribution of libraries in American states [18]. Guo mentioned a strong correlation between demographic and economic factors and library accessibility in Hong Kong based on a spatial lag model [27]. Leem et al. showed that income level and road networks affect the accessibility of public cultural facilities in Daejeon via a comparative analysis [28]. Sung indicated a strong correlation between apartment prices and cultural facilities in Seoul by using a spatial error model [29]. Ballatore et al. pointed out that population density and tourist activity have a large impact on the distribution of museums in the UK, based on qualitative analysis [15].

Based on qualitative analysis, Kim pointed out that the location of art galleries in Seoul is influenced by the commercial art business and public policy rather than by the artist community embedded in the local area [30]. Based on qualitative analysis, Liu and Działek et al. concluded that institutional transformation is the main factor for the spatial expansion of public cultural facilities in Chengdu and Krakow [25,31].

In the multiple-factor approach, the existing studies explore the influence of social, economic, policy, education, built environment, and resident groups on the distribution of public cultural facilities. For example, Woronkowicz identified capital and labor stocks, cultural sector composition, demographic changes, education, and household income levels as the main factors influencing the construction of public cultural facilities in the United States using a two-part model [32]. Liu et al. argued that policy and education are the primary factors influencing the distribution of museums in China based on GeoDetector, followed by social and economic factors [33]. Based on GeoDetector, Li et al. concluded that the distribution pattern of libraries in China is the result of a combination of economic, social, cultural, and policy factors, but there are differences in the dominant factors and their effects on the spatiotemporal differentiation of libraries in different periods and regions [13]. Li et al. showed that population density, transportation accessibility, and economic development level significantly influence the spatial location choice of new brick-and-mortar bookstores by using a linear regression model [19]. Zhao et al. pointed out that, in addition to population, transportation, economy, urban planning, and other external environmental factors, residents' disposable time, consumption habits, and residents' cultural level have a greater influence on the spatial distribution of public cultural facilities in Zhengzhou based on GeoDetector [23]. Based on a spatial lag model, He et al. pointed out that the density of financial institutions, building density, the density of securities companies, housing rent, and distance from the nearest scenic spot are the main factors affecting the distribution of public cultural facilities in Beijing [3]. Zhang et al. identified demand, transportation, labor costs, and facilities as the main factors affecting the distribution of museums in London based on an OLS model [34]. Based on the GWR model, Liu et al. indicated that road network density, bus stop density, population density, commercial housing prices, and the distance to the nearest university were positively correlated with the distribution of physical bookstores in Xi'an, while the distance to the nearest subway station, the distance to the nearest public library, and the distance to the nearest scenic spot of grade 4A or above in urban areas are negatively correlated with the distribution of physical bookstores in Xi'an [35]. Zhao et al. explained that government policies, population density, demographic structure, transportation, and cultural space have a strong influence on the spatial distribution of cinemas in Shanghai from a historical-geographical perspective [36].

Overall, there are still two limitations in the research on the driving factors of public cultural facilities. First, for the research indicators, multifactor studies have become the mainstream path, with the existing studies exploring the influencing factors of the spatial distribution of public cultural facilities from the perspectives of social economy, cultural education, spatial environment, and residents' preferences, but most of the studies only focus on some areas of the influencing factors, and there is still room for the systematic and integrated application of indicators to improve this. Second, regarding the research method, methods such as the OLS model, spatial lag model, GWR model, and GeoDetector are widely used, especially GeoDetector, which is used widely as a powerful tool to study the driving factors of spatial differentiation, but the existing studies only deal with the driving forces of those factors acting individually, with less attention given to the driving forces from the interactions between factors.

3. Research Design

3.1. Study Area: China

This paper identifies six categories of public cultural facilities: libraries, museums, theaters, art galleries, exhibition halls, and cultural centers, in accordance with the *Regulations of the People's Republic of China on Public Cultural and Sports Facilities* (2003), the

Public Cultural Service Guarantee Law of the People's Republic of China (2016), and related studies [23,37]. After a comprehensive comparison of data accessibility and consistency, this paper identifies 29 provinces (municipalities directly under the central government and autonomous regions) in mainland China as the study area and 285 cities as the study units. For the purpose of description, the cities in different regions are classified according to the relevant studies [38,39], including 100 in the east, 100 in the center, and 85 in the west. It should be noted that cities are used as the basic study unit in this paper, but in order to better summarize the spatial patterns, three groups of geographical units, namely cities, provinces, and urban clusters, are used simultaneously in characterizing public cultural facilities. Some important place names are marked in Figure 1.

Figure 1. Study area.

China had 25,370 and 86,281 public cultural facilities in 2012 and 2020, an increase of 3.4 times during the period, but an uneven distribution among the three major regions persisted, with eastern cities accounting for the largest share, between 55.78% and 57.50%, followed by central and western cities, accounting for 22.35% to 25.44% and 18.79% to 20.15%, respectively. The number of libraries, museums, theaters, art galleries, cultural centers, and exhibition halls in 2012 and 2020 were recorded as 4570, 2277, 6225, 532, 9424, and 2342 and 13,291, 7691, 24,344, 6765, 23,631, and 9571, respectively, characterized by a large difference in the number of different types of public cultural facilities, with cultural centers and theaters accounting for the largest share, in the range of 27.71~37.15% and 24.54~28.54%, and art museums accounting for the smallest share, ranging between 2.10% and 7.93%. The three regions showed nearly the same distribution characteristics (Table 1).

Table 1. Quantity of public cultural facilities in different regions; obtained by summarizing the POI quantity of public cultural facilities.

Period	Region	Library	Museum	Theater	Art Gallery	Cultural Center	Exhibition Hall	Total Cultural Facility
2012	All cities	4570	2277	6225	532	9424	2342	25,370
	Eastern cities	2535	1240	3619	373	5301	1519	14,587
	Central cities	1092	508	1477	81	2098	415	5671
	Western cities	943	529	1129	78	2025	408	5112
2020	All cities	13,291	7691	24,344	6765	23,631	9571	85,293
	Eastern cities	7735	4201	12,729	4263	12,538	6107	47,573
	Central cities	3240	1841	6697	1583	6444	1892	21,697
	Western cities	2316	1649	4918	919	4649	1572	16,023

3.2. Index Selection and Data Sources

Because of the incomplete official statistics on public cultural facilities in the cities and the lack of statistics on public cultural facilities built under the drive of the market, we obtained public cultural facilities data, i.e., POI data, by accessing the open-source web map API. The open-source map used in this paper is Amap, which is the web map provider with the highest market share in China and contains abundant geographic information data with good representativeness. Given the availability of the data and the typicality of the time period, the data on public cultural facilities in mainland China for two years, 2012 and 2020, were collected for this paper, and the data were cleaned through both the classification table (via Amap) and manual screening, item by item. Finally, we obtained the complete POI data of public cultural facilities for two years and summarized the number of all public cultural facilities in the cities using the ArcGIS 10.2 spatial statistics tool, mainly as shown in Table 2.

Table 2. Statistical features of public cultural facilities; obtained by counting the POI quantity of public cultural facilities in different cities.

Period	Type	Library	Museum	Theater	Art Gallery	Cultural Center	Exhibition Hall	Total Cultural Facility
2012	Min	1	0	1	0	0	1	5
	Max	240	145	277	64	151	397	1092
	Mean	16	8	22	2	8	33	89
2020	Min	2	1	7	0	6	0	27
	Max	622	392	840	475	598	728	3573
	Mean	47	27	85	24	83	37	303

The studies available have demonstrated the influence of social, economic, policy, transportation, education, tourism, built environment, and resident groups on the spatial distribution of public cultural facilities. Based on the principles of quantifiable indicators and easy access to data, this paper designs a five-dimensional framework of "economy-urbanization-education-infrastructure-opening-up" with reference to relevant studies to analyze the influencing factors on public cultural facilities. Accordingly, this paper takes the number of public cultural facilities as the dependent variable and chooses the influencing factors from the economy, urbanization, education, infrastructure, and opening-up as the independent variables (Table 3).

In terms of economy: the economic base directly determines the development of public cultural facilities as a "superstructure". Since the studies available have confirmed the strong contribution of GDP to the construction of public cultural facilities [12,13,19], this paper will not provide further discussion. It is worth noting that the three major industries of real estate, consumption, and tourism will drive the development of public cultural facilities through real estate support, consumer diversification, and cultural and tourism integration [40–44]. This paper focuses on the driving role of these three on public cultural facilities. Therefore, investment in real estate development (X_1), the total retail sales of consumer goods (X_2), and the revenue from domestic and inbound tourism (X_3) were selected as indicators to characterize the economic factors.

Table 3. Dependent and independent indicator description.

Variables	Code	Indicators	Implication
Dependent Y_i	Y_1	Public cultural facilities in 2012	Performance
	Y_2	Public cultural facilities in 2020	
Independent X_i	X_1	Investment in real estate development (CNY 10,000)	Economy
	X_2	Total retail sales of consumer goods (CNY 10,000)	
	X_3	Revenue from domestic and inbound tourism (CNY 100,000)	
	X_4	Population urbanization rate (%)	Urbanization
	X_5	Area of land used for urban construction (square kilometer)	
	X_6	Regular higher education institutions (HEI) (school)	Education
	X_7	Undergraduates in regular HEIs (person)	
	X_8	Education expenditure in local general public budget (CNY 10,000)	
	X_9	Area of paved roads (10,000 square meters)	Infrastructure
	X_{10}	Number of buses and trolley buses under operation (vehicle)	
	X_{11}	Number of subscribers to internet services (10,000 households)	
	X_{12}	Import and export volume of goods (CNY 10,000)	Opening up
	X_{13}	Actual use of foreign direct investment (USD 10,000)	

In terms of urbanization: urbanization has a very rich connotation, including the improvement of residents' living standards, changes in consumption patterns, and optimization of the spatial environment [45,46], which are all closely related to the development of public cultural facilities. In addition, urbanization is a key indicator of urban development and is also an important basis for formulating urban development policies. This paper analyzes the impact of the urbanization process on public cultural facilities in terms of population urbanization and land urbanization and selects the population urbanization rate (X_4) and the area of land used for urban construction (X_5) as indicators to characterize urbanization factors.

In terms of education: education and culture promote and complement each other: education development itself needs the support of cultural facilities and, in turn, cultural facilities provide more diverse educational services and forms of education to promote the growth of talent [47]; besides, education development provides more professional talent for the development of cultural facilities, and residents will have more demand for cultural facilities when their education level is improved [23]. In this paper, regular higher education institutions (X_6), undergraduates in regular HEIs (X_7), and education expenditure in the local general public budget (X_8) were selected as indicators for characterizing the education factor.

In terms of infrastructure: as a higher level of public service, public cultural facilities have higher requirements for location, and infrastructure is a primary criterion for judging the location conditions. Transportation facilities are currently the most concerned infrastructure [19,23,35]. In order to echo the background of the information era, this paper adds to exploring the impact of information infrastructure on the distribution of public cultural facilities. Therefore, the area of paved roads (X_9), the number of buses and trolley buses under operation (X_{10}), and the number of subscribers to internet services (X_{11}) were selected as the indicators for characterizing the infrastructure factor.

In terms of opening-up: the studies available have paid less attention to the impact of external factors on public cultural facilities. However, in the context of globalization, opening-up may attract foreign investment, and the tax revenue it brings will enhance financial support for the construction of public cultural facilities, although it rarely enters China's cultural market directly [48]; in addition, the diversified cultural forms and elements introduced by opening-up will also promote the construction of new public cultural facilities [49], such as Western opera houses, art galleries, and other cultural venues. In this paper, the import and export volume of goods (X_{12}) and the actual use of foreign direct investment (X_{13}) were selected as indicators to characterize the opening-up factor.

The dependent variable data used in this paper are from Amap, and the independent variable data are from the *China City Statistical Yearbook*, provincial statistical yearbooks, and the statistical bulletins of cities, with a small amount of missing data supplemented by trend extrapolation.

3.3. Research Methods

3.3.1. CV and GI

Both the coefficient of variation (CV) and Gini index (GI) can be used to show the degree of divergence or dispersion of the sample data, and they are used in this paper to measure the unbalanced distribution characteristics of public cultural facilities in cities. The CV is relatively simple to calculate by dividing the standard deviation of the sample data by the mean, but when the mean is negative or close to zero, the CV may be negative or infinite [50,51]. The GI can be obtained by calculating the ratio of the area between the Lorentz curve and the perfectly equal distribution curve, but the process is quite complicated, and GI is sensitive to changes in the middle sample data [52,53]. In order to circumvent the computational shortcomings of the CV and GI, both of them are introduced in this paper for cross-checking, and according to relevant studies [52,54,55], when the CV $\leq$ 0.15 or the GI < 0.4, this paper concludes a low degree of differentiation for the public cultural facilities of the cities with less prominent imbalance; when 0.16 $\leq$ CV $\leq$ 0.35 or 0.4 $\leq$ GI < 0.6, we conclude a moderate degree of differentiation with serious imbalance; when CV $\geq$ 0.36 or GI $\geq$ 0.6, we conclude a high degree of differentiation with very serious imbalance.

3.3.2. ESDA

Exploratory spatial data analysis (ESDA) is a process of exploring data patterns using GIS and spatial statistics to discover the spatial patterns, trends, and anomalies behind the data [56]. ESDA contains a variety of tools, such as spatial autocorrelation and spatial hotspots. In this paper, we use the global Moran I to explore the whole spatial aggregation characteristics of public cultural facilities, and use the hot and cold spot tool to explore the local spatial aggregation characteristics of public cultural facilities.

(1) The global Moran I is used to analyze the spatial aggregation of public cultural facilities as a whole [57]. The equation is as follows:

$$I = \frac{n}{s_0} \times \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \overline{x})(x_j - \overline{x})}{\sum_{i=1}^{n}(x_i - \overline{x})^2},\ s_0 = \sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij} \tag{1}$$

where I is the global Moran I; x_i and x_j are the numbers of public cultural facilities in the cities i and j, respectively, and $i, j = 1, 2, 3, \ldots n$, and n represents the total number of sample cities, (here, 285); $\overline{x}$ is the average of the numbers of public cultural facilities in all cities; w_{ij} is the spatial weight matrix, which takes a value of 1 when spatially adjacent and 0 when not adjacent, and s_0 is the sum of all w_{ij} values. The global Moran I takes the value of $[-1, 1]$. It indicates prominent spatial aggregation features when positive and prominent spatial dispersion features when negative. Aggregation or dispersion is more pronounced at higher absolute values.

(2) The hot and cold spot tool is used to analyze the specific location and the spatial aggregation of public cultural facilities [58,59]. The equation is as follows:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}x_j - \overline{x}\sum_{j=1}^{n} w_{i,j}}{s\sqrt{\frac{n\sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2}{n-1}}},\ \overline{x} = \frac{\sum_{j=1}^{n} x_j}{n},\ s = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\overline{x})^2} \tag{2}$$

where G_i^* is the aggregation index; x_j is the number of public cultural facilities in each city; $\overline{x}$ and s are the mean and standard deviation of public cultural facilities across cities; i, j = 1, 2, 3, ..., n, and n represents the number of sample cities (here, 285); $w_{i,j}$ is the spatial weight between cities i and city j, and the weights of different cities intersect with each other to form a spatial weight matrix. The statistical significance of G_i^* can be tested by the standardized Z-score. A positive Z-score with a higher value indicates tighter high-value clustering, i.e., a hot spot, while a negative Z-score with a lower value indicates tighter low-value clustering, i.e., a cold spot. In addition, according to the relevant studies [51,60,61], the aggregation characteristics of public cultural facilities can be graded by the value of the Z-score, commonly performed by quartering, i.e., hot spot, sub-hot spot, sub-cold spot, and cold spot.

3.3.3. GeoDetector

GeoDetector is designed to detect the spatial heterogeneity of a phenomenon and the driving factors behind it. It can be used to measure the spatial heterogeneity of a single variable or to detect the possible causal relationship between two variables by measuring the consistency of their spatial distribution. It offers four functions: factor detection, interaction detection, risk detection, and ecological detection [56,62,63]. In this paper, we choose factor detection and interaction detection to analyze the causes of the spatial distribution of public cultural facilities across cities. GeoDetector is currently available in Excel and R language versions. In this paper, we use R language to perform calculations.

(1) Factor detection is mainly used to calculate the degree of influence of a single independent variable on the spatial divergence of the dependent variable. The equation is as follows:

$$q = 1 - \frac{1}{N\sigma^2}\sum_{h=1}^{L} N_h\sigma_h^2 \quad (3)$$

where q measures the driving force of a driving factor on the spatial distribution of public cultural facilities in each city; N is the total number of sample cities (here, 285), where h = 1, 2, 3, . . . L, and L represents the number of zonings or layers; σ^2 is the total discrete variance of the number of public cultural facilities across cities, and σ_h^2 is the discrete variance of the number of public cultural facilities in the h-th zoning or layer. The value of q is in a range of 0~1, and a larger value indicates that the driving factor X has a stronger driving force on the number of public cultural facilities, Y, and is, conversely, weaker.

(2) Interaction detection is mainly used for calculating the degree of influence of the two-by-two interactions of all independent variables on the spatial divergence of the dependent variable. We reviewed all the possible interactions of the independent variables based on GeoDetector and finally identified five results: nonlinearly weaken, nonlinearly weaken, bilinearly strengthened, nonlinearly strengthened, and mutually independent. See Table 4 for a detailed mathematical explanation.

Table 4. Interaction relationship.

Graphical Representation	Description	Interaction
	$q(X_i \cap X_j) < \min(q(X_i), q(X_j))$	Weaken, nonlinear
	$\min(q(X_i), q(X_j)) < q(X_i \cap X_j) < \max(q(X_i)), q(X_j))$	Weaken, uni
	$q(X_i \cap X_j) > \max(q(X_i), q(X_j))$	Enhance, bi
	$q(X_i \cap X_j) > q(X_i) + q(X_j)$	Enhance, nonlinear
	$q(X_i \cap X_j) = q(X_i) + q(X_j)$	Independent

Legend: ● $\min(q(X_i), q(X_j))$; ● $\max(q(X_i), q(X_j))$; ● $q(X_i) + q(X_j)$; ▼ $q(X_i \cap X_j)$.

3.4. Research Steps

The study route in this paper consists of five steps and eight points (Figure 2). Step 1: Put forward the research questions—present the research question and research gap in this paper based on the background analysis and the literature review. Step 2: Define the study area and data processing—identify 285 cities in China as the study units, acquire the independent and dependent variables through an open-source map and statistical yearbooks, and classify the independent variables into 3–10 categories via a natural break and find the optimal classification. Step 3: Determine the research methods—perform CV and GI calculations via Excel 2016 to reflect the spatial dispersion, spatial clustering by ArcGIS 10.2 to reflect the spatial differences, ESDA analysis by Geoda 1.12 to reflect the spatial aggregation, and factor detection and interaction detection by GeoDetector to reflect the driving effects. Step 4: Conduct result analysis—reveal the spatial characteristics of public cultural facilities by differentiation analysis and aggregation analysis, recognize the core, important, and auxiliary factors of public cultural facilities by identifying the strong, medium, and weak factors, as well as the super-interaction factors, and clarify their driving mechanisms. Step 5: Practice conclusion application—delineate the policy zonings based on the Boston Consulting Group (BCG) matrix and make policy recommendations accordingly.

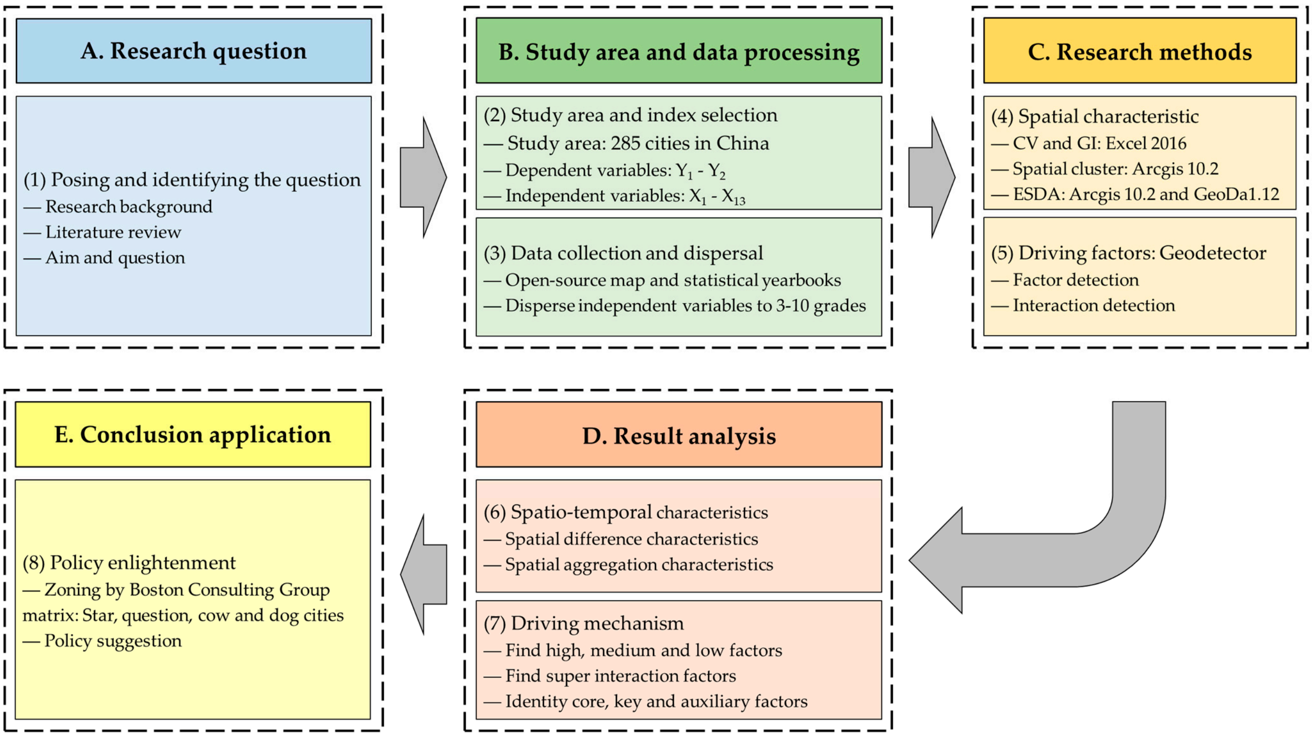

Figure 2. Research steps.

This paper chose two episodes from 2012 and 2020 for two reasons. The first reason is that the POI data for these two years are the most complete, and the second reason is that the year 2012 is typical in terms of a starting point to usher in the rapid development of public cultural facilities after the strategy of "building a cultural power" was proposed in the "18th National Congress" report, and a series of related policies and measures were issued in the year [64].

4. Results

4.1. Spatial Difference Characteristics

4.1.1. Spatial Heterogeneity Characteristics

The spatial distribution of public cultural facilities in Chinese cities is highly uneven, and there are significant differences in the spatial dispersion intensity and its changes regarding different types of public cultural facilities. In 2012, the CV and GI of public cultural facilities were 1.39 and 0.53, respectively, and they ranged from 1.39 to 2.69 and 0.53 to 0.80, respectively, for different types of public cultural facilities. The CV and GI of public cultural facilities in 2020 were 1.32 and 0.52, respectively, and they ranged from 1.06 to 1.92 and 0.47 to 0.62, respectively, for different types of public cultural facilities (Table 5). Although the CV and GI of both periods have slightly decreased, their absolute values remain relatively high, indicating that the distribution of public cultural facilities, both overall and by type, is highly uneven across time. There are significant differences in the changes of dispersion intensity of different types of public cultural facilities, with libraries, museums, theaters, art galleries, and cultural centers becoming less differentiated and exhibition halls becoming more differentiated.

Table 5. CV and GI of public cultural facilities in 2012 and 2020; obtained by the calculation formulas of CV and GI.

Period	Type	Library	Museum	Theater	Art Gallery	Cultural Center	Exhibition Hall	Total Cultural Facility
2012	CV	1.61	1.52	1.39	2.69	1.86	1.39	1.39
	GI	0.56	0.54	0.54	0.80	0.64	0.53	0.53
2020	CV	1.57	1.44	1.32	1.70	1.06	1.92	1.32
	GI	0.58	0.53	0.52	0.61	0.47	0.62	0.52

4.1.2. Spatial Cluster Characteristics of Total Cultural Facilities

The number of public cultural facilities in the 285 cities is classified into five categories: higher, high, medium, low, and lower, via a natural break (Figure 3). It can be seen that the regional gradient difference of public cultural facilities in China is very prominent, showing a gradual decrease from east to west, and the spatial differentiation patterns of the two years have changed significantly. In 2012, higher, high, medium, low, and lower cities accounted for 1.05%, 2.46%, 8.77%, 19.30%, and 68.42%, respectively. There were a very small number of higher and high cities, including 10 cities: Beijing, Shanghai, Guangzhou, Tianjin, Hangzhou, Ningbo, Taizhou, Shenzhen, Chengdu, and Chongqing; the medium cities were scattered, including most provincial capitals and some key cities; the low cities were clustered, mainly in the Beijing-Tianjin-Hebei Region, the Yangtze River Delta, Pearl River Delta, and Shandong Peninsula, and some regions in Shanxi, Henan, Fujian, Jiangxi, and Guangxi; the lower cities were scattered in the central and western regions. In 2020, higher, high, medium, low, and lower cities accounted for 0.70%, 4.91%, 10.88%, 33.33%, and 50.18%, respectively. There were relatively few higher and high cities, mainly including the provincial capitals and some key cities in the middle east, as well as Xi'an, Chengdu, and Chongqing in the west; the medium cities were clustered, with clusters appearing in the Beijing-Tianjin-Hebei Region, Shandong Peninsula, Yangtze River Delta, Pearl River Delta, Fujian, Heilongjiang, and Jilin, as well as Nanchang and Luoyang in the central region and Kunming and Nanning in the south; the low cities were broadly expanded, mainly in most of the central regions, also including Shaanxi and Sichuan in the west; the lower cities were obviously contracted, scattered in the west and other regions, such as Heilongjiang, Jilin, and Liaoning.

4.1.3. Spatial Cluster Characteristics of Different Cultural Facilities

The classification of all types of public cultural facilities across the cities using the above method revealed that the different types of public cultural facilities in China also show an evident regional gradient, except for different distribution characteristics and evolution patterns. The high-value areas of libraries are always scattered in a distribution; the high-value areas of museums and theaters are gradually shifting from scattered distribution to aggregation; the high-value areas of art galleries and cultural centers are clustering and expanding in scope, while the high-value areas of exhibition halls are also clustering, but in a shrinking scope. The higher, high, medium, low, and lower cities with libraries in 2012 and 2020 accounted for 0.70%, 3.85%, 6.67%, 24.21%, and 62.45% and 1.05%, 3.15%, 9.12%, 27.36%, and 58.60%, respectively. Despite an increase in higher, high, and medium cities, these were scattered in most of the provincial capitals and the key cities in both periods (Figure 4a).

The higher, high, medium, low, and lower cities with museums accounted for 0.35, 2.45%, 9.47%, 31.93%, and 55.79% and 1.05, 4.21%, 14.39%, 29.12%, and 51.23% in 2012 and 2020, respectively. The higher, high, and medium cities evolved from a scattered distribution into a pattern of three agglomerations in the Beijing-Tianjin-Hebei Region, Shandong Peninsula, and Yangtze River Delta and a scattered distribution in central and western China (Figure 4b).

The higher, high, medium, low, and lower cities with theaters accounted for 0.70%, 3.51%, 10.53%, 25.26%, and 58.60% and 1.40%, 3.51%, 12.28%, 31.23%, and 51.58% in 2012 and 2020, respectively. The higher, high, and medium cities evolved from agglomeration in the Yangtze River Delta and a scattered distribution in central and western China to the pattern of agglomerations in the Beijing-Tianjin-Hebei Region and the Yangtze River Delta and a scattered distribution in the central and western regions (Figure 4c).

The higher, high, medium, low, and lower cities with art galleries accounted for 0.35%, 1.40%, 9.12%, 15.09%, and 74.04% and 0.35%, 3.51%, 13.68%, 40.35%, and 59.30% in 2012 and 2020, respectively. The higher, high, and medium cities mainly showed a pattern of three agglomerations in the Beijing-Tianjin-Hebei Region, Shandong Peninsula, and Yangtze River Delta and scattered distribution in the central and western regions of the country, with the high-value areas continuing to increase and the agglomeration range continuing to expand (Figure 4d).

The higher, high, medium, low, and lower cities with cultural centers accounted for 2.46%, 6.67%, 14.04%, 36.49%, and 40.35% and 2.81%, 9.12%, 15.09%, 34.04%, and 38.95% in 2012 and 2020, respectively. The higher, high, and medium cities developed into contiguous agglomerations in the Beijing-Tianjin-Hebei Region, Shandong Peninsula, Yangtze River Delta, Pearl River Delta, Chengdu-Chongqing, and Henan-Shanxi, and the scope continued to expand (Figure 4e).

The higher, high, medium, low, and lower cities with exhibition halls accounted for 0.70%, 4.91%, 8.07%, 23.16%, and 63.16% and 0.70%, 2.11%, 5.61%, 13.33%, and 78.24 in 2012 and 2020, respectively. The higher, high, and medium cities evolved into a pattern of agglomerations in the Shandong Peninsula, Yangtze River Delta, Pearl River Delta, Beijing-Tianjin, and Fuzhou-Quanzhou and scattered distribution in central and western China, but this was accompanied by contraction, significantly in Heilongjiang, Jilin, and Liaoning (Figure 4f).

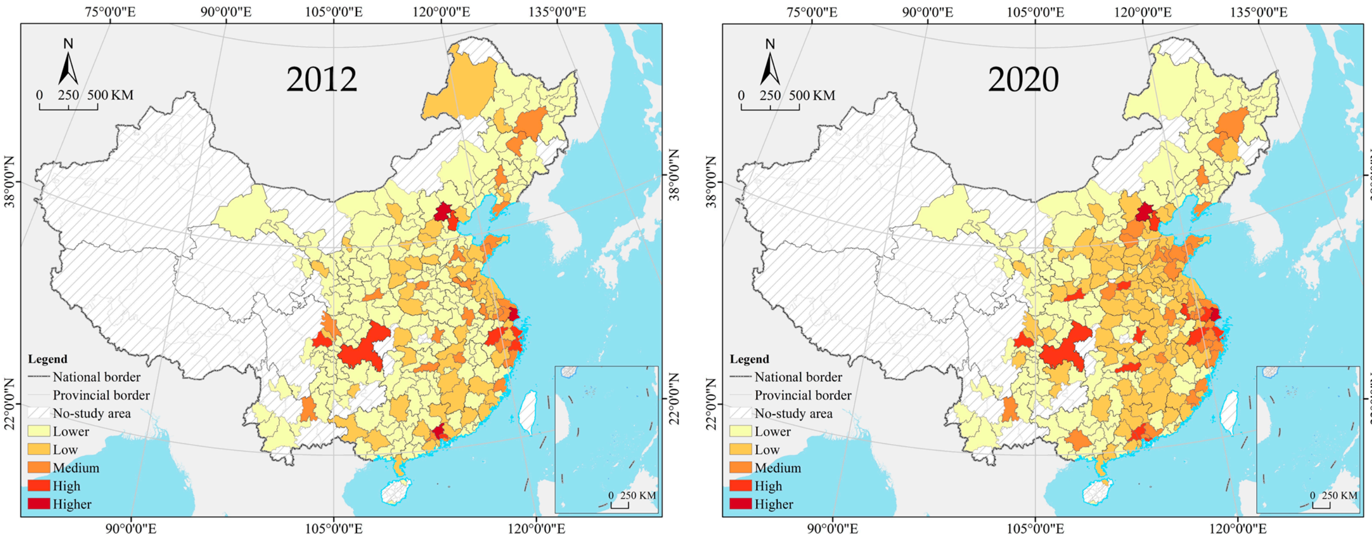

Figure 3. Cluster maps of total cultural facilities.

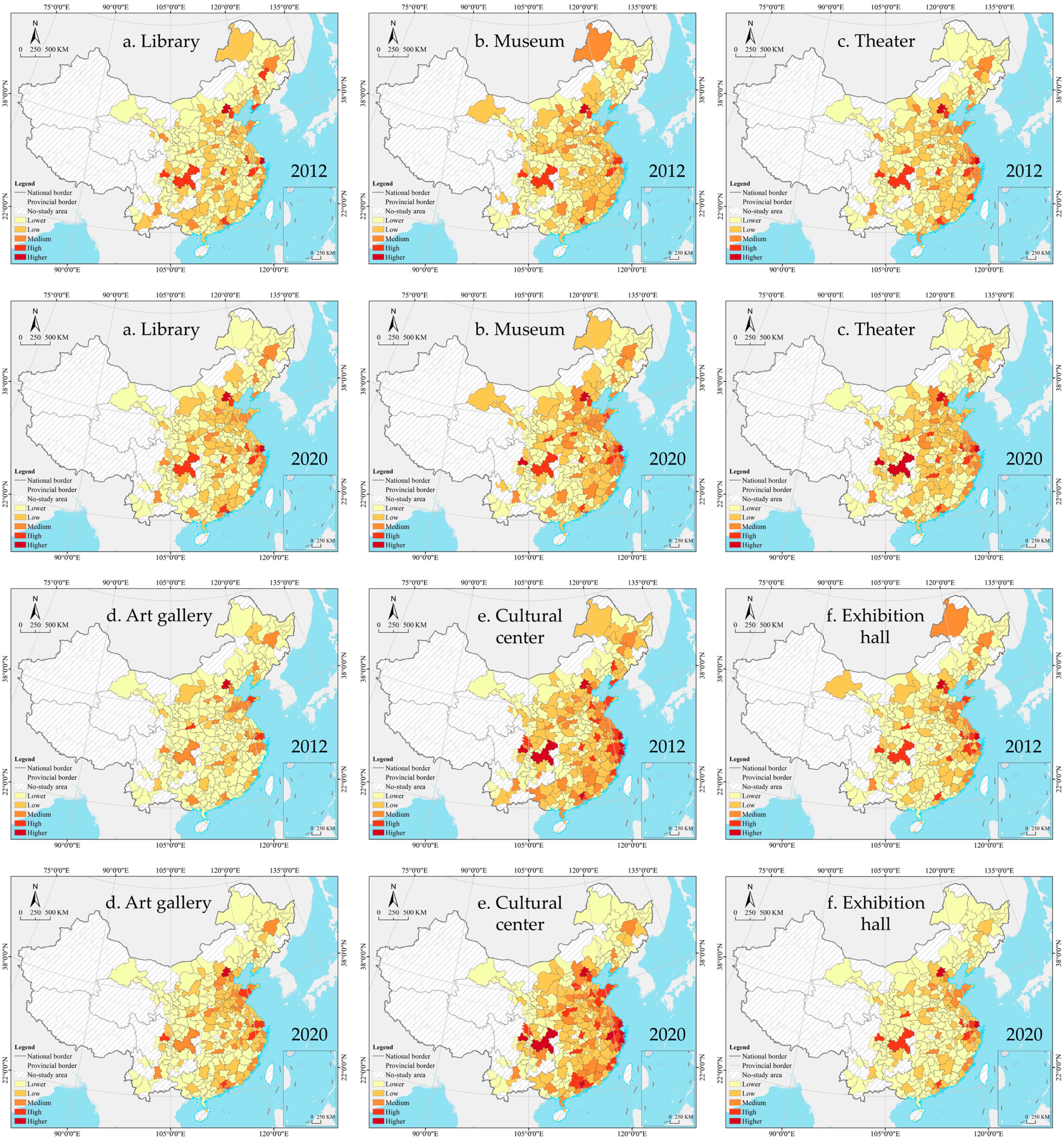

Figure 4. Cluster maps of different cultural facilities in 2012 and 2020.

4.2. Spatial Aggregation Characteristics

4.2.1. Global Aggregation Characteristics

Public cultural facilities across cities in China exhibit weak and stable aggregation overall, but different types of public cultural facilities differ significantly in their degree of aggregation and show both strengthening and weakening signs. On the whole, the global Moran I for the total cultural facility was 0.15 in both years, showing weak and stable aggregation. By type, the global Moran I for libraries, museums, art galleries, and cultural centers in both years was 0.08, 0.10, 0.09, and 0.20 and 0.14, 0.12, 0.17, and 0.24, respectively, showing weak aggregation with an enhancing trend; the global Moran I for theaters and exhibition halls in both years was 1.19 and 0.15 and 0.1 and 0.09, respectively, showing weak aggregation with a declining trend (Table 6).

Table 6. Global Moran I of public cultural facilities in 2012 and 2020; obtained by Geoda software. All Moran I values passed the significance test at the 90% level.

Period	Type	Moran I	*p*-Value	Z-Score
2012	Library	0.08 **	0.03	2.39
	Museum	0.10 **	0.01	3.22
	Theater	0.19 ***	0.00	5.52
	Art gallery	0.09 **	0.01	3.06
	Cultural center	0.20 ***	0.00	5.77
	Exhibition hall	0.15 ***	0.00	4.59
	Total cultural facility	0.15 ***	0.00	4.45
2020	Library	0.14 ***	0.00	3.99
	Museum	0.12 ***	0.00	3.48
	Theater	0.11 **	0.01	3.17
	Art gallery	0.17 ***	0.00	5.42
	Cultural center	0.24 ***	0.00	6.58
	Exhibition hall	0.09 **	0.02	2.94
	Total cultural facility	0.15 ***	0.00	4.40

Note: ** means $p < 0.05$, and *** means $p < 0.01$; the same below.

4.2.2. Local Aggregation Characteristics of the Total Cultural Facilities

The 285 urban public cultural facilities are classified into four types: hot spot, sub-hot spot, sub-cold spot, and cold spot via a natural break (Figure 5). It can be seen that the hot spots and sub-hot spots of China's public cultural facilities are mainly gathered in the east, covering an expanding area, while the cold spots and sub-cold spots are mainly in the central and western regions of the country, with the sub-cold spots expanding and the cold spots shrinking. In 2012, the hot, sub-hot, sub-cold, and cold spots covered 5.96%, 16.14%, 21.05%, and 56.84%, respectively, with the hot spots mainly in the core region of the Yangtze River Delta, the sub-hot spots in the Beijing-Tianjin-Hebei Region, Pearl River Delta, and the peripheral regions of the Yangtze River Delta, the sub-cold spots in some of the eastern and western regions, and the cold spots in most of the central and western regions. In 2020, hot, sub-hot, sub-cold, and cold spots covered 6.31%, 21.05%, 35.79%, and 36.84%, respectively, with the hot spots still gathered in the core area of the Yangtze River Delta, except for a few that can be found in the Shandong Peninsula, with the sub-hot spots expanding outward with continuous stretches in the Beijing-Tianjin-Hebei Region, Shandong Peninsula, and the Yangtze River Delta; the sub-cold spots expanded to the central and western regions, while the cold spots shrank and gathered in clusters in the northwest, southwest, and northeast regions.

4.2.3. Local Aggregation Characteristics of Different Cultural Facilities

The classification of the hot and cold points of all the public cultural facilities by the above method shows that different types of public cultural facilities in China show a clear pattern of "hot in the east and cold in the west", with significant clustering characteristics, but there are still some differences in the aggregation and evolution patterns. The hot spots for libraries are relatively stable in the Beijing-Tianjin-Hebei Region, the Yangtze River Delta, and the Pearl River Delta, while the cold spots are in the central and western regions and shrinking continuously; the hot spots for theaters are shrinking from the Beijing-Tianjin-Hebei Region, the Yangtze River Delta, and the Pearl River Delta to only the Yangtze River Delta, while the cold spots are shrinking dramatically in the central region; the hot spots of cultural centers are gathered in the Yangtze River Delta, while the cold spots are also shrinking dramatically in the central region; the hot spots for museums, art galleries, and exhibition halls are relatively stable in the Beijing-Tianjin-Hebei Region, the Yangtze River Delta, and the Shandong Peninsula, while the cold spots are clustered in the central and western regions and are gradually shrinking. The hot, sub-hot, sub-cold, and cold spots for libraries accounted for 17.19%, 8.07%, 36.14%, and 38.60% and 19.30%, 11.58%, 30.88%, and 38.25% in 2012 and 2020, respectively. The hot spots developed into three agglomerations in the Beijing-Tianjin-Hebei Region, Yangtze River Delta, and Pearl River Delta; the sub-hot spots were distributed in the periphery of the hot spots and gradually expanded, with the sub-cold spots expanding from the central and eastern areas of China to the central and western regions of the country. The cold spots shrank on a large scale into three agglomerations in the northeast, northwest, and southwest regions (Figure 6a).

The hot, sub-hot, sub-cold, and cold spots for museums accounted for 12.63%, 21.05%, 30.88%, and 35.44% and 14.04%, 16.49%, 33.68%, and 35.79% in 2012 and 2020, respectively. The hot spots evolved into two aggregations in the Beijing-Tianjin-Hebei Region and Yangtze River Delta and spread to the Shandong Peninsula. The sub-hot spots were distributed in the eastern and southern regions, with few distributed in the west, while the sub-hot spots in the east gradually shrank. The sub-cold spots were scattered in the central and western regions, while the cold spots shifted from a northeast, southwest, and central aggregation to a northeast, southwest, and northwest aggregation (Figure 6b).

The hot, sub-hot, sub-cold, and cold spots for theaters accounted for 17.19%, 10.88%, 26.67%, and 45.26% and 7.37%, 20.35%, 42.80%, and 29.47% in 2012 and 2020, respectively. The hot spots shrank from the three aggregations in the Beijing-Tianjin-Hebei Region, Yangtze River Delta, and Pearl River Delta to aggregation in the Yangtze River Delta only. The sub-hot spots expanded into two aggregations in the Beijing-Tianjin-Hebei Region and Pearl River Delta, with some distributed in the periphery of the Yangtze River Delta and Sichuan. The sub-cold spots spread widely from the central and eastern regions to the central and western regions, while the cold spots shifted from a northwest, southwest, northeast, and central aggregation to a northeast, southwest, and northwest aggregation (Figure 6c).

The hot, sub-hot, sub-cold, and cold spots for art galleries accounted for 14.74%, 13.68%, 41.75%, and 29.82% and 16.49%, 18.95%, 28.07%, and 36.49% in 2012 and 2020, respectively. The hot spot formed three aggregations in the Beijing-Tianjin-Hebei Region, Shandong Peninsula, and Yangtze River Delta and gradually evolved into a distribution in continuous stretches. The sub-hot spots gathered in Shandong, the Pearl River Delta, and the periphery of the Yangtze River Delta, gradually evolving into a distribution in continuous stretches. The cold spots shifted from a southwest and central aggregation to a northwest, southwest, and northeast aggregation (Figure 6d).

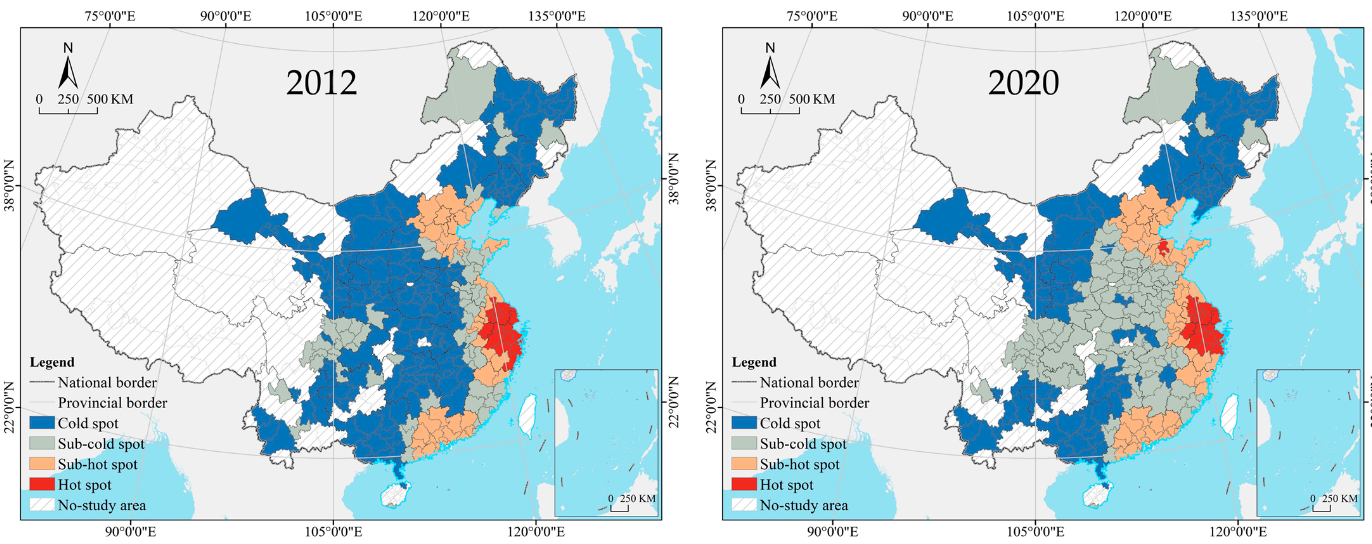

Figure 5. Spatial hot and cold maps of total cultural facilities.

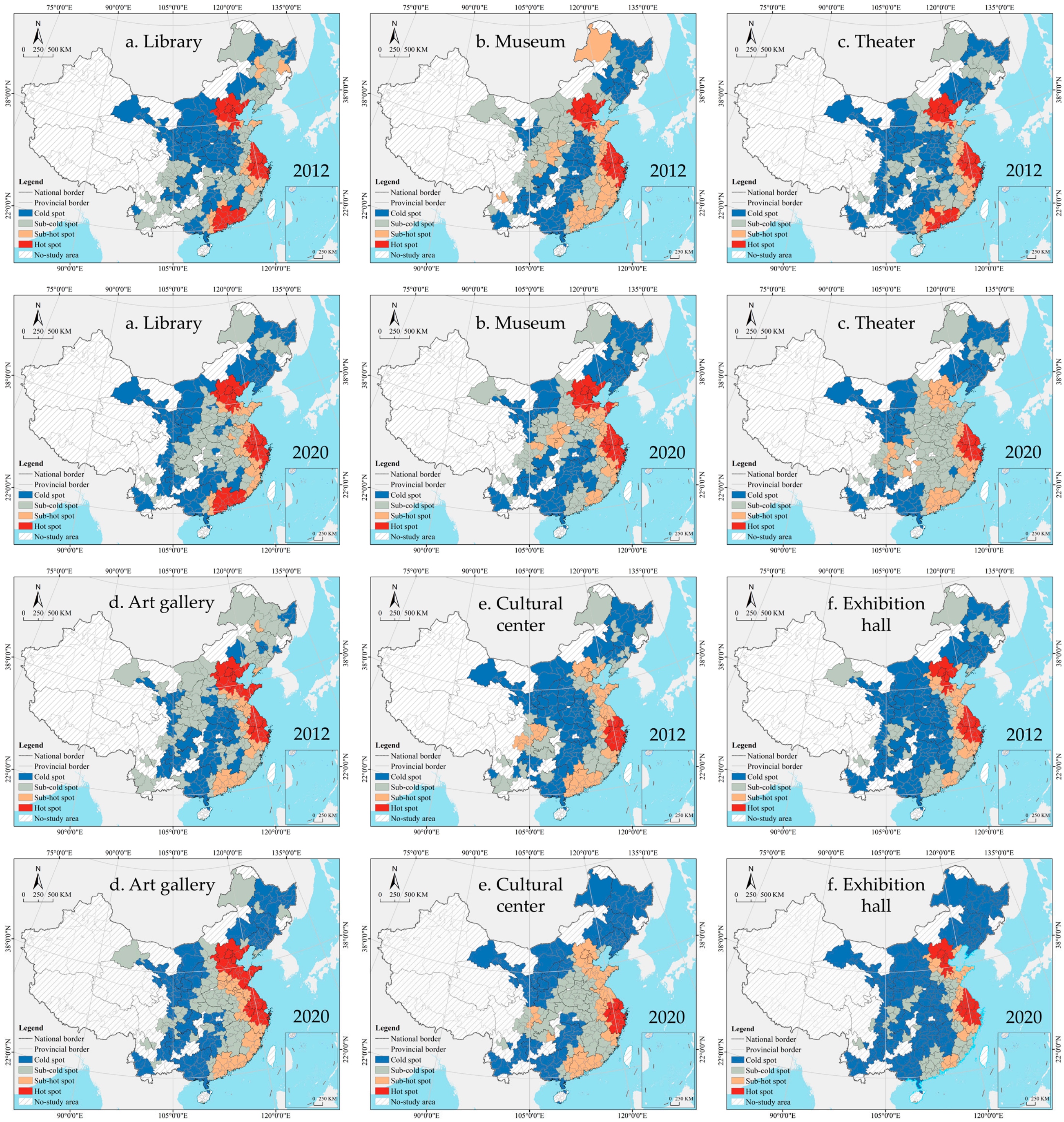

Figure 6. Spatial hot and cold maps of different cultural facilities in 2012 and 2020.

The hot, sub-hot, sub-cold, and cold spots for cultural centers accounted for 6.32%, 23.16%, 22.46%, and 48.07% and 6.32%, 23.16%, 31.58%, and 38.95% in 2012 and 2020, respectively. The hot spots were steadily gathered in the Yangtze River Delta. The sub-hot spots formed many aggregations in the Beijing-Tianjin-Hebei Region, Shandong Peninsula, Pearl River Delta, eastern Sichuan, and the periphery of the Yangtze River Delta, gradually evolving into a distribution in continuous stretches in the east. The sub-cold spots expanded from the central region to the central and western regions, while the cold spots shifted from a central and western aggregation to a northeast, northwest, and southwest aggregation (Figure 6e).

The hot, sub-hot, sub-cold, and cold spots for exhibition halls accounted for 10.87%, 12.28%, 21.05%, and 55.79% and 10.88%, 11.58%, 20.70%, and 56.84% in 2012 and 2020, respectively. Exhibition halls maintained a stable spatial pattern. The hot spots developed into two agglomerations in the Beijing-Tianjin-Hebei Region and Yangtze River Delta. The sub-hot spots were clustered and distributed in the Shandong Peninsula, the Pearl River Delta, and the periphery of the Beijing-Tianjin-Hebei Region and the Yangtze River Delta. The sub-cold spots were distributed in the central and southern regions, with a few in eastern Sichuan, and the cold spots were distributed in a large area in the central and western regions (Figure 6f).

4.3. Driving Factor Characteristics

4.3.1. Factor Detection

All independent variables in the factor detection results passed the significance test of 0.1 (Table 7). It can be seen that the driving forces of the independent variables vary significantly across the regions, and the ranking varies widely across time. The minimum value of the driving factor in 2012 across these Chinese cities was 0.25, the maximum value was 0.72, and the average was 0.57, sorted as follows: $X_4 < X_{12} < X_6 < X_7 < X_{13} < X_5 < X_9 < X_8 < X_1 < X_3 < X_{10} < X_{11} < X_2$. The minimum value of the driving factor in 2020 was 0.22, the maximum value was 0.79, and the average was 0.61, sorted as follows: $X_4 < X_7 < X_9 < X_3 < X_6 < X_{13} < X_{12} < X_5 < X_{10} < X_8 < X_{10} < X_1 < X_2$. The 13 factors are divided into weak, medium, and strong levels by the "5-4-4" interval, with the total retail sales of consumer goods (X_2) and the number of buses and trolley buses under operation (X_{10}) being stable, strong factors, and investment in real estate development (X_1) and education expenditure in the local general public budget (X_8) being new strong factors.

Table 7. Result of factor detection of $\boldsymbol{Y}_1$, which is in 2012 and $\boldsymbol{Y}_2$, which is in 2020; obtained by R language. All q-values passed the significance test at the 90% level.

Type	X_i	All Cities		Eastern Cities		Central Cities		Western Cities	
		2012	2020	2012	2020	2012	2020	2012	2020
Economy	X_1	0.65 ***	0.71 ***	0.65 ***	0.72 ***	0.69 ***	0.75 ***	0.44 ***	0.59 ***
	X_2	0.72 ***	0.79 ***	0.70 ***	0.77 ***	0.65 ***	0.82 ***	0.78 ***	0.88 ***
	X_3	0.65 ***	0.59 ***	0.75 ***	0.73 ***	0.62 ***	0.68 ***	0.79 ***	0.37 ***
Urbanization	X_4	0.25 ***	0.22 ***	0.40 ***	0.37 ***	0.11 ***	0.15 **	0.12 *	0.14 *
	X_5	0.57 ***	0.65 ***	0.68 ***	0.61 ***	0.66 ***	0.66 ***	0.52 ***	0.86 ***
Education	X_6	0.51 ***	0.60 ***	0.60 ***	0.70 ***	0.74 ***	0.77 ***	0.58 ***	0.66 ***
	X_7	0.51 ***	0.51 ***	0.55 ***	0.56 ***	0.72 ***	0.77 ***	0.46 ***	0.60 ***
	X_8	0.60 ***	0.69 ***	0.67 ***	0.78 ***	0.52 ***	0.69 ***	0.77 ***	0.79 ***
Infrastructure	X_9	0.59 ***	0.57 ***	0.50 ***	0.52 ***	0.59 ***	0.71 ***	0.77 ***	0.86 ***
	X_{10}	0.69 ***	0.67 ***	0.73 ***	0.62 ***	0.73 ***	0.74 ***	0.77 ***	0.65 ***
	X_{11}	0.69 ***	0.70 ***	0.73 ***	0.75 ***	0.69 ***	0.80 ***	0.78 ***	0.80 ***
Opening-up	X_{12}	0.43 ***	0.64 ***	0.59 ***	0.74 ***	0.16 *	0.71 ***	0.21 ***	0.85 ***
	X_{13}	0.55 ***	0.62 ***	0.57 ***	0.70 ***	0.65 ***	0.69 ***	0.76 ***	0.54 ***

Note: * presents $p < 0.1$, ** presents $p < 0.05$, *** presents $p < 0.01$.

The minimum value of the driving factor in 2012 across eastern cities was 0.40, the maximum value was 0.63, and the average was 0.75, sorted as follows: $X_4 < X_9 < X_7 < X_{13} < X_{12} < X_6 < X_1 < X_8 < X_5 < X_2 < X_{10} < X_{11} < X_3$. The minimum value of the driving factor in 2020 was 0.37, the maximum value was 0.78, and the average was 0.66, sorted as follows: $X_4 < X_{12} < X_6 < X_7 < X_{13} < X_5 < X_9 < X_8 < X_1 < X_3 < X_{10} < X_{11} < X_2$. Total retail sales of consumer goods (X_2), revenue from domestic and inbound tourism (X_3), number of buses and trolley buses under operation (X_{10}), and the number of subscribers to internet services (X_{11}) are all stable, strong factors.

The minimum value of the driving factor in 2012 across central cities was 0.11, the maximum value was 0.74, and the average was 0.58, sorted as follows: $X_4 < X_{12} < X_8 < X_9 < X_3 < X_{13} < X_2 < X_5 < X_{11} < X_1 < X_7 < X_{10} < X_6$. The minimum value of the driving factor in 2020 was 0.15, the maximum value was 0.82, and the average was 0.69, sorted as follows: $X_4 < X_5 < X_3 < X_8 < X_{13} < X_9 < X_{12} < X_{10} < X_1 < X_7 < X_6 < X_{11} < X_2$. Regular higher education institutions (X_6) and undergraduates in regular HEIs (X_7) are stable, strong factors; total retail sales of consumer goods (X_2) and the number of subscribers to internet services (X_{11}) are new strong factors.

The minimum value of the driving factor in 2012 across western cities was 0.12, the maximum value was 0.79, and the average was 0.60, sorted as follows: $X_4 < X_{12} < X_1 < X_7 < X_5 < X_6 < X_{13} < X_9 < X_{10} < X_8 < X_2 < X_{11} < X_3$. The minimum value of the driving factor in 2020 was 0.14, the maximum value was 0.88, and the average was 0.66, sorted as follows: $X_4 < X_3 < X_{13} < X_1 < X_7 < X_{10} < X_6 < X_8 < X_{11} < X_{12} < X_9 < X_5 < X_2$. The total retail sales of consumer goods (X_2) is a stable, strong factor; the area of land used for urban construction (X_5), the area of paved roads (X_9), and the import and export volume of goods (X_{12}) are new strong factors.

The driving factors of the five types of independent variables were averaged to get the driving strength of the different types of variables (Figure 7). The calculation results show a relatively stable trend in the distribution of different types of driving forces in terms of strengths and weaknesses, but some fluctuations are still found between different regions. The driving forces in 2012 across the Chinese cities had a minimum value of 0.41, a maximum value of 0.67, and an average of 0.55 in strength, ranked as urbanization < opening-up < education < infrastructure < economy. The driving forces in 2020 had a minimum value of 0.44, a maximum value of 0.70, and an average of 0.60 in strength, ranked as urbanization < opening-up < education < infrastructure < economy. The economic factor was the strongest, and the urbanization factor was the weakest at these two stages.

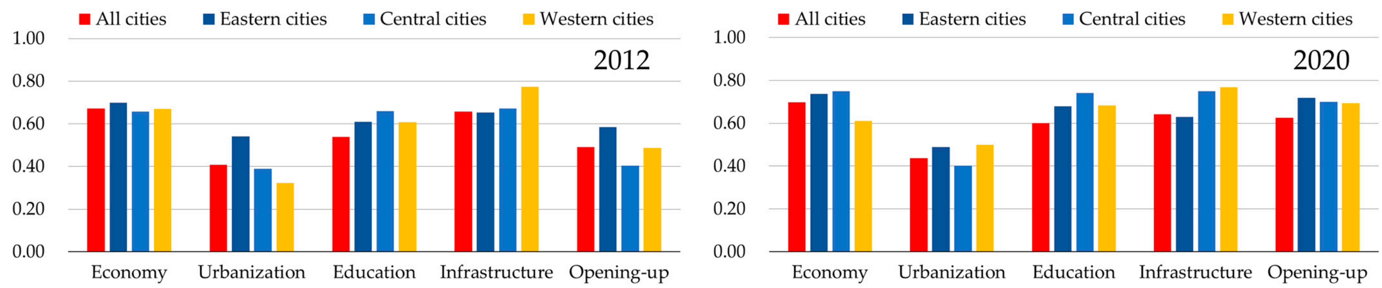

Figure 7. Driving force in 2012 and 2020.

The driving forces in 2012 across the eastern cities had a minimum value of 0.54, a maximum value of 0.70, and an average value of 0.62 in strength, ranked as urbanization < opening-up < education < infrastructure < economy. The driving forces in 2020 had a minimum value of 0.49, a maximum value of 0.74, and an average of 0.65 in strength, ranked as urbanization < infrastructure < education < opening-up < economy. The economic factor was the strongest, and the urbanization factor was the weakest at these two stages.

The driving forces in 2012 across the central cities had a minimum value of 0.39, a maximum value of 0.67, and an average of 0.56 in strength, ranked as urbanization < opening-up < economy < education < infrastructure. The driving forces in 2020 had a minimum value of 0.40, a maximum value of 0.75, and an average of 0.67 in strength, ranked as urbanization < opening-up < education < economy < infrastructure. The infrastructure factor was the strongest, and the urbanization factor was the weakest at these two stages.

The driving forces in 2012 across the western cities had a minimum value of 0.32, a maximum value of 0.77, and an average of 0.57 in strength, ranked as urbanization <

opening-up < education < economy < infrastructure. The driving forces in 2020 had a minimum value of 0.50, a maximum value of 0.77, and an average of 0.65 in strength, ranked as urbanization < economy < education < opening-up < infrastructure. The infrastructure factor was the strongest, and the urbanization factor was the weakest at these two stages.

4.3.2. Interaction Detection

Interaction detection was dominated by bilinear enhancement, with significant interaction differences and multiple super-interaction factors. Interaction detection came with 78 factor pairs per region per year, with 624 factor pairs in total: 87.66% bifactor-enhanced, 1.12% nonlinearly enhanced, 0.32% nonlinearly weaken, and 6.57% single-factor nonlinearly weaken. The interaction detection values of different regions were divided into weak, medium, and strong levels by the interval of "10–30–60%", and the factor with the highest frequency in the strong-acting factor pairs was regarded as the super-interaction factor. Interaction detection across Chinese cities in 2012 had a minimum value of 0.57, a maximum value of 0.83, and an average of 0.72, and the strong-acting factor pairs were $X_6 \cap X_{12}$, $X_{10} \cap X_{13}$, $X_2 \cap X_6$, $X_2 \cap X_{10}$, $X_1 \cap X_{10}$, $X_7 \cap X_{12}$, $X_3 \cap X_{10}$, $X_{11} \cap X_{13}$, with number of buses and trolley buses under operation (X_{10}) being the super-interaction factor. Interaction detection in 2020 had a minimum value of 0.57, a maximum value of 0.85, and an average of 0.76, and the strong-acting factor pairs were $X_2 \cap X_6$, $X_3 \cap X_8$, $X_7 \cap X_{12}$, $X_2 \cap X_{10}$, $X_{11} \cap X_{12}$, $X_2 \cap X_{12}$, $X_2 \cap X_8$, $X_6 \cap X_{12}$, with total retail sales of consumer goods (X_2) and import and export volume of goods (X_{12}) being the super-interaction factors (Tables 8 and 9).

Table 8. Result of interaction detection in all cities of Y_1 for 2012; obtained by R language.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
X_1	0.65												
X_2	0.74	0.72											
X_3	0.71	0.75	0.65										
X_4	0.65	0.74	0.65	0.25									
X_5	0.71	0.72	0.71	0.57	0.57								
X_6	0.71	0.78	0.74	0.59	0.66	0.51							
X_7	0.71	0.77	0.68	0.60	0.65	0.57	0.51						
X_8	0.76	0.74	0.75	0.71	0.69	0.76	0.70	0.60					
X_9	0.69	0.72	0.70	0.62	0.64	0.65	0.66	0.71	0.59				
X_{10}	0.79	0.78	0.81	0.73	0.73	0.76	0.74	0.77	0.75	0.69			
X_{11}	0.75	0.76	0.75	0.71	0.72	0.75	0.73	0.75	0.74	0.77	0.69		
X_{12}	0.76	0.77	0.76	0.60	0.70	0.77	0.80	0.73	0.71	0.76	0.77	0.43	
X_{13}	0.68	0.74	0.71	0.61	0.69	0.75	0.69	0.73	0.70	0.78	0.83	0.66	0.55

Table 9. Result of interaction detection in all cities of Y_2 for 2020; obtained by R language.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
X_1	0.71												
X_2	0.81	0.79											
X_3	0.74	0.80	0.59										
X_4	0.71	0.79	0.64	0.22									
X_5	0.76	0.82	0.74	0.65	0.65								
X_6	0.76	0.83	0.69	0.61	0.71	0.60							
X_7	0.73	0.81	0.65	0.57	0.70	0.66	0.51						
X_8	0.80	0.85	0.83	0.76	0.77	0.80	0.75	0.69					
X_9	0.73	0.82	0.70	0.62	0.70	0.74	0.62	0.78	0.57				
X_{10}	0.81	0.84	0.78	0.68	0.72	0.77	0.75	0.79	0.73	0.67			
X_{11}	0.80	0.81	0.80	0.78	0.80	0.82	0.77	0.79	0.80	0.83	0.70		
X_{12}	0.82	0.84	0.80	0.67	0.76	0.85	0.83	0.82	0.77	0.74	0.84	0.64	
X_{13}	0.79	0.82	0.72	0.66	0.74	0.72	0.70	0.80	0.74	0.77	0.83	0.80	0.62

Interaction detection across the eastern cities in 2012 had a minimum value of 0.61, a maximum value of 0.89, and an average of 0.78, and the strong-acting factor pairs were $X_2 \cap X_5$, $X_{11} \cap X_{13}$, $X_8 \cap X_{12}$, $X_1 \cap X_{11}$, $X_5 \cap X_{11}$, $X_5 \cap X_{11}$, $X_1 \cap X_{12}$, $X_1 \cap X_3$, $X_3 \cap X_{11}$, with number of subscribers to internet services (X_{11}) being the super-interaction factor. Interaction detection in 2020 had a minimum value of 0.62, a maximum value of 0.91, and an average of 0.80, and the strong-acting factor pairs were $X_3 \cap X_8$, $X_6 \cap X_{11}$, $X_3 \cap X_{13}$, $X_2 \cap X_3$, $X_7 \cap X_{12}$, $X_6 \cap X_{12}$, $X_3 \cap X_5$, $X_3 \cap X_{12}$, with revenue from domestic and inbound tourism (X_3) being the super-interaction factor (Tables 10 and 11).

Table 10. Result of interaction detection in eastern cities of Y_1 for 2012; obtained by R language.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
X_1	0.65												
X_2	0.86	0.70											
X_3	0.87	0.78	0.75										
X_4	0.68	0.73	0.78	0.40									
X_5	0.84	0.86	0.86	0.69	0.68								
X_6	0.83	0.84	0.83	0.82	0.80	0.60							
X_7	0.75	0.76	0.76	0.67	0.81	0.65	0.55						
X_8	0.82	0.75	0.77	0.75	0.83	0.81	0.71	0.67					
X_9	0.71	0.72	0.77	0.61	0.70	0.69	0.61	0.72	0.50				
X_{10}	0.85	0.76	0.84	0.75	0.84	0.81	0.82	0.84	0.76	0.73			
X_{11}	0.87	0.78	0.89	0.79	0.87	0.83	0.84	0.86	0.78	0.77	0.73		
X_{12}	0.87	0.78	0.86	0.72	0.82	0.84	0.85	0.86	0.70	0.76	0.78	0.59	
X_{13}	0.84	0.76	0.73	0.72	0.82	0.82	0.73	0.74	0.65	0.84	0.86	0.72	0.57

Table 11. Result of interaction detection in eastern cities of Y_2 for 2020; obtained by R language.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
X_1	0.72												
X_2	0.81	0.77											
X_3	0.86	0.89	0.73										
X_4	0.72	0.79	0.81	0.37									
X_5	0.78	0.84	0.91	0.63	0.61								
X_6	0.87	0.85	0.83	0.76	0.83	0.70							
X_7	0.77	0.86	0.85	0.71	0.74	0.76	0.56						
X_8	0.85	0.82	0.88	0.83	0.82	0.84	0.84	0.78					
X_9	0.77	0.79	0.80	0.63	0.72	0.76	0.62	0.80	0.52				
X_{10}	0.79	0.81	0.84	0.63	0.66	0.80	0.71	0.83	0.76	0.62			
X_{11}	0.77	0.81	0.87	0.77	0.80	0.88	0.78	0.84	0.76	0.81	0.75		
X_{12}	0.81	0.80	0.91	0.75	0.80	0.91	0.90	0.85	0.74	0.79	0.82	0.74	
X_{13}	0.84	0.84	0.89	0.75	0.76	0.85	0.87	0.81	0.75	0.78	0.86	0.81	0.70

Interaction detection across the central cities in 2012 had a minimum value of 0.39, a maximum value of 0.81, and an average of 0.73, and the strong-acting factor pairs were $X_3 \cap X_6$, $X_5 \cap X_{13}$, $X_6 \cap X_{13}$, $X_9 \cap X_{11}$, $X_8 \cap X_{13}$, $X_9 \cap X_{13}$, $X_{11} \cap X_{13}$, $X_{10} \cap X_{13}$, with actual use of foreign direct investment (X_{13}) being the super-interaction factor. Interaction detection in 2020 had a minimum value of 0.73, a maximum value of 0.93, and an average of 0.84, and the strong-acting factor pairs were $X_2 \cap X_6$, $X_7 \cap X_8$, $X_3 \cap X_8$, $X_6 \cap X_8$, $X_4 \cap X_8$, $X_8 \cap X_9$, $X_3 \cap X_7$, $X_3 \cap X_{11}$, with education expenditure in local general public budget (X_8) being the super-interaction factor (Tables 12 and 13).

Interaction detection across the western cities in 2012 had a minimum value of 0.17, a maximum value of 0.87, and an average of 0.74, and the strong-acting factor pairs were $X_2 \cap X_3$, $X_2 \cap X_8$, $X_2 \cap X_{13}$, $X_3 \cap X_{11}$, $X_8 \cap X_9$, $X_8 \cap X_{11}$, $X_5 \cap X_{11}$, $X_{11} \cap X_{13}$, with number of subscribers to internet services (X_{11}) being the super-interaction factor. Interaction detection in 2020 had a minimum value of 0.31, a maximum value of 0.92, and an average of 0.77, and the strong-acting factor pairs were $X_{11} \cap X_{12}$, $X_9 \cap X_{11}$, $X_8 \cap X_{12}$, $X_5 \cap X_{11}$,

$X_5 \cap X_8$, $X_2 \cap X_{11}$, $X_8 \cap X_9$, $X_2 \cap X_8$, with number of subscribers to internet services (X_{11}) being the super-interaction factor (Tables 14 and 15).

Table 12. Result of interaction detection in central cities of Y_1 for 2012; obtained by R language.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
X_1	0.69												
X_2	0.72	0.65											
X_3	0.72	0.71	0.62										
X_4	0.72	0.72	0.67	0.11									
X_5	0.70	0.71	0.74	0.67	0.66								
X_6	0.77	0.77	0.79	0.73	0.76	0.74							
X_7	0.75	0.76	0.77	0.69	0.76	0.78	0.72						
X_8	0.77	0.71	0.72	0.69	0.75	0.78	0.76	0.52					
X_9	0.72	0.73	0.72	0.74	0.69	0.67	0.75	0.71	0.59				
X_{10}	0.74	0.77	0.75	0.73	0.77	0.77	0.77	0.76	0.75	0.73			
X_{11}	0.78	0.74	0.74	0.75	0.76	0.77	0.78	0.76	0.79	0.81	0.69		
X_{12}	0.70	0.68	0.68	0.39	0.64	0.68	0.72	0.66	0.68	0.76	0.52	0.16	
X_{13}	0.78	0.77	0.69	0.74	0.79	0.79	0.77	0.80	0.80	0.78	0.80	0.61	0.65

Table 13. Result of interaction detection in central cities of Y_2 for 2020; obtained by R language.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
X_1	0.75												
X_2	0.83	0.82											
X_3	0.84	0.88	0.68										
X_4	0.77	0.86	0.86	0.15									
X_5	0.82	0.85	0.81	0.76	0.66								
X_6	0.85	0.89	0.86	0.79	0.81	0.77							
X_7	0.84	0.87	0.91	0.80	0.80	0.84	0.77						
X_8	0.83	0.87	0.89	0.90	0.86	0.89	0.89	0.69					
X_9	0.85	0.87	0.82	0.77	0.73	0.81	0.83	0.90	0.71				
X_{10}	0.83	0.86	0.81	0.86	0.74	0.83	0.81	0.88	0.77	0.74			
X_{11}	0.86	0.88	0.93	0.85	0.85	0.88	0.83	0.88	0.87	0.85	0.80		
X_{12}	0.78	0.83	0.83	0.75	0.79	0.83	0.83	0.83	0.83	0.82	0.87	0.71	
X_{13}	0.77	0.84	0.80	0.74	0.86	0.83	0.86	0.82	0.86	0.84	0.88	0.74	0.69

Table 14. Result of interaction detection in western cities of Y_1 for 2012; obtained by R language.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
X_1	0.44												
X_2	0.81	0.78											
X_3	0.81	0.87	0.79										
X_4	0.45	0.72	0.25	0.12									
X_5	0.55	0.87	0.81	0.36	0.52								
X_6	0.61	0.80	0.83	0.63	0.57	0.58							
X_7	0.47	0.82	0.84	0.47	0.57	0.61	0.46						
X_8	0.82	0.87	0.80	0.24	0.81	0.84	0.84	0.77					
X_9	0.80	0.78	0.86	0.69	0.85	0.79	0.82	0.87	0.77				
X_{10}	0.80	0.78	0.86	0.69	0.85	0.79	0.82	0.87	0.78	0.77			
X_{11}	0.82	0.78	0.87	0.73	0.87	0.80	0.82	0.87	0.79	0.79	0.78		
X_{12}	0.59	0.79	0.83	0.39	0.56	0.60	0.62	0.81	0.79	0.79	0.80	0.21	
X_{13}	0.81	0.87	0.80	0.17	0.80	0.83	0.83	0.79	0.85	0.85	0.87	0.78	0.76

4.3.3. Driving Mechanism

The core, important, and auxiliary factors that influence the distribution pattern of public cultural facilities in China were extracted from the aforementioned driving factors in accordance with the following screening principles: (1) Based on the factor ranking of

Y_1 and Y_2, the factors ranked in the top 4 for Y_2 and top 4 for Y_1 were extracted as the core factors, and the remaining factors in the top 4 for Y_2 were taken as the important factors; the factors ranked in the top 8 for Y_2 and top 8 for Y_1 were extracted as the important factors, and the remaining factors in the top 8 for Y_2 were taken as the auxiliary factors; all the remaining factors were taken as auxiliary factors. (2) Based on the super-interaction factors of Y_1 and Y_2, if a factor is a super-interaction factor of both Y_1 and Y_2, it is used as a core factor; if a factor is only a super-interaction factor of Y_2 but not of Y_1, it is used as an important factor; if a factor is only a super-interaction factor of Y_1 but not of Y_2, it is used as an auxiliary factor (Figure 8).

Table 15. Result of interaction detection in western cities of $\mathbf{Y_2}$ for 2020; obtained by R language.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
X_1	0.59												
X_2	0.89	0.88											
X_3	0.62	0.89	0.37										
X_4	0.60	0.84	0.53	0.14									
X_5	0.88	0.89	0.86	0.83	0.86								
X_6	0.67	0.89	0.60	0.57	0.88	0.66							
X_7	0.61	0.89	0.62	0.61	0.89	0.67	0.60						
X_8	0.87	0.92	0.38	0.36	0.91	0.86	0.87	0.79					
X_9	0.87	0.89	0.86	0.81	0.87	0.88	0.88	0.92	0.86				
X_{10}	0.66	0.89	0.60	0.56	0.88	0.66	0.67	0.86	0.87	0.65			
X_{11}	0.85	0.91	0.45	0.37	0.91	0.86	0.86	0.83	0.91	0.85	0.80		
X_{12}	0.87	0.89	0.87	0.82	0.87	0.88	0.90	0.91	0.86	0.88	0.90	0.85	
X_{13}	0.67	0.84	0.79	0.67	0.81	0.69	0.69	0.37	0.81	0.69	0.31	0.81	0.54

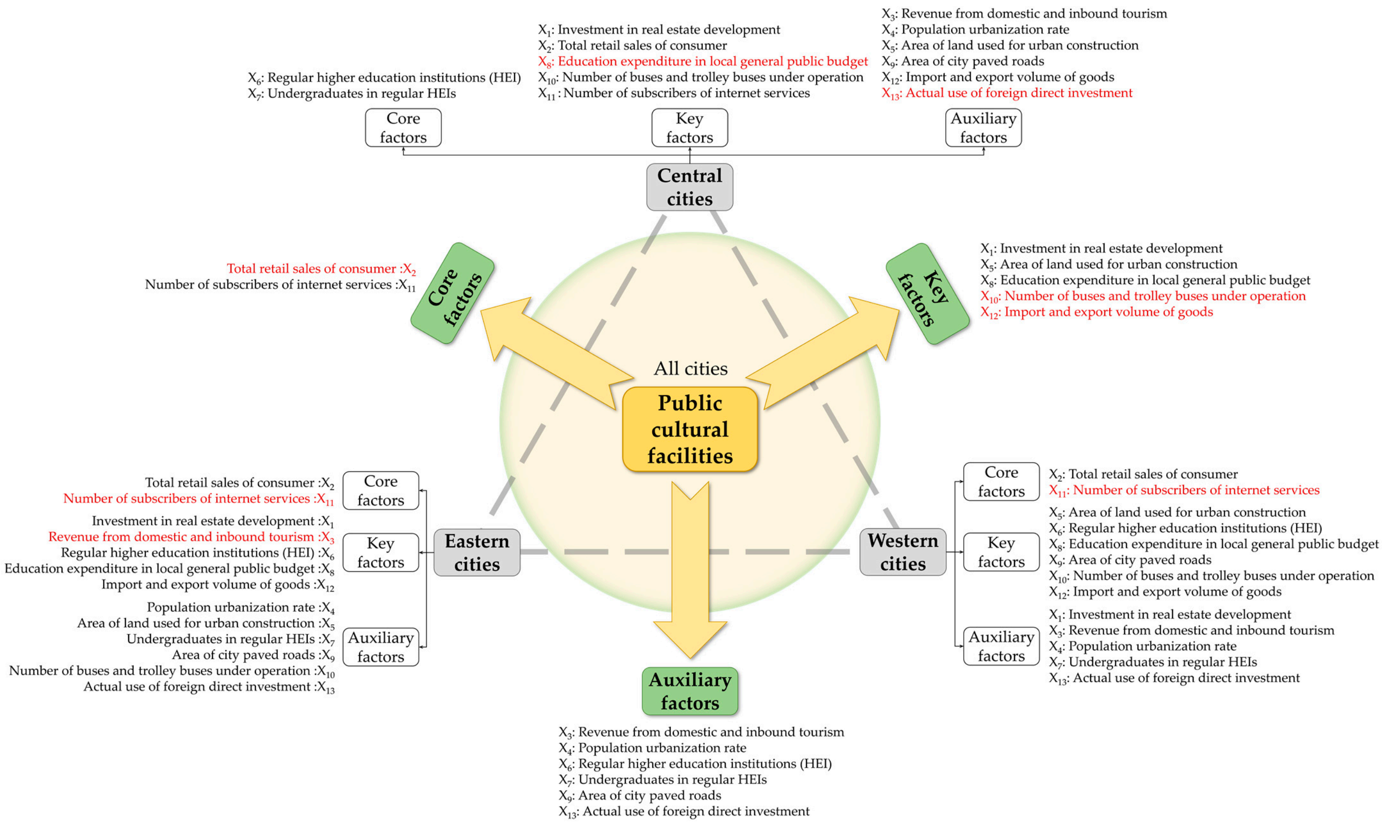

Figure 8. Driving mechanism of public cultural facilities in China. The super interactive factors of different regions are marked in red.

The results showed that the main influencing factors on public cultural facilities in the different regions differed, with the core factors showing both direct and interactive effects, and the important factors being dominated by direct effects and supplemented by interactive effects. In these Chinese cities, the total retail sales of consumers and the number of subscribers to internet services are core factors, while investment in real estate development, the area of land used for urban construction, education expenditure in the local general public budget, the number of buses and trolley buses under operation, and the import and export volume of goods are important factors. Super-interaction factors were found in the core and important factors.

In the eastern cities, the total retail sales of consumers and the number of subscribers to internet services are the core factors, while investment in real estate development, revenue from domestic and inbound tourism, regular higher education institutions, education expenditure in the local general public budget, and the import and export volume of goods are important factors. Super-interaction factors were found in the core and important factors.

In the central cities, regular higher education institutions and undergraduates in regular HEIs are the core factors, while investment in real estate development, the total retail sales of consumers, education expenditure in the local general public budget, the number of buses and trolley buses under operation, and the number of subscribers to internet services are important factors. Super-interaction factors were found in the important and auxiliary factors.

In the western cities, the total retail sales of consumers and the number of subscribers to internet services are core factors, while the area of land used for urban construction, regular higher education institutions, education expenditure in the local general public budget, the area of paved roads, the number of buses and trolley buses under operation, and the import and export volume of goods are important factors. Super-interaction factors were found in the core factors only.

5. Discussion

5.1. Theoretical Thinking and External Evidence

This paper finds that the spatial distribution of public cultural facilities in China, as a whole and by type, shows very obvious gradient differences between the east and west, with prominent spatial imbalances and spatial aggregation characteristics. Among the established studies, Zhang, Zhang, Li, Li, and Ma et al. pointed out that China is characterized by pronounced regional imbalance and spatial aggregation regarding cultural facilities, museums, libraries, and bookstores [7,12–14,19], and Ballatore, Kervankıran, De Graaff and Donnelly et al. also pointed out that the spatial imbalance and spatial aggregation of museums and libraries in the UK, Turkey, the Netherlands, and the United States are equally significant [15–18]. The findings of this paper are largely consistent with their conclusions, suggesting that the uneven distribution and spatial aggregation pattern of public cultural facilities is a widespread geographic phenomenon worldwide. This paper also finds that the intensity of spatial dispersion and the degree of spatial aggregation vary significantly among different types of public cultural facilities. Among the existing studies, Zhao et al. pointed out that museums, libraries, and cultural centers in Zhengzhou are in a uniform spatial distribution, while the spatial distribution of art galleries and theaters varies significantly [23]; He et al. stated that libraries, cultural centers, and art centers in Beijing are in a relatively even spatial distribution, while the spatial distribution of concert halls, exhibition halls, and performing arts centers is less balanced [65]; Shan et al. showed that museums, libraries, and activity centers in Wuhan are distributed in a centripetal pattern, while theaters, bookstores, and concert halls are clustered in the central urban area [66]. The reason for this phenomenon is that museums, libraries, and cultural centers, as public welfare or government-funded public cultural facilities, are built with more equity in mind, while exhibition halls, theaters, and art galleries, as commercial public cultural facilities, are built with more commercial benefits in mind. This paper also finds that on the scale of prefecture-level cities, museums and cultural centers in

China have small spatial differentiation, while art galleries and exhibition halls have large spatial differentiation. However, the difference is that the spatial differentiation is large for libraries (nonprofit) while being small for theaters (commercial), which should be related to the consumption preferences and cultural promotion policies of the city. Besides, this paper also finds that there are differences in the spatial variation characteristics of different types of public cultural facilities, with a decreasing degree of differentiation detected for libraries, museums, theaters, art galleries, and cultural centers while an increasing degree for exhibition halls was found; libraries, museums, art galleries, and cultural centers show an increasing tendency to gather, while theaters and exhibition halls show a weakening tendency. This result is supposed to be caused by the different rates of construction of public cultural facilities due to inherent local development differences, which have not been paid much attention to in the existing studies.

This paper finds that the driving factors of public cultural facilities in China are diverse, with significant differences in the effects of the five categories of variables on the different regions and more diverse and complex influencing mechanisms. In the studies by Zhang, Liu, Li, Li, Ballatore, and Woronkowicz et al., they pointed out that economic, social, educational, tourism, and transportation factors have strong positive effects on the spatial distribution of public cultural facilities, museums, libraries, and bookstores in China, the United States, and the United Kingdom [12,13,15,19,32,33]; Zhao, Zhao, Zhang, Liu, Guo, and Leem et al. pointed out that economic, transportation, and tourism factors have a strong positive influence on the spatial distribution of public cultural facilities, libraries, museums, cinemas, and bookstores in Hong Kong, Daejeon, Zhengzhou, London, Xi'an, and Shanghai [23,27,28,34–36]. The findings of this paper are largely identical to their conclusions, suggesting that the driving mechanisms of public cultural facilities share certain similar patterns across countries and at different scales. In this paper, it was found that the opening-up factor has an influence on the spatial distribution of public cultural facilities to some extent, and this influence is getting stronger, indicating that China's long-held opening-up policy has profoundly affected the development of cultural undertakings. In addition, this paper also finds that the five variables—economy, urbanization, education, infrastructure, and opening-up—have different influences in different regions, having different changes, indicating differences in the influential roles of public cultural facilities in the different regions, with increasingly diversified and complex driving mechanisms. These two findings are the original conclusions of this paper and help to implement zoning policies in different regions.

It was also found that a few sister factors have essentially equivalent forces but are mostly quite different, and multiple super-interacting factors have emerged. The economic factor and total retail sales of consumer goods have significantly larger roles than investment in real estate development and revenue from domestic and inbound tourism, suggesting that consumer services are better able to promote the construction of public cultural facilities. Among the urbanization factors, the area of land used for urban construction has a significantly stronger effect than the population urbanization rate, indicating that the land resources provided by land urbanization and the aggregation effect produced are more favorable to the construction of public cultural facilities. The education factor and education expenditure in the local general public budget have significantly larger roles than regular higher education institutions and undergraduates in regular HEIs, indicating that the supportive effect and spillover effect brought by the government's education investment funds are more stimulating to the development of public cultural facilities. The infrastructure factor and the number of subscribers to internet services have significantly greater roles than the area of paved roads and the number of buses and trolley buses under operation, indicating that information infrastructure contributes more to public cultural facilities than traditional infrastructure. For the opening-up factors, the roles of the import and export volume of goods and actual use of foreign direct investment have changed from relatively different to largely equivalent, suggesting that the tax revenue and culture generated by foreign trade and foreign investment have contributed significantly to the development of public cultural facilities. In addition, this article found that the total retail sales of consumer goods, the revenue from domestic and inbound tourism, education expenditure in the local general public budget, the number of buses and trolley buses under operation, the number of subscribers to internet services, the import and export volume of goods, and actual use of foreign direct investment are super-interaction factors, which significantly enhance the promotion effect on public cultural facilities when combined with other factors. These findings are the original conclusions of this paper and help to implement policies for different factors by type.

5.2. Policy Suggestions in Sustainable Development

The development characteristics of public cultural facilities in China are divided into four types of star, cow, question, and dog cities based on the BCG matrix. The steps are as follows: (1) calculate the ratio between the number of public cultural facilities in each city and the largest number of public cultural facilities across cities as the horizontal co-ordinate based on the period of Y_1; (2) calculate the normalized value of the average annual increment in public cultural facilities in each city as the vertical co-ordinate based on the growth period of $Y_1 \sim Y_2$; (3) classify the 285 cities into four categories using the average of the results of the horizontal and vertical co-ordinates as the threshold (Figure 9).

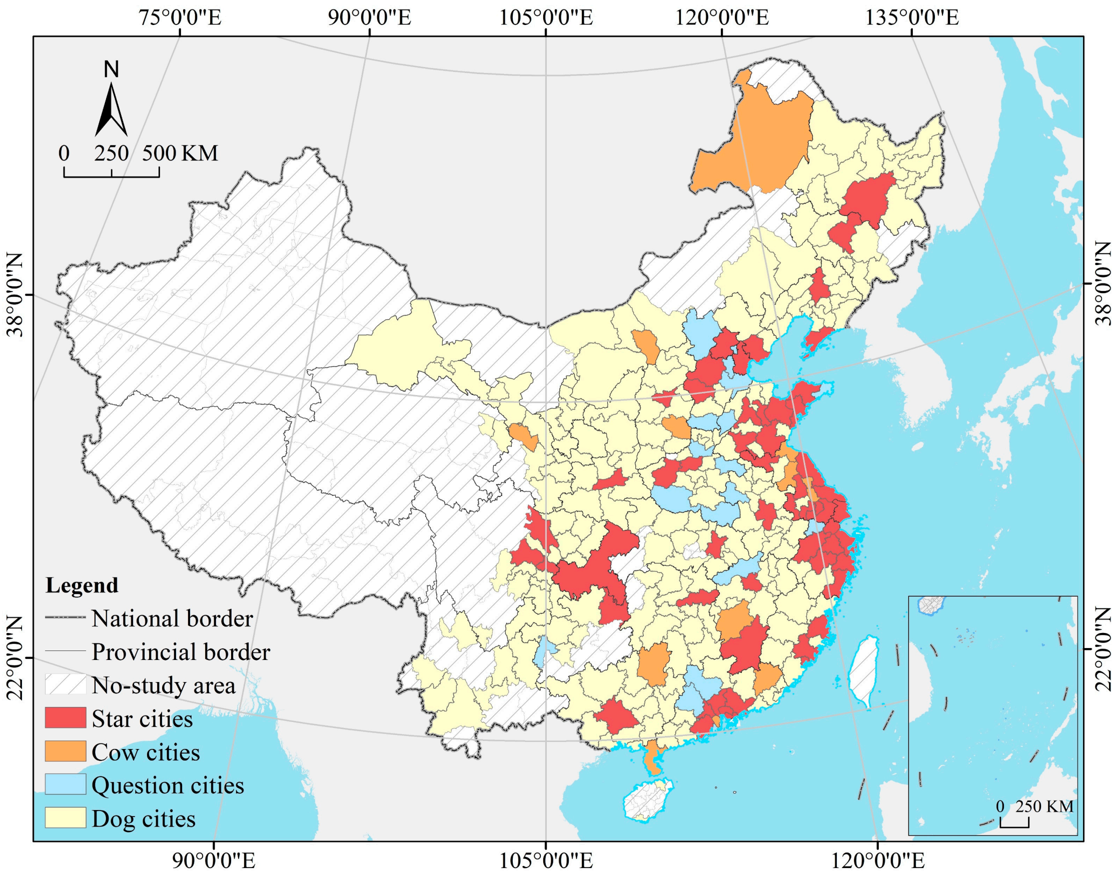

Figure 9. Policy zoning map of public cultural facilities in China.

Star cities are of the "high-high" type, accounting for 19.65%, gathered in Beijing, Tianjin, Hebei, the Yangtze River Delta, and the Pearl River Delta, including most provincial capitals and key cities, with a sound foundation for the development of public cultural facilities and great potential for incremental growth. Cow cities are of the "high-low" type, accounting for 4.21%, scattered in parts of Gansu, Guangxi, Jiangxi, Inner Mongolia, Heilongjiang, Guangdong, Jiangsu, and Shanxi, with a sound foundation for the development of public cultural facilities but lackluster growth. Question cities are of the "low-high" type, accounting for 5.96%, scattered in Beijing, Tianjin, and Hebei, the Pearl River Delta, and the central region, with a small number of public cultural facilities but great potential for incremental growth. Dog cities are of the "low-low" type, accounting for 70.18%, widely distributed in most regions, with a small number of public cultural facilities and a low potential for incremental growth.

Star cities should try to maintain their status quo, and we do not recommend that they take excessive policy intervention measures, while regulatory policies are necessary for cow cities, question cities, and dog cities. Dog cities and cow cities, due to the backwardness or bottleneck in the development of public cultural facilities, should focus on the core factors and the important factors regarding policy to give play to their strong promoting effect or strong interaction and boost the construction of public cultural facilities. Question cities are in the process of growth, and improper guidance may disrupt the pace of their development, so the auxiliary factors should be the focus of policy to promote the development of public cultural facilities. In addition, policy design should highlight the differences in the way the core factors, important factors, and auxiliary factors work in different regions in the east and west, and they should formulate policies for the development of public cultural facilities according to local conditions.

5.3. Research Insight and Deficiency

This paper theoretically analyzes the evolutionary characteristics of six types of public cultural facilities with the help of multi-temporal POI data to compensate for the lack of application of dynamic POI data in the existing studies and the lack of exploration of the distribution patterns of multiple types of public cultural facilities. In addition, this paper analyzes the driving factors of the spatial differentiation of public cultural facilities by factor detection and interaction detection based on the five-dimensional framework of "economy-urbanization-education-infrastructure-opening-up", which represents the systematic and integrated application of the multi-indicator system and is a further extension of GeoDetector, helping to deeply understand the driving mechanisms of the spatial differentiation of public cultural facilities. In practice, the main findings in this paper can serve as a basis for the Chinese government to formulate regulatory policies for public cultural facilities, especially the delineation of public cultural facility policy zonings, and the development of proposals based on the BCG model can be directly used as an important reference for the Chinese government to manage public cultural facilities. As the per capita GDP in a large number of developing countries, such as India, Egypt, Brazil, Thailand, and Turkey, has exceeded USD 3000, it can be predicted that these countries will also witness faster growth regarding public cultural facilities and the main findings of this paper also provide a reference for their management of public cultural facilities.

However, there are still some limitations in this paper due to data shortage, length limits, and technological hurdles. First of all, this paper only analyzes the quantitative distribution characteristics of public cultural facilities without devoting much attention to matching public cultural facilities with the population and the economy. Secondly, this paper only analyzes the influential mechanism of the spatial differentiation of public cultural facilities from the macroscopic socio-economic level, with no detailed discussion of micro factors, such as corporate subjects and operation modes. Thirdly, obtaining data on public cultural facilities by means of geographic big data makes this paper inevitably flawed in terms of data acquisition and data cleaning, which may bring a certain level of interference to the analysis results. Finally, this paper did not conduct a detailed analysis of the spatial characteristics of the influencing factors, as GeoDector cannot spatially display the analysis results, and we will try to introduce the geographically weighted regression method for further in-depth exploration in the future.

6. Conclusions

With the intensification of international competition in the background of globalization, the construction of public cultural facilities has become an important means to shape the competitiveness of cities and is no longer limited to meeting the cultural needs of the public.

Studying public cultural facilities from a spatial perspective will help to gain a deeper understanding of their development patterns and provide a more refined basis for the government to formulate policies to promote public cultural facilities. This paper collects POI data and socio-economic statistics on China from 2012 to 2020, and we conduct an empirical study on the spatial variation patterns and driving mechanisms of urban-scale public cultural facilities based on a combination of the coefficient of variation, Gini index, ESDA, and GeoDetector.

Findings: (1) a CV greater than 1.3 and a GI greater than 0.5 for both years indicate that the regional gradient differences and uneven spatial distribution of public cultural facilities across Chinese cities have always been prominent. The CV of different types of public cultural facilities changed from 1.39~2.69 in 2012 to 1.06~1.92 in 2020, and the GI changed from 0.53~0.80 to 0.47~0.62, indicating that the spatial differentiation pattern of different types of public cultural facilities differed, with the differentiation degree of libraries, museums, theaters, art galleries, and cultural centers becoming smaller, while that of exhibition halls becoming larger.

(2) A Moran I of 0.15 for both years indicates that public cultural facilities are clustering at a weak level in Chinese cities in a spatial cluster pattern of "hot in the east and cold in the west". Different types of public cultural facilities differ in their aggregation patterns. The Moran I of libraries, museums, art galleries, and cultural centers changed from 0.08~0.20 in 2012 to 0.12~0.24 in 2020, showing a weak aggregation characteristic with an increasing aggregation trend; the Moran I of theaters and exhibition halls changed from 0.15~1.19 to 0.09~0.1, also showing a weak aggregation characteristic but with a declining trend.

(3) There are multiple driving factors for China's public cultural facilities. The five driving variables exhibit significant differences in their strength across time and across regions, with the economic and infrastructure factors being the strongest and the urbanization factor the weakest. The intensity of the driving forces varies significantly among the different factors, and there are many super-interaction factors. The total retail sales of consumers, the number of subscribers to internet services, regular higher education institutions, and undergraduates in regular HEIs are the core factors, playing both direct and interactive roles.

(4) The 285 cities were classified into four policy zonings of star, cow, question, and dog cities, based on the proportion and increment of the number of public cultural facilities in China. Star cities should maintain their status quo without involving too much policy intervention, with the core and important factors being the focus of policy in dog cities and cow cities and the auxiliary factors being the focus of policy for question cities. In addition, this paper also suggests that public cultural facility development policies need to be tailored according to the differences in the way factors work in different regions in the east, middle, and west.

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