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# Spatial distribution of Chinese churches in the early 21st century

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**The development of Christianity in China has garnered significant interest from scholars across various disciplines, including religion, sociology, economics, and political science. This paper examines the spatial distribution of Chinese churches in the early 21st century using 10,579 samples collected from WebGIS. Two methods for analyzing spatial patterns, kernel density estimation, and spatial autocorrelation, are reported. The study reveals a significant concentration of churches in the coastal provinces of Southeast China, including Jiangsu, Zhejiang, Fujian Provinces, and Shanghai City, which collectively account for 35.8% of the total. At the city level, local hotspots in terms of church count are mainly observed in these areas. Specifically, 25 cities exhibit a high-high cluster pattern, and these cities are interconnected. Furthermore, combined with census data from 2020, local hotspots in terms of the church-to-population ratio are observed not only in the southeastern coastal provinces but also in the northeastern provinces of Heilongjiang and Jilin. The paper concludes that the "Bible Belt" in Southeast China has formed for historical reasons, as Christianity was predominantly introduced to China from the coastal provinces. The emergence of hotspots in Northeast China is attributed to the small population, which increases the church-to-population ratio.**

**Key words:** Christian church, spatial distribution, kernel density estimation, spatial autocorrelation.

## INTRODUCTION

The early 21st century has witnessed tremendous and unprecedented growth of Christianity in China. Some religious observers claim to have noticed a genuine spiritual eagerness among Chinese citizens (Dibin, 2010). Today, on any given Sunday, it is almost certain that more Protestants attend church in China than in all of Europe (Bays, 2003). According to the Pew Research Center, the Chinese Christian population reached 68 million by 2010, accounting for 5% of the country's total population (Pew-Templeton Global Religious Futures Project, 2010). An estimate from the Chinese Religious Report of 2010 (Jin and Qiu, 2010) states a Christian population of 23.05 million, accounting for 1.8% of the total population. Although controversy exists regarding the actual number of Christians in China, many scholars have diligently worked to understand the discrepancies (Lambert, 2003; Abel, 2006). With the increase in the Christian population, the number of churches tends to rise as well. However, to date, little attention has been given to the locations of churches or to related matters.

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Mapping is perhaps the best way to study location-related issues. The earliest and most detailed missionary map of China is the book “The Christian Occupation of China: A General Survey of the Numerical Strength and Geographical Distribution of the Christian Forces in China, Made by the Special Committee on Survey and Occupation, China Continuation Committee, 1918-1921” (Stauffer, 1922), which was simultaneously published in English and Chinese in 1922. This volume was intended as a progress report on the status of Christian churches in China, including social and economic backgrounds and local conditions. Approximately 320 maps were scattered throughout the book, including many different missionary maps, such as Protestant Mission Fields, Communicants per 10,000 Population, Distribution of Works, Stations and Evangelistic Centers, Mission Schools, etc. The modern mapping effort was originally conducted at the Center on Religion and Chinese Society at Purdue University. Purdue researchers have attempted to represent regional differences in religious affiliation (Pew Research Center, 2011). Their mapping project was based on a 2004 economic census conducted by the Chinese government, which reported the numbers and locations of economic institutions, including religious organizations officially registered with the government. This map distinguished between Protestant and Catholic institutions; the former were predominantly in the eastern region, whereas the latter were predominantly located in the northern and central regions of the country. Notable religious mapping efforts have been conducted outside China. For example, in the United States, the Association of Religion Data Archives (Quality Data on Religion, 2018) provides online thematic maps, such as total adherents or rates of adherence per 1000 people, according to user-designated states and denominations. This group also provides an electronic map displaying church locations according to the zip code or city name entered by the user.

Church mapping in China is currently a challenging process due to outdated or missing data. In this paper, we exploit WebGIS to obtain church data. WebGIS, such as Google Maps, Bing Maps, and OpenStreetMap, provides numerous geographical datasets and location-based services, such as address finding or pathfinding. In geographical datasets, POI (point of interest) is a specific point location that may be considered useful or interesting. POI usually includes latitude and longitude coordinates, as well as other information, such as a name or telephone number. In the present study, each church is a POI, and a WebGIS API (application program interface) is used to obtain the church POI.

## MATERIALS AND METHODS

This paper utilized the Amap service to obtain church data. Amap is a domestic location-based service provider in China, boasting 18 years of specialization in map services and claiming to include more than 70 million POIs. We employed a JavaScript API provided by Amap to search for church POIs in every city of China. Due to the daily API search limit, data collection required multiple calls over several days to complete. The search results also contained some incorrect data observations, such as Buddhist temples, Islamic mosques, or church buildings in theme parks. These inaccuracies were identified and eliminated based on the POI names. Additionally, some instances involved multiple POIs in close proximity that were actually the same church. We merged these POIs into one based on a distance threshold (140 m), utilizing the Quantum GIS Development Team 2024 (QGIS) platform. The POI coordinates provided by Amap were biased, necessitating the use of the QGIS plug-in GeoHey to convert them into WGS coordinates. The final POI dataset comprised 10,579 observations.

The population data utilized in this study were extracted from the 2020 census of the Chinese population (Office of the Leading Group for the Seventh National Census of the State Council, 2022). These data were aggregated into two spatial units: province-level and county-level cities. County-level cities are subunits of prefecture-level administrative divisions. As of the end of 2023, there were 397 county-level cities in China. For simplicity, county-level cities are hereafter referred to as cities. Notably, provinces also contain province-level municipalities, which are cities that operate directly under the Central Government. There are four of these municipalities in China: Beijing, Tianjin, Shanghai, and Chongqing. Moreover, the dataset excludes Hong Kong, Macao, or Taiwan.

### Kernel density estimation

When church POI data are plotted as dots on a map, they may not effectively communicate the desired message because it can be challenging to count large numbers of dots. For individual point-level data, kernel density estimation (or kernel density interpolation) is considered a highly suitable interpolation technique (Bailey and Gatrell, 1995) and a powerful method for conducting hotspot analysis by generating a smooth, continuous surface that delineates the level of clusters for a specific area (Bithell, 1990). Kernel density estimation was developed in the late 1950s as an alternative method for estimating the density of a histogram (Rosenblatt, 1956; Parzen, 1962). It is suitable for visualizing a broad, regional view of events (Silverman, 1986; Bowman and Azzalini, 1997) and has been utilized in research areas such as public health (Arden and Leitner, 2008), crime (Ned, 2015), and traffic injuries (Reardon et al., 2017).

Technically, a symmetrical kernel function is placed over each point, and the density distribution is estimated by summing the individual kernel functions at all locations to produce a smooth cumulative density function. A range of kernel functions has been used, including uniform, triangular, quartic, triweight, and normal. In this study, the quartic function was utilized, represented by Equation 1:

$$g(j) = \sum_{i=1}^{M_j} \left[ \frac{15}{16} \left( 1 - \frac{d_{ij}^2}{h^2} \right)^2 \right] \tag{1}$$

where *g(j)* is the density of all cells *j*, $d_{ij}$ is the distance between cell *j* and an incident location *i*, *h* is the radius of the search area (the bandwidth), and $M_j$ is all the incidents that fall within the bandwidth search area of cell *j*. The function assigns near points a greater weight than far points, and the weight falls off gradually with distance until the bandwidth radius is reached. As a result, a density raster of an input vector is created, with larger numbers of clustered points resulting in larger values. In general, compared with the kernel function, the bandwidth *h* often has a greater influence on outcomes. Larger *h* values result in greater smoothing, but smaller values may show finer details and variations in point density. After testing different radii, we chose a radius of 400 km, which we expected to reveal the appropriate spatial pattern.

### Spatial association analysis

The putative causes of geographical hotspots are all spatial processes, in that what occurs in one place is likely to occur in neighboring places. Additionally, conditions in one place are likely to influence, and be influenced by, those in neighboring places. A LISA (local indicators of spatial association) analysis that allows for neighboring values is therefore appropriate. For this research, we counted the number of churches located in each city polygon and then used the local Moran's I statistic ($I_i$) to examine spatial associations between cities. A local Moran's value $I_i$ (Equation 2) was calculated for each location (city) $i$ to assess the spatial structure of the count values using GeoDa version 1.22.0.2 (Anselin, 2024).

$$I_i = \frac{(x_i - \bar{x})}{S^2} \sum_{j=1, j\neq i}^{n} w_{ij}(x_j - \bar{x}) \quad (2)$$

where $x_i$ is the value at location $i$, $\bar{x}$ is the dataset mean, $n$ is the number of locations (cities) in the dataset, and $w_{ij}$ is the spatial weight between location $i$ and location $j$. $S^2$ is the dataset variance, which is calculated as Equation 3:

$$S^2 = \sum_{j=1}^{n} (x_j - \bar{x})^2 / n \quad (3)$$

A positive $I_i$ indicates that the value of $i$ and the average of its neighbors $j$ are similar (positively autocorrelated), both being greater than or less than $\bar{x}$. A negative $I_i$ indicates that the value at $i$ is dissimilar to its neighbors $j$ (negatively autocorrelated). If the value at $i$ is less than $\bar{x}$, the average $j$ is greater, and vice versa. The $I_i$ values can be classified into four types based on the values of the central location and the neighbors relative to the mean (Anselin et al., 2007): high-high, low-low, high-low and low-high. The first two are positively autocorrelated clusters, while the latter two are negatively autocorrelated outliers. A critical decision when calculating any spatial statistic is the definition of the neighbors to use in the calculations (Laffan, 2002). In this case, we define the neighbors of a contiguity such that $w_{ij} = 1$ when areal units $i$ and $j$ share a physical boundary, and $w_{ij} = 0$ otherwise.

The significance of $I_i$ can be assessed by comparing the standardized z value for $I_i$ to its probability in a standard normal table. However, the possible presence of global spatial autocorrelation will influence the distribution of the values, with the most significant effect appearing to be on the skewness of the distribution (Anselin, 1995). The conditional randomization approach is suggested by Anselin (1995) to be a viable alternative in practice, in both the absence and the presence of global spatial autocorrelation. This approach is implemented by fixing the value of interest at location i, and the remaining values are randomly permuted over the space occupied by the dataset. For each permutation, the value of $I_i$ is computed, thus yielding an empirical distribution instead of a hypothetical normal distribution, with probability values ($p_i$) for each location. For these analyses, we used 999 permutations (default setting) and set the significance level to 0.05. Figure 1 shows the flow chart of methodology used in this paper.

## RESULTS

### Kernel density estimates

Kernel density estimates were calculated using the QGIS heatmap algorithm. A density raster is displayed as the output (Figure 2). All Figures in the article are presented as Mercator projections. Based on a casual glance at Figure 2, the density of church POIs varies substantially. Churches are primarily concentrated in coastal regions of Southeast China and in inland provinces, such as Anhui and Henan. For Shanghai and Zhejiang, almost all places are shaded with the darkest hue, which represents the greatest number of churches. Churches in Shanghai and Zhejiang account for 18.2% of the total number of churches. Three provinces adjacent to this "hotspot", Jiangsu, Anhui and Fujian, are shaded with gradient hues. The color transitions from dark to light radiating outward from the hotspot, suggesting that the influence of the hotspot decreases with distance. Churches in Jiangsu, Anhui and Fujian account for 22.6% of the total number of churches. Overall, a clear decrease in density occurs from east to west, and the "coldest" areas are located in extreme southwest provinces, including part of Qinghai, part of Xinjiang and almost all of Xizang (Tibet). Table 1 lists the top ten provinces in terms of church count.

As illustrated in Table 1, Zhejiang leads the provinces with 1654 churches, comprising 15.6% of the total number of churches in China. Jiangsu Province, ranking second, is also a coastal province, with close to 1000 churches (988), representing approximately 9.3% of the total. As an inland province, Henan ranks third with 871 churches, accounting for 8.2%, closely followed by Fujian Province. Two other inland provinces in Table 1, Anhui and Heilongjiang, are also listed. Anhui ranks 8th and is geographically surrounded by Henan, Jiangsu, and Zhejiang Provinces. Heilongjiang, positioned in the northeastern most part of China, is the last province on the list. Among the three northeastern provinces, Liaoning Province ranks 9th with 423 churches. Additionally, Jilin Province, another northeastern province situated between Heilongjiang and Liaoning, is not depicted in Table 1 but is ranked 11th with 309 churches, representing 8.2%. Figure 2 and Table 1 collectively elucidate the spatial distribution of churches in China, particularly in hotspot areas.

### LISA analyses of church count

The local Moran's $I_i$ results indicate that there are significant nonrandom clusters of church counts at the city level (Figure 3). As shown in Figure 3, high-high

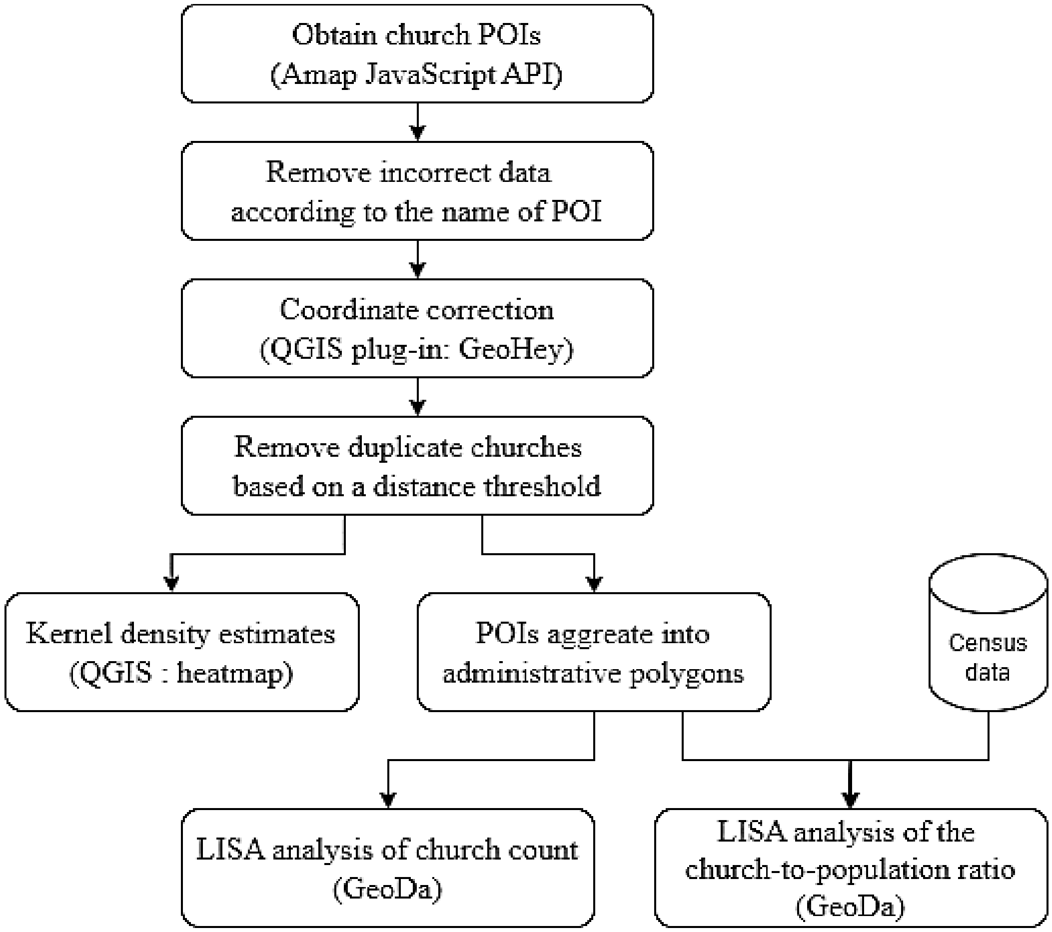


**Figure 1.** flow chart of methodology
Source: Authors' construct.

**Table 1.** Top ten provinces in terms of church count.

| Province | Churches | % |
|---|---|---|
| Zhejiang | 1654 | 15.6 |
| Jiangsu | 988 | 9.3 |
| Henan | 871 | 8.2 |
| Fujian | 867 | 8.2 |
| Guangdong | 684 | 6.5 |
| Hebei | 573 | 5.4 |
| Shangdong | 562 | 5.3 |
| Anhui | 539 | 5.1 |
| Liaoning | 423 | 4.0 |
| Heilongjiang | 317 | 3.0 |

Source: Authors' construct.

clusters (rendered in red) are concentrated mainly on the eastern coast, with a total of 25 cities. These cities are connected together, from Lianyungang (#2) in the north to Xiamen (#5) in the south, distributed in a strip (the "Bible Belt"). The Bible Belt has 3141 churches, accounting for 29.6% of the total number of churches in China. The total population in this area was 162.21 million in 2020, accounting for 11.2% of China's total population (1443.49 million). Within the belt, Wenzhou (#3) has the largest number of churches, at 547, while

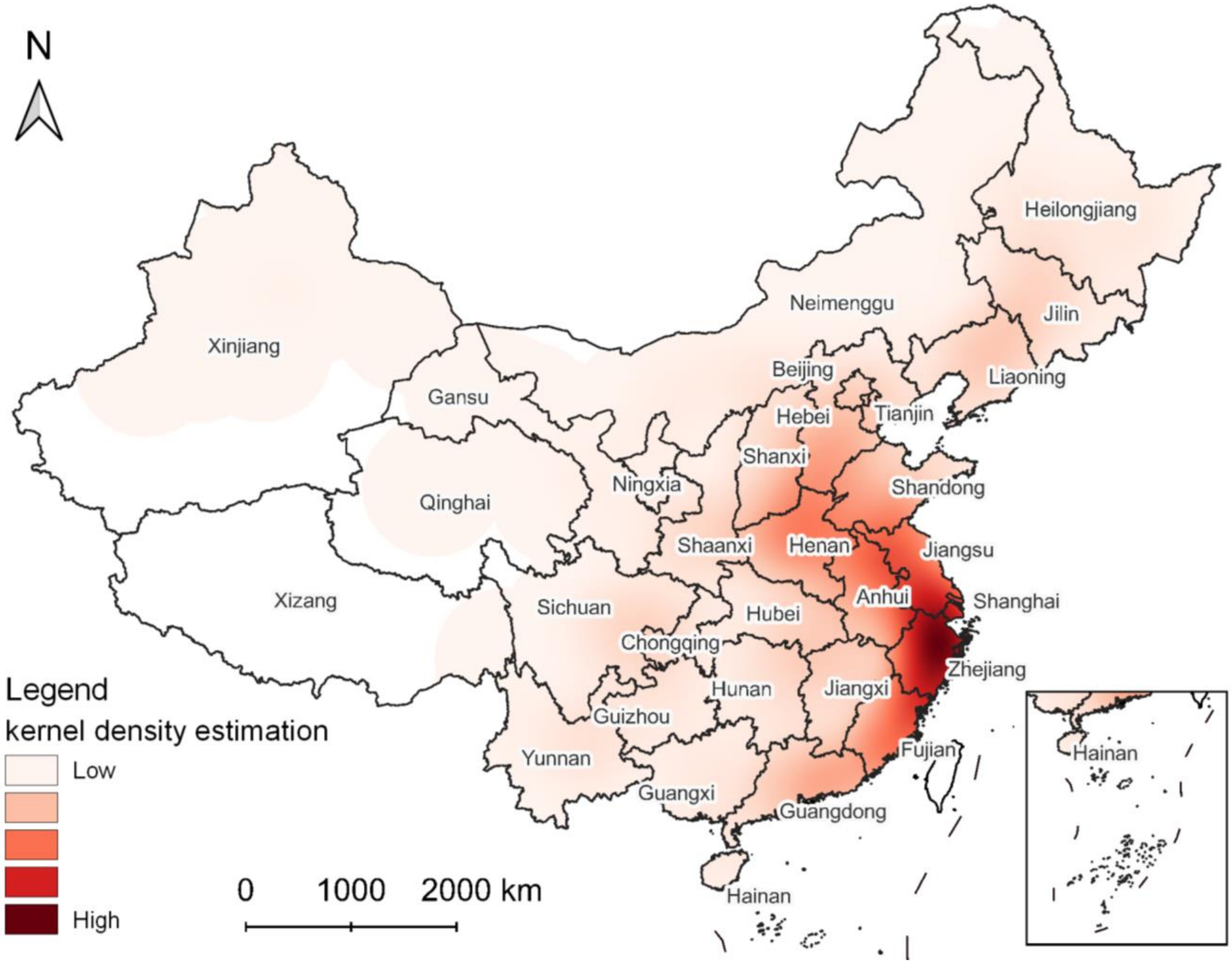


**Figure 2.** Kernel density estimation map of church POIs (radius = 400 km)
Source: Authors' construct.

Sanming (#4) has the smallest number, at 33. On average, each city has 126 churches. The 26th high-high city is Pingdingshan (#1), which has 43 churches. Although the neighboring cities of Pingdingshan have many churches (the highest number is 133), they are not classified into the high-high category according to the significance criterion of 0.05.

There are 5 low-high cities adjacent to the Bible Belt (purple). Low-high cities have small church count values but are surrounded by cities with high church count values. The low-high type cities are usually isolated and tend to border high-high cities, although this is to be expected given the formulation of the statistic. From a development perspective, low-high cities may develop into high-high cities in the future. Located in central China, Chongqing (#6) is the only high-low city (orange color) with 118 churches. Among its neighboring cities, the largest one reports only 19 churches.

*There are 72 low-low-type cities* (rendered in blue), most of which are distributed in the western region and are connected together, while in the central and southern regions, there are sporadic distribution patterns. There are 290 churches in the 72 cities, accounting for 2.7% of the total number of churches, and 104.35 million people live in this area, accounting for 7.2% of the total population. There are 256 nonsignificant cities with a total of 6844 churches, accounting for 64.6% of the total number of churches, and with a population of 1089.40 million, accounting for 75.4% of the total population.

## LISA analyses of the church-to-population ratio

A church is a people-oriented congregation, and the combination of church data with population data, or, in other words, the calculation of the church-to-population ratio, is meaningful. In the United States, this ratio is calculated as the number of churches per 10,000 people (Steven, 2017). However, in China, the number of churches is quite small relative to the population. Thus, we

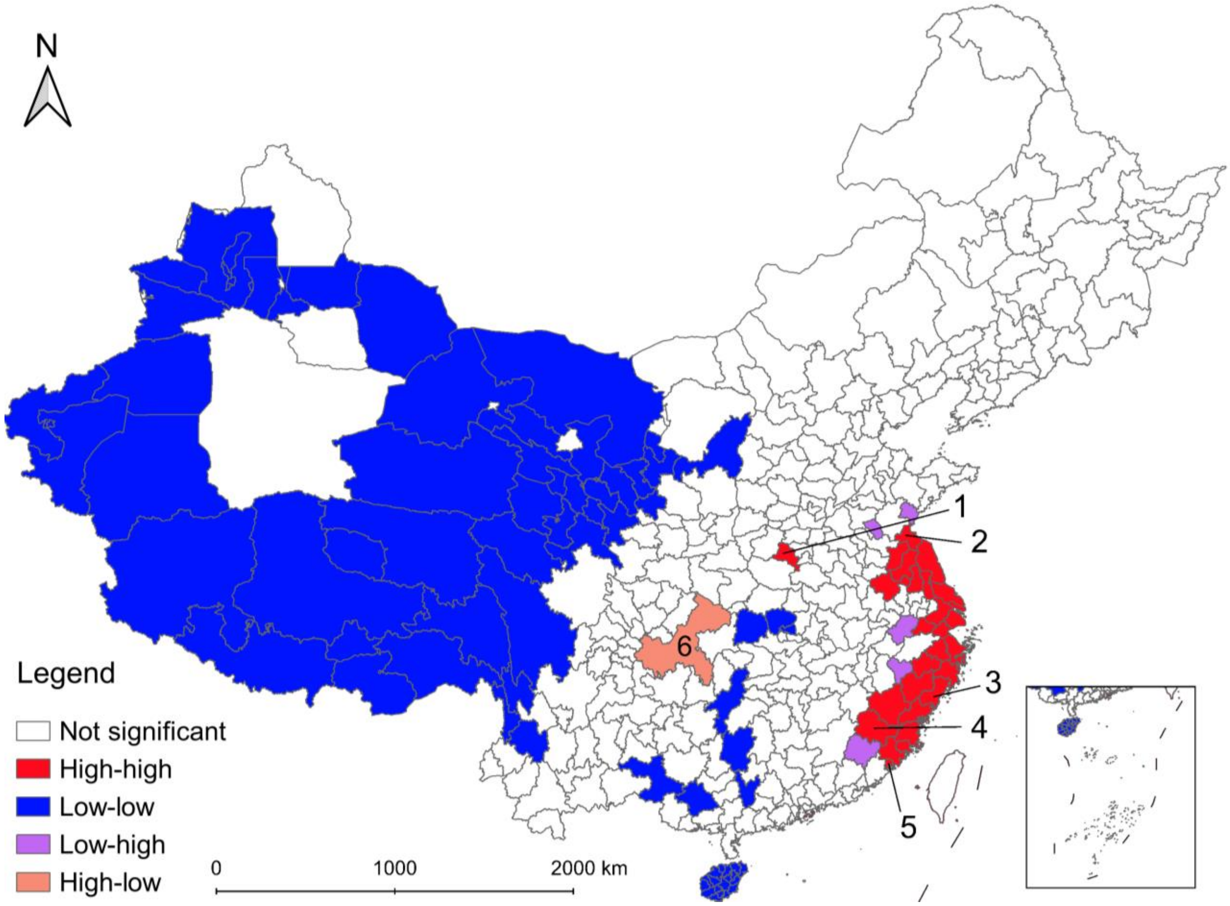


**Figure 3.** Moran's $I_i$ cluster map of church counts (significance level = 0.05)
Source: Authors' construct.

counted churches per million people for a comprehensible ratio. Using the same LISA analysis as above, Figure 4 shows the spatial autocorrelation pattern of the church-to-population ratio.

Interestingly, the pattern in Figure 4 is obviously different from that in Figure 3. The high-high area still appears in the southeastern coastal area, but it is divided into two separate areas, one in the north and one in the south. The northern area consists of 7 cities. The highest ratio is 23.70 (#8), which means that there are approximately 24 churches for every million people. In other words, each church in this area serves more than 42,000 people. The smallest ratio is 9.65. The high-high area in the south consists of 19 cities, with the highest ratio being 57.14 (#1) and the lowest ratio being 9.10. There are an average of 127 churches per city and an average population of 5.4 million. Located between the northern and southern regions, several cities belong to the high-high type, as shown in Figure 3, but do not exhibit significant patterns, as shown in Figure 4. For example, Shanghai has 278 churches and a population of approximately 24.8 million. The church-to-population ratio is 11.17, which means that each church has to serve almost 90,000 people. The large population dilutes the advantage of many churches. A similar situation is observed in cities around Shanghai, which is why Shanghai quited the high-high type in Figure 4. The emergence of high-high areas in Northeast China can also be explained by population. This high-high area consists of 10 cities. Originally, there were few churches in the region (an average of 31.5 churches per city), but due to the small population (average population of 2.5 million), the ratio becomes larger; the largest is 24.17, and the smallest is 6.79. Table 2 lists the top 10 cities in terms of the church-to-population ratio.

As shown in Table 2, the top 6 cities in terms of ratio are all high-high types, and geographically, they are all coastal cities and are connected together, with Wenzhou (known as China's Jerusalem) reporting the highest ratio with approximately 57 churches per million people. In 7th and 8th place are other high-high type cities, Fushun (#7) and Huaian (#8). Although the number of churches in Huaian is 2.4 times that in Fushun, the population is also approximately 2.4 times that of Fushun, which makes its

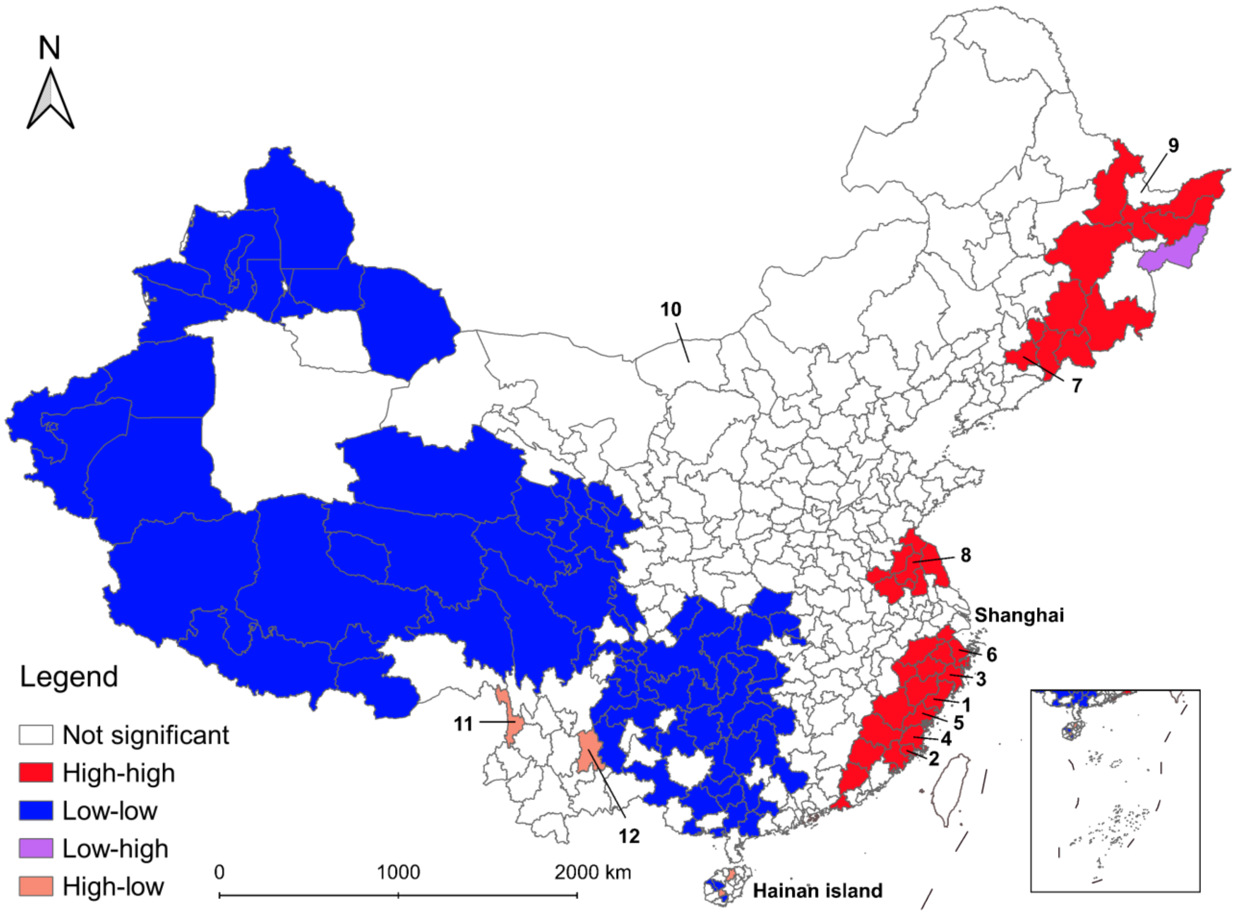


**Figure 4.** Moran's $I_i$ cluster map of the church-to-population ratio (significance level = 0.05).
Source: Authors' construct.

**Table 2.** Top ten cities in terms of the church-to-population ratio.

| City name | Province | Churches | Population 2020 | Church/population Ratio | LISA CLASS |
|---|---|---|---|---|---|
| Wenzhou | Zhejiang | 547 | 9,572,903 | 57.14/one million | High-high |
| Putian | Fujian | 136 | 3,210,714 | 42.35/one million | High-high |
| Taizhou | Zhejiang | 239 | 6,622,888 | 36.08/one million | High-high |
| Fuzhou | Fujian | 280 | 8,291,268 | 33.77/one million | High-high |
| Ningde | Fujian | 92 | 3146789 | 29.23/one million | High-high |
| Ningbo | Zhejiang | 262 | 9404283 | 27.86/one million | High-high |
| Fushun | Liaoning | 45 | 1861372 | 24.17/one million | High-high |
| Huaian | Jiangsu | 108 | 4556230 | 23.70/one million | High-high |
| Hegang | Heilongjiang | 20 | 891271 | 22.44/one million | Not Significant |
| Bayannaoer | Neimenggu | 33 | 1538715 | 21.44/one million | Not Significant |

Source: Authors' construct.

ratio lower. Hegang and Bayannaoer, which are ranked 9 and 10th, respectively, are both northern border cities, and their ratios are greater than 20, but there is no significant spatial autocorrelation with their neighbors.

There is only one low-high type city, Jixi, located in the northeast corner of China and next to a high-high type city. There are 4 high-low cities, two of which are located on Hainan Island, with 5 and 1 church each, and their neighbors have fewer or even no churches. The other two cities are Nujianglisuzu (#11), with 11 churches and a population of approximately 550,000, and Kunming (#12), the capital city of Yunnan Province, with 63 churches and a population of approximately 8.46 million. There are 83 low-low cities in the western and southwestern regions, with the highest ratio of 6.69, the lowest value of 0, and an average of 247. There are 236 cities with nonsignificant patterns, with the highest value of the ratio being 22.44, the lowest value being 0, and the average value being 6.51.

## DISCUSSION

Historical factors may be the most important factor for explaining the geographical patterns of the Christian church in China. By examining historical documents, we conclude that the “Bible Belt” of churches in southeast coastal provinces predominantly formed because Christianity was historically introduced into China from the coastal provinces, and the intensive evangelical preaching in this area by Western missionaries laid the seeds for the thriving Christian church in China today.

*The First Opium War* (1839-1842) forced the Qing Dynasty to open its doors to the outside world. In the Treaty of Nanjing, which ended the war, four treaty ports opened for foreign trade in addition to Canton: Xiamen (#5 in Figure 3), Fuzhou (#4 in Figure 4), Ningbo (#6 in Figure 4) and Shanghai. Notably, all four treaty ports are located in coastal provinces and belong to the high-high type according to the church count statistics, while Xiamen, Fuzhou and Ningbo belong to the high-high type according to the church-to-population count statistics. Furthermore, in 1844, the Treaty of Wanghia was signed between the Qing Dynasty and the United States, with one notable clause, “The right to buy land in the five treaty ports and erect churches there” (Kuo, 1933). The Treaty of Whampoa signed between the Qing Dynasty and France in 1844 was also significant. During negotiations, the French prime minister tried to secure a rescission of the prohibition of Christianity in China signed in 1724. As a result, the Qing emperor issued an edict in 1846 that legalized the practice of Christianity in China (Cady, 1954). After that, Western Protestant missionaries entered China in succession. In “The Christian Occupation of China”, Stauffer summarized the degree of Christian occupation in terms of foreign residential centers as follows: “Before 1860, the work of missionaries was restricted largely to the treaty ports. Between 1860 and 1880, evangelism was considerably extended in the neighborhood of treaty ports, and inland provinces were explored and entered as far as Sichuan province. From 1881 to 1900, the advance of Christian missions was more rapid. North China had received special attention. By 1900, foreign Protestant missionaries were residing in every province of China. Then came the Boxer disturbance and its early settlement, after which the number of residential centers in China almost doubled. By 1920, there were over 130 missionary societies and at least 7000 regularly employed Protestant missionaries in China engaged in direct evangelistic work.” This book illustrated a dotted map of “Missionary residential centers classified according to first date of opening” on page 285. It is easy to see that the dots are concentrated along the coastal provinces in southeast China. With the founding of the People’s Republic of China in 1949, the Chinese church has since entered into its own experience. The Christian faith suffered during the antireligious movement of the Chinese Cultural Revolution (1966-1976), as virtually all churches were closed (Hunter and Chan 1993). However, a spectacular resurgence of Christianity was observed after 1980, and churches were gradually refurbished and reopened (Bays, 2003; Kindopp and Hamrin, 2004). Currently, new churches are continuously being built in China (The Protestant Churches in China, 2024).

Finke and Stark (2005) noted, “First and most obviously, religious entrepreneurs are the engine of growth; without missionary efforts, new religious ideas and practices would remain unknown to potential converts”. There is reason to think that the pioneering seed planting work of the Western missionaries a century ago explains in part the flourishing Christian church in contemporary China, particularly in coastal provinces where preachers have historically been more active.

## Conclusions

As companies and organizations behind various WebGIS platforms increase their data collection efforts, the amount of church data collected on the Internet is expected to continue to increase. This research outlines a methodology for collecting church data from the WebGIS platform. This is the first attempt of its type and is expected to provide an important new source of church data in China, where data on religions are difficult to obtain. We employed kernel density estimation and spatial autocorrelation techniques to study the spatial distribution patterns of churches. Both techniques offer easy ways to visualize trends across geographic areas and can reveal "hotspots" in the spatial distribution of churches. The difference lies in that the former analyzes point data directly, while the latter entails analysis after summarizing point data into polygons. The spatial autocorrelation technique can also reveal other correlation patterns between spatial units and adjacent units, such as low-low, high-low, and low-high patterns.

Combining the above two analysis methods, we found that there is a "Bible Belt" located on the southeast coast of China, consisting of Jiangsu, Zhejiang, Fujian Provinces, and Shanghai City. This area has 35.8% of the total number of churches and 14.9% of the total population. The distribution of churches shows a decreasing trend from east to west. The number of churches in several western provinces, including Tibet, Qinghai, Gansu, Ningxia, and Xinjiang, only accounts for 1.56% of the total, while the population accounts for 4.68% of the total population.

The analysis of the number of churches and the church-to-population ratio reveals the spatial distribution characteristics of churches from different perspectives. The number of churches is a very important indicator of the development of Christianity, while the church-to-population ratio reflects the church's service capacity. Notably, the church-to-population ratio is only of reference value. A small ratio does not mean that more churches need to be built there, and a high ratio does not mean that there are enough churches there. There are many people who never go to church, especially in atheist countries, such as China. We believe that surveying the number of people attending the church would provide a clearer picture of the development of Christianity, and one way is to estimate the number of people by counting the number of seats in the church.

There are two limitations of this study. First, this paper did not consider "house churches." "House churches" are Protestant assemblies that operate independently from the state-sanctioned Three-Self Patriotic Movement and China Christian Council. These communities often congregate in homes or other informal venues, making it difficult to count. Second, Protestant churches and Catholic churches are not distinguished in this study. Although it can sometimes be judged based on the name, for example, the names of Catholic churches often include "Holy Mother" or "Mary", there is no strict method of distinction. Given the significant differences in theological doctrines between these two denominations, this classification may be meaningful in future studies.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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