RESEARCH

Spatial distribution and pedigree age of intangible cultural heritage along the Grand Canal of China

Shuying Zhang[1,2,4], Xin Zhang[3*] and Jiaming Liu[1,4]

Abstract

Intangible cultural heritage is the carrier of national memory and a historical witness. Exploring the spatial distribution and chronological evolution of intangible cultural heritage is of great significance to understand the cultural integrity and historical continuity. Taking the intangible cultural heritage along the Grand Canal as an example, this study carries out spatial deconstruction based on the extent of the spread of intangible cultural heritage and reveals the aggregation pattern through spatial autocorrelation analysis. Then, the historical process and the spatial center of gravity are shown through an evolution tree model. The influencing factors are illustrated via the methods of Geo-detector and qualitative analysis. The results are as follows: (1) The two ends of the canal exhibit obvious advantages in the number of intangible cultural heritage items; however, the existence of a spatial mismatch at the city–county level makes the southern endpoint occupy a dominant position. (2) Although there is a high–high aggregation pattern along the whole canal, 29.82% of the counties are distributed widely with low–low aggregation. (3) The spatial center of intangible cultural heritage items from different historical periods generally presents a changing path from north to south and returning north. (4) Intangible cultural heritage items are mainly distributed in areas with a prosperous culture, a high level of economic development, and strong policy and financial support from government. Changes in the natural environment, population migration, economic development, war disasters, and canal shipping have profound impacts over time. This study provides a new idea for the methodological advancement of spatial distribution of intangible cultural heritage, as well as studies on local cultural identity and regional consistency.

Keywords Intangible cultural heritage, Spread range, Spatial deconstruction, Pedigree age, Influencing factors, The Grand Canal

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Introduction

Intangible cultural heritage (hereafter referred to as ICH) is a special cultural heritage, with important historical, cultural, artistic, aesthetic and tourist values [1]. It is a treasure of civilization that relies on human beings for cultural transmission and is in the form of traditional culture [2]. In virtue of practices, performances, expressive forms, knowledge systems, and skills, as well as related tools, objects, crafts, and cultural sites [3, 4], ICH carries the cultural memory of a region or country and displays profound regional and national characteristics. In view of its prominent role in promoting cultural soft power and

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enhancing national cultural self-confidence [4], ICH is regarded as an important factor in measuring the creativity and comprehensive competitiveness of a country or nation by the international community [5]. However, along with the rapid advancement of urbanization and global economic integration, as well as the continuous emergence of new media and new technologies, cultural ecology has undergone drastic changes [6]. In this context, ICH and its living environment have likewise been strongly impacted [5]. Hence, how to understand, develop and protect ICH reasonably and effectively has aroused extensive attention from all walks of life.

The protection and inheritance of ICH are facing an urgent situation, and the academic world has responded eagerly. Previous studies primarily focus on conceptual definition [7, 8], typology and characteristics [9, 10], value assessment [11, 12], and activation and utilization [13]. Most scholars prefer to conduct studies on a certain type or a particular region of ICH from the perspectives of folklore, tourism, sociology, and management [5, 14]. Geography plays an increasingly prominent role in the study of ICH due to the consideration of the ICH's living environment. Existing studies have revealed the spatiotemporal patterns and influencing factors of ICH [14–16], providing theoretical guidance for ICH development at a localized level. In addition to natural factors such as climate, water resources and terrain, socio-economic factors such as population, transportation and policies also have a huge impact on the distribution of ICH [17, 18]. However, it is noteworthy that the contribution of these influencing factors is not invariable [19], which serves as a factual basis for different regions and different types of specific research on ICH.

Although the research areas of existing studies involve various spatial scales such as the nation, province, or county, few of them focus across regions [20]. Studies on ICH originating from different historical periods are also lacking [5]. More fundamentally, most of the spatial analysis methods adopted are based on point pattern analysis, such as kernel density estimation, nearest neighbor index, and K function. [4, 14], which is contrary to the features of the planar distribution of ICH in geographical space. In other words, it is precisely because ICH is transmitted and inherited by human that it should not be regarded as an independent point like immovable material heritage. ICH protection areas are often delimited in a certain spatial scope [9], which also confirms the characteristics of its planer distribution. Therefore, it is necessary to consider the extent of the spread of ICH in the study of spatial distribution and historical evolution. It is precisely the difference between ICH and other resources in survival form and inheritance mode that leads to the uniqueness of ICH in spatial distribution research.

The Grand Canal is the earliest, longest, and largest man-made canal in the world, representing the achievements of China's ancient water conservancy and shipping engineering technology, and it is an irreplaceable production, living, and ecological infrastructure [21]. It was successfully included in the *World Heritage List* in 2014. With a total length of over 2700 km, the Grand Canal flows through eight provincial-level administrative regions of China and bears witness to 2500 years of history of China. The Grand Canal contains rich historical and cultural relics, carrying the cultural memory of the Chinese nation. In the context of China's vigorous promotion of the construction of the Grand Canal Belt and National Cultural Park, attaching importance to the distribution characteristics and historical evolution of ICH along the canal plays a vital role in in excavating the cultural connotations, establishing a national image, and enhancing cultural soft power.

To embrace above-mentioned problems, taking the ICH along the Grand Canal as an example, this study explores the spatial distribution characteristics and historical evolution of ICH based on knowledge concerning the extent of the spread of ICH. Precisely, the purpose of this study is threefold: (1) to analyze spatial deconstruction and aggregation pattern based on the extent of the spread of ICH; (2) to reveal the historical process and space center of gravity of the pedigree age of ICH; and (3) to understand the influencing factors of ICH distribution in modern society and historical periods. This study provides new thinking for the spatial distribution and historical process of ICH, and a set of guidelines to optimize the relationship between ICH inheritance and regional cultural protection.

Materials and methods
Study areas
The Grand Canal is an important cultural heritage in China and even in the world, with outstanding functions and values of culture, shipping, economy, ecology, tourism, science and education [21]. It was first built in the Spring and Autumn Period and has witnessed over 2500 years of Chinese history. With a total length of 3200 km (including 1011 km of heritage river), the Grand Canal is the earliest, largest, and longest canal in the world. It has been placed as *World Heritage List* in 2014 and the most influential waterway in the *International List of Canal Monuments* by the International Committee for the Protection of Industrial Heritage. Meantime, the Grand Canal is the only living cultural heritage of the world canal, which has traditionally been in a state of multi-functional use [23], and is an irreplaceable production, living and ecological infrastructure.
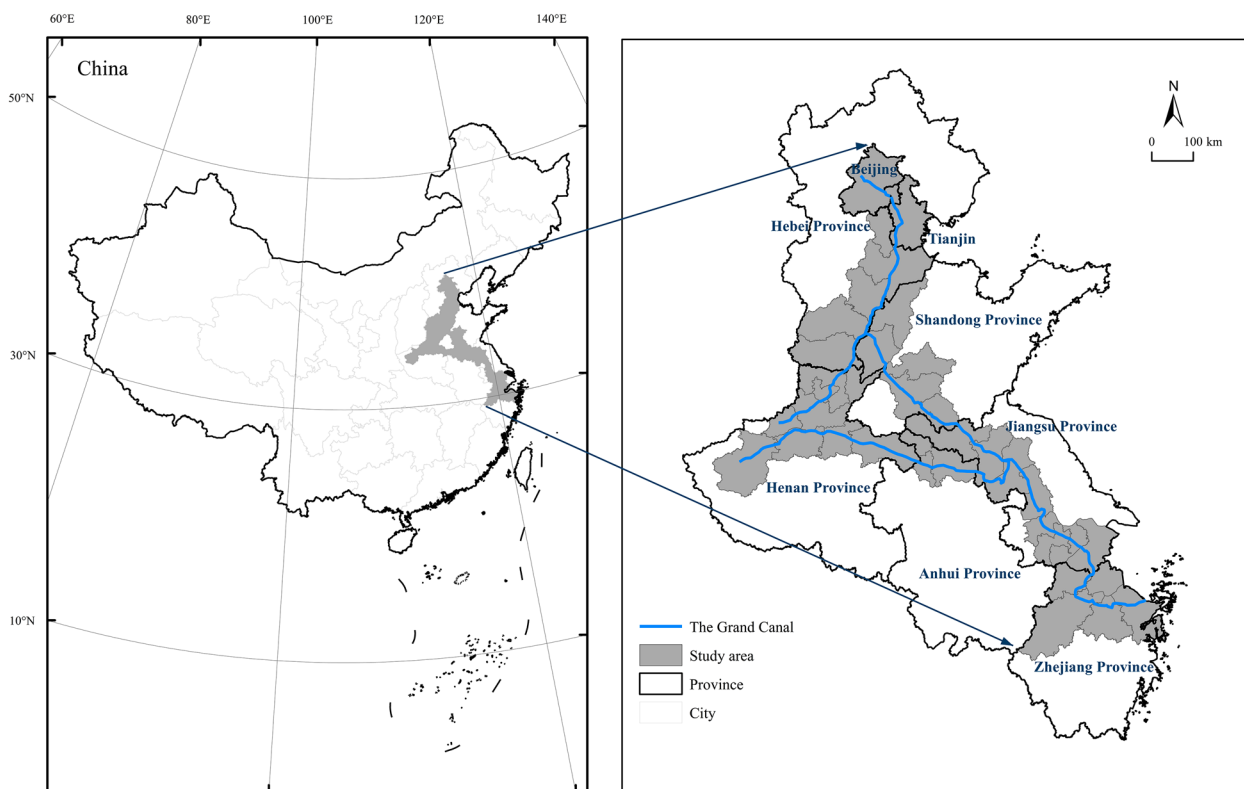
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Fig. 1 Research region

The Grand Canal runs through Beijing, Tianjin, Hebei, Shandong, Jiangsu, Zhejiang, Henan, Anhui 8 provinces (municipalities directly under the Central government), and 36 cities at the prefecture level and above (Fig. 1). It links five rivers of the Yellow River, Haihe River, Huaihe River, Yangtze River and Qiantang River, and connects the principal historical and cultural regions of China, such as Yanzhao culture, Qilu culture, Huaihe culture and Wuyue culture. It represents one of the regions with the most concentrated distribution and richest content of China's cultural heritage. The area along the canal accommodates nearly 40% of the population with less than 10% of the country's land area. In 2020, the regional GDP reached 42 trillion yuan, accounting for 41.39% of national total [22], which is the guarantee for China's future high-quality economic development.

Data collection

ICH data

For the effective protection and inheritance of diverse ICH items, China has established a hierarchical system of national, provincial, municipal, and country-level ICH. The higher the level of ICH, the greater its historical, literary, artistic, and scientific values. Among these, the evaluation of national-level ICH has strict criteria,

requiring it to be an outstanding expression of folk traditional culture or cultural space; or to possess typical significance within intangible cultural heritage; or to hold significant value in fields such as history, art, ethnology, folklore studies, sociology, anthropology, linguistics, and literature. The list of representative items of national intangible cultural heritage released by The State Council of China has a total of 3610 national ICH items in 5 batches and 10 categories nationwide. As currently the only available, reliable and officially published source of ICH data [5], the list contains outstanding traditional Chinese culture with important historical, artistic, literary and scientific values and distinctive regional characteristics. Compared with other levels of ICH items, these national ICH items are more representative and typical, and can reflect the current situation of regional ICH items to a greater extent. Therefore, considering the differences in the levels of the ICH items and their representativeness, we have chosen to focus our research on national-level ICH items. According to the application regions of ICH items, we ultimately obtained 630 ICH items (including expanded sites) of 36 cities along the Grand Canal by using the method of one-by one searching from the list of representative items of national intangible cultural heritage posted on the China ICH network

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Table 1 Numbers-types of intangible cultural heritage along the Grand Canal

Province (municipality directly under the central government)	Traditional handicraft	Traditional drama	Folk custom	Traditional music	Traditional art	Traditional dance	Folk literature	Quyi	Traditional medicine	Traditional sports, recreation, and acrobatics	Quantity/ percentage (%)
Beijing	41	5	7	4	18	9	8	7	9	12	120/19.05
Tianjin	8	4	2	5	3	1	1	7	8	8	47/7.46
Hebei	11	20	7	12	9	5	2	7	0	20	93/14.76
Shandong	7	6	3	6	6	3	6	3	3	6	49/7.78
Henan	4	19	7	7	8	8	5	2	3	7	70/11.11
Anhui	1	7	0	2	0	0	0	1	0	1	12/1.90
Jiangsu	24	14	8	16	24	5	7	7	3	0	108/17.14
Zhejiang	30	12	19	7	11	6	15	18	7	6	131/20.79
Total	126	87	53	59	79	37	44	52	33	60	630/100

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(http://www.ihchina.cn). According to the national classification standards, they were divided into ten types by Chinese standards (Table 1).

Additionally, considering the immaterial nature and region-specific transmission characteristics of these items, representing their spatial location solely through points or coordinates has certain limitations. Therefore, this study analyzes the spatial distribution of national-level ICH items based on their spread scope. Specifically, we categorize statistical areas into three levels: province, municipality, and county/district according to the applying units or regions of ICH items, with county/district being the smallest statistical unit. For instance, "The Legend of the White Snake" is applied by Hangzhou, and each county in Hangzhou will add a project; Similarly, "Lion Dance" is declared by Beijing, and the number of ICH projects within the jurisdiction of Beijing will be increased by 1. By adopting this approach, we obtain a comprehensive number of intangible cultural heritages for each county and city which can be used to create a map illustrating their spatial distribution.

Furthermore, we obtained the age of origin of these ICH items by consulting publicly released online information, books, and documents. However, there are 24 items whose origin periods are not verifiable and have been excluded from the studies about pedigree age.

Influencing factors data

Based on previous studies, 15 factors referring to natural geography, human and society, and government support were selected as influencing factors (Table 2).

Natural geography is the basis for ICH generation and development. The areas with suitable climate and ecological environment are conducive to the origin and spread of civilization [23]. This study selects six indexes X1 Channel length of the canal, X2 Water system, X3 Altitude, X4 Precipitation, X5 Temperature, and X6 Distance to explore the influences of the natural environment on the spatial distribution of ICH.

Human and society create a favorable environment for ICH inheritance [24]. Developed economy provides material conditions for ICH, convenient transportation is conducive to the spread and diffusion of ICH, the prosperity of population and culture facilitates the continuation and inheritance of ICH, and the tourism industry further expands the influence of ICH. In this study, seven indexes, X7 Economic development level, X8 Urbanization level, X9 Traffic condition, X10 Population, X11 Culture, X12 Ethnicity, X13 Tourism industry, were considered as influencing factors of ICH spatial distribution.

The support from the government is undoubtedly a strong guarantee for the protection of ICH [2]. This study examines the influence of two indexes, namely X14

Policy support and X15 Financial support, on the spatial distribution on ICH.

Vector data such as administrative divisions, canal and water system data, and topographic data are derived from standard map services, and the Resources and Environment Data Cloud of Chinese Academy of Sciences (https://www.resdc.cn). Relevant climatic data were obtained from National Meteorological Science Data Center (https://data.cma.cn). Humanities data, economic data, culture data, policy information, and financial data are derived from the statistical yearbooks, government work reports, and official websites of various provinces and municipalities.

Data analysis

Spatial statistical method of ICH based on the extent of spreading

ICH is attached to the entity, but it has intangible characteristics. As a kind of ideology and abstract cultural thinking that can be inherited, intangible cultural heritage spreads and distributes in geographical space, showing facial characteristics [5]. Therefore, it is confined to express the spatial distribution of ICH by the point position. This study analyzes the spatial deconstruction of ICH along the Grand Canal based on the distribution range. The distribution range can be divided into province, city and county according to the application regions of the list of representative items of national intangible cultural heritage. Based on the county-level administrative unit, the number of ICH distributed in each county (district) and its local city or province is counted and accumulated, so as to obtain the actual number of ICH items based on the distribution scope. This statistical method based on the distribution scope of ICH can reflect the centralized distribution of ICH, and also indirectly illustrate which regions have wider distribution scope, stronger consistency and higher local identity.

Spatial autocorrelation analysis

Spatial autocorrelation aims at analyze the aggregation and dispersion characteristics and anomalies of statistical data in geographical space, which is an important concept in spatial statistics [25]. Based on global and local perspectives, this study uses Moran's *I* index, *Getis's G*, and *Getis-Ord Gi** to explore the spatial correlation and spatial heterogeneity characteristics of ICH.

Moran's *I* can represent the spatial correlation characteristics of the whole elements with a value between − 1 and 1. If Moran's *I* is significantly positive, there are significant clusters of ICH. Conversely, when Moran's *I* is significantly negative, there is a spatial difference between the sample and the surrounding area [26]. The smaller the negative value, the greater the overall spatial difference is; the

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Table 2 Influencing factors and definitions

Dimension	Factor variable		Index definition
Natural geography	X1	Channel length of the canal	Channel length (km)
	X2	Water system	Standard-reaching rate of water quality at and above Class III (%)
	X3	Altitude	Mean altitude (m)
	X4	Precipitation	Mean annual precipitation (mm)
	X5	Temperature	Mean annual temperature (℃)
	X6	Distance	Distance to the grand canal (m)
Human and society	X7	Economic development level	GDP (100 million yuan)
	X8	Urbanization level	Urbanization rate (%)
	X9	Traffic condition	Per capita road area (km^2)
	X10	Population	Permanent population size (thousands of people)
	X11	Culture	Culture industry value-added (100 million yuan)
	X12	Ethnicity	The proportion of the population of ethnic minorities (%)
	X13	Tourism industry	Gross tourism income (million yuan)
Government support	X14	Policy support	ICH-related regulations implementation rules, opinions, and measures
	X15	Financial support	Expenditure for culture and media (thousands of yuan)

greater the positive value, the fewer clusters in the overall space. Moran's $I=0$ proves to be spatially unrelated units. Basically, global spatial autocorrelation was used to determine whether aggregation features existed for ICH along the canal; while the specific location of the spatial pattern was explored by local indicators of spatial association (LISA). In addition, this study further evaluated the significance of Moran's I index by calculating Z-score and P-value. Global and local Moran's I were measured and defined, respectively, as:

$$I = \frac{n}{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}} \times \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \quad (1)$$

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

where n is equal to the total number of features, x_i is the an attribute for feature i, $\bar{x}$ the mean of all the corresponding attribute, and w_{ij} is the spatial weight between feature i and j.

In order to reflect the spatial heterogeneity of ICH, the *Getis's G* and *Getis-Ord Gi** model was used to verify whether there were statistically significant high or low values. These values in local autocorrelation analysis can be used to analyze hot-spot and cold-spot areas. For a space *i*, the model in global and local autocorrelation analysis are expressed as follows:

$$G_i = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} x_i x_j}{\sum_{i=1}^{n} \sum_{j \neq i}^{n} x_i x_j} \quad (3)$$

$$G_i^* = \frac{\sum_{i=1}^{n} w_{ij} x_j}{\sum_{j \neq i}^{n} w_j} \quad (4)$$

where n is equal to the total number of features; x_i is the attribute value for feature i; x_j the attribute value for feature j; w_{ij} is the spatial weight matrix between counties i and j.

Geodetector

Geodetector is an effective tool for exploring the causes and mechanisms of spatial patterns of geographical elements [27]. In this study, the explanatory power and interaction of different influencing factors on ICH spatial distribution were discussed via factor detector and interaction detector. The factor detector is utilized to detect whether a geographical factor is the cause of the difference in spatial distribution [27]. The power of the determinant (q_X) is used to reflect the spatial correlation by using the following equation:

$$q_X = 1 - \frac{\sum_{h-1}^{L} N_h \sigma_h^2}{N\sigma^2} \quad (5)$$

where N is the number of samples in the study area, N_h is the number of samples in zone (category) h of factor X, σ^2 is the total variance of Y within zone (category) h of factor X, and L is the number of zones (categories) of factor X. $\sum_{h-1}^{L} N_h \sigma_{h^2}$ is the within-sum of variances, and $N\sigma^2$ is the total sum of variances. The greater the value of q_X, the more factor X explains Y, and vice versa.

In addition, the interaction detector is designed to verify the interaction between factors [27], and its purpose is to evaluate whether the combination of factors increases
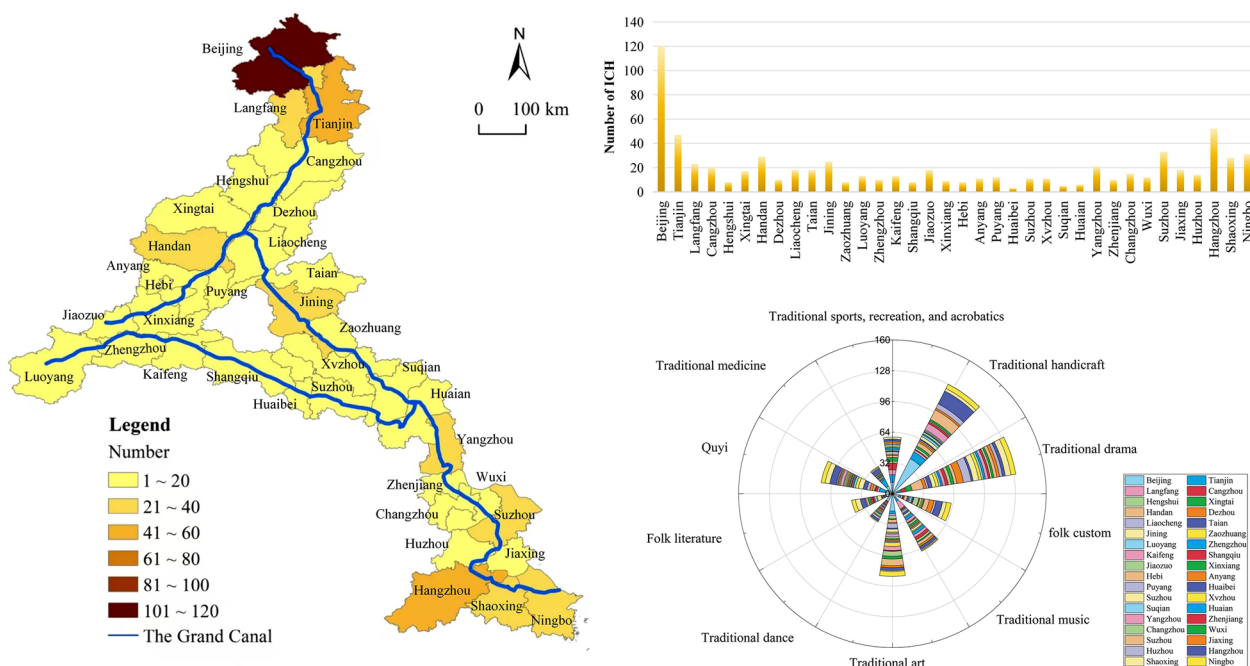
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Fig. 2 Distribution characteristics of ICH at the city level

or decreases the explanatory power of the dependent variable.

The method of Nature Breaks in ArcGIS was adopted to divide each influencing factor into six grades based on the distribution law of data. Next, this study regarded the number of ICH in each city as dependent variables and influencing factors as independent variables to conduct Geodetector analysis. Furthermore, due to the complex measurement standards of historical and cultural factors, it is impossible to select appropriate indexes and values to analyze the reasons for the changes of the spatial center in the historical evolution of ICH. Therefore, this study adopts qualitative analysis method to analyze the influence of historical and cultural factors on the spatial pattern of ICH.

Results
Spatial distribution characteristics
City-level distribution
The distribution pattern of ICH along the Grand Canal at the city level is basically higher in the north than in the south and higher at both ends than in the middle (Fig. 2). Beijing, as the northern endpoint, occupies the leading position with a very large numerical advantage (120 items). While the central cities, excluding Handan and Jining, are bad performers, the cities of Tianjin and Langfang in the northern region, as well as Zhejiang Province and Suzhou Province in the southern region perform well. In terms of categories, national ICH has the

structural characteristics of dense distribution of traditional drama and traditional handicraft as well as scarcity of traditional medicine (Fig. 2). Specifically, traditional drama and traditional handicraft accounts for the largest number with 33.08% of the total, while traditional medicine account for only 4.62%.

County-level distribution
To further delicately explore the spatial distribution characteristics of ICH, this study takes the smallest regional unit in the national intangible heritage list, as the basic unit to deconstruct the spatial pattern of national ICH based on the extent of spreading. Although there are still obvious advantages in the middle and both ends of the canal in terms of the quantity of ICH, it was clear that the southern region of the canal, especially the counties in Suzhou and Hangzhou, takes the leading position instead of Beijing (Fig. 3). Various types of ICH mainly gather in Beijing–Tianjin in the northern region, and Yangzhou-Suzhou-Hangzhou in the southern region with high economic development level (Fig. 4). The middle and lower reaches of the Yellow River with profound cultural resources, such as Zhengzhou and Dezhou, are also important gathering areas of ICH. Compared with the traditional drama (Fig. 4b), which is almost spread along the canal, the rare ICH represented by traditional dance (Fig. 4f) and traditional medicine (Fig. 4i) is scattered. In addition, the performance of certain types of ICH in some regions is also worthy of attention. For example, the
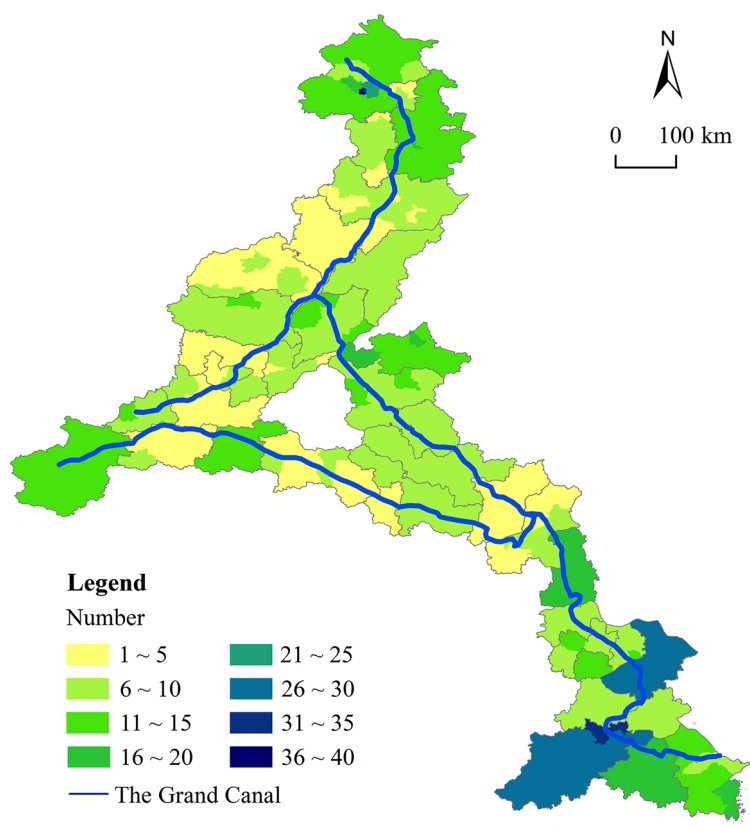
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Fig. 3 Distribution characteristics of ICH at the county level

area under the jurisdiction of Cangzhou has the highest number of traditional sports, recreation, and acrobatics (Fig. 4J), which confirms this type of ICH has been recognized within the city.

However, what is interesting is that the distribution at the county level is not consistent with the city level, and there is even a mismatch. This shows that a large number of ICH distributed in county-level units still cannot break through the regional restrictions to be popularized in the city, province or even the whole country. The most typical example is Beijing, which has the largest number of ICH items, but it is mainly distributed in a scattered way in counties, which results in the reduction of the number of ICH in each county and shows the characteristics of spatial dispersion. On the contrary, although Suzhou and Hangzhou do not have the largest number of ICH items, ICH represented by traditional handicraft, art, and quyi is widely distributed throughout the city, and the number of ICH in county-level units under the jurisdiction of the two cities exceeds that of Beijing.

Spatial pattern analysis

As shown in Table 3, the Global Moran's *I* and *Getis's G* of ICH is 0.852400 and 0.000001, respectively. The results

indicate there is a significant positive spatial autocorrelation of the ICH along the Grand Canal, showing the molds of high–high gather.

This study further explores the precise locations of the agglomeration effect via the methods of Anselin local Moran's *I* and *Getis-Ord Gi**. Table 4 and Fig. 5(a) show the number of counties with negative spatial autocorrelation is greater than with positive spatial autocorrelation. The former is distributed in the middle of the canal, and the latter is distributed at both ends. This also confirms that there exists indeed spatial heterogeneity of ICH along the Grand Canal. Even though there is a high–high aggregation pattern along the whole canal, there are still many partial areas distributed widely with low–low aggregation. In addition, high–low gather and low–high gather are respectively scattered in Hebei and Henan provinces in the middle of the canal, and Jiangsu and Zhejiang provinces in the south of the canal. Figure 5(b) further clarifies the degree of spatial aggregation of high or low values of ICH, and the results are consistent with Fig. 5(a). At the 99% confidence level, the two ends of the canal are still important gathering areas of ICH, but Suzhou, Jiaxing, and Hangzhou at the southern endpoint are obviously more competitive than Beijing at

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Fig. 4 Spatial distribution of ICH by type

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Table 3 Global Moran's *I*, *Getis's G* and their statistic test of ICH

Global Moran's *I*		Getis's G	
Moran's I	0.852400	General Index	0.000001
Z score	23.403024	Z score	8.274004
p value	0.000000	p value	0.000000
Schematic diagram		Schematic diagram	

Table 4 Significant clustering of ICH

Type	Quantity/percentage (%)	Examples of main clustering counties (cities)
High–high cluster	42/12.28	Chaoyang, Changping, and Daxing districts (Beijing); Beichen, Dongli, and Jinnan districts (Tianjin); Gusu, Huqiu, and Wuzhong districts (Suzhou); Xihu, Gongshu, and Yuhang districts (Hangzhou)
High–low outlier	2/0.58	Yongnian District (Handan); Wuzhi District (Jiaozuo)
Low–high outlier	7/2.05	Tongxiang, and Haining cities (Jiaxing); Liangxi, and Xishan districts (Wuxi)
Low–low cluster	102/29.82	Wuqiang, and Wuyi Counties (Hengshui); Zhongyuan, Erqi, and Jinshui districts (Zhengzhou); Sucheng, and Suyu districts (Suqian)

the northern endpoint, indicating that the popularity of ICH and local identity are stronger. Meantime, Hebei and Henan provinces are still the main areas of cold spots, and concentrated in the middle of the canal on the right bank.

Pedigree age

Chronological distribution

The historical period of China is divided into 9 stages: Pre-Qin Period (Xia, Shang, and Zhou dynasties), Qin and Han Dynasties, the period from Three Kingdoms to the Southern and Northern Dynasties (referred to as Wei and Jin Dynasties), Sui and Tang Dynasties (including Five Dynasties and Ten Countries), Song Dynasty (before the Ming Dynasty), Yuan Dynasty, Ming Dynasty, Qing Dynasty, from 1912 to present, and the total number of national ICH items from each historical period is counted respectively.

In general, the number of ICH originating from Qing and Ming dynasties is the largest, while that originating from the Yuan Dynasty is the least (Fig. 6). Most of the ICH in pre-Qin period is related to legends, such as Kylin legend, and unfounded legend. With the rapid development of Taoism and Buddhism in the Wei, Jin and Southern and Northern Dynasties, ICH items with religious culture and stone carvings as themes were greatly developed [28]. Wood carving art and ceramic firing skills developed vigorously in Sui and Tang Dynasties, while weaving and textile skills mostly originated from the Song and Yuan Dynasties. During the Ming and Qing Dynasties, folk activities continued to flourish, but traditional handicrafts and traditional dramas were still the most important types, accounting for 34.48% of the total.

Changes in spatial distribution

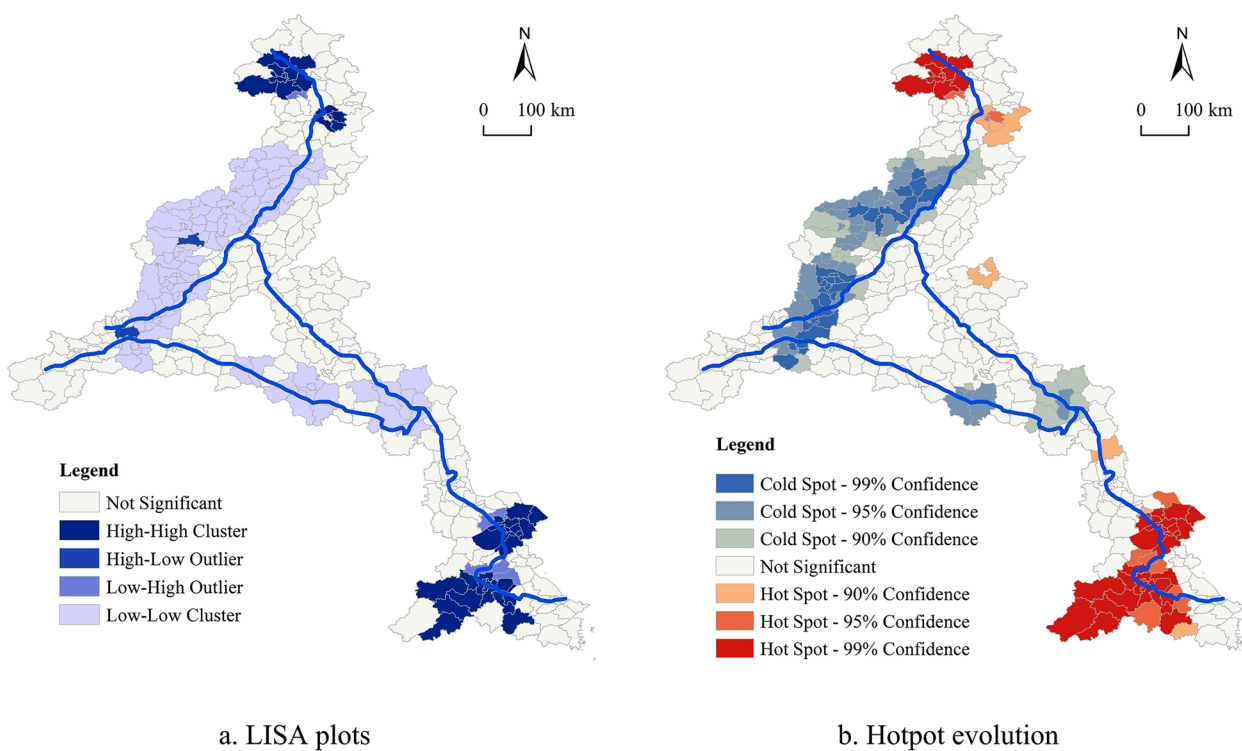Figure 7 shows the evolution of ICH in different provinces along the Grand Canal from different historical

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a. LISA plots

b. Hotpot evolution

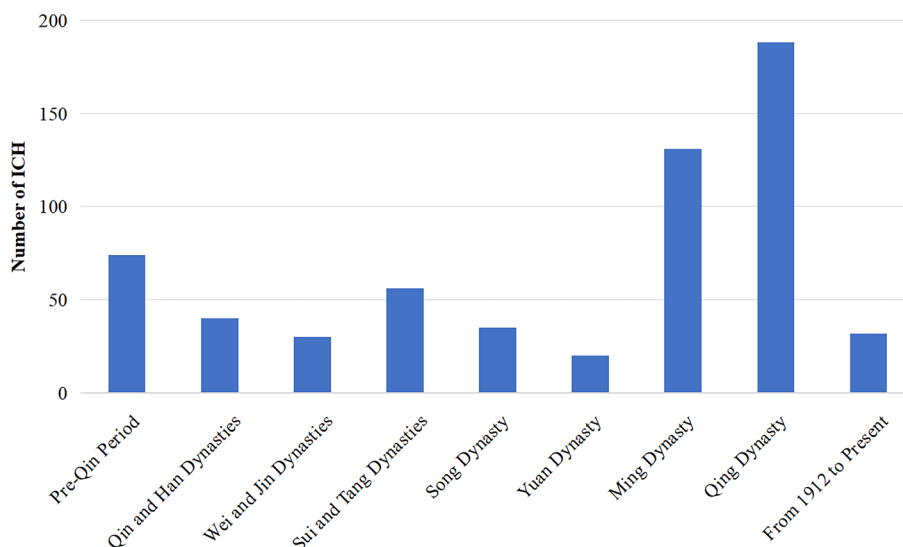**Fig. 5** Spatial pattern of ICH along the Grand Canal

Fig. 6 Chronological distribution of ICH

periods, and Fig. 8 reveals the change process of the spatial center from north to south and then returning north. The ICH items originating from the pre-Qin period are mainly distributed in the lower reaches of the Yellow River Basin, as well as in Jiangsu and Zhejiang provinces

with its types of traditional art, music, handicraft, and folk literature. During the Qin and Han Dynasties, Luoyang became a pivotal node along the Grand Canal, facilitating enhanced economic exchanges between the regions from east to west along the canal. This laid a solid
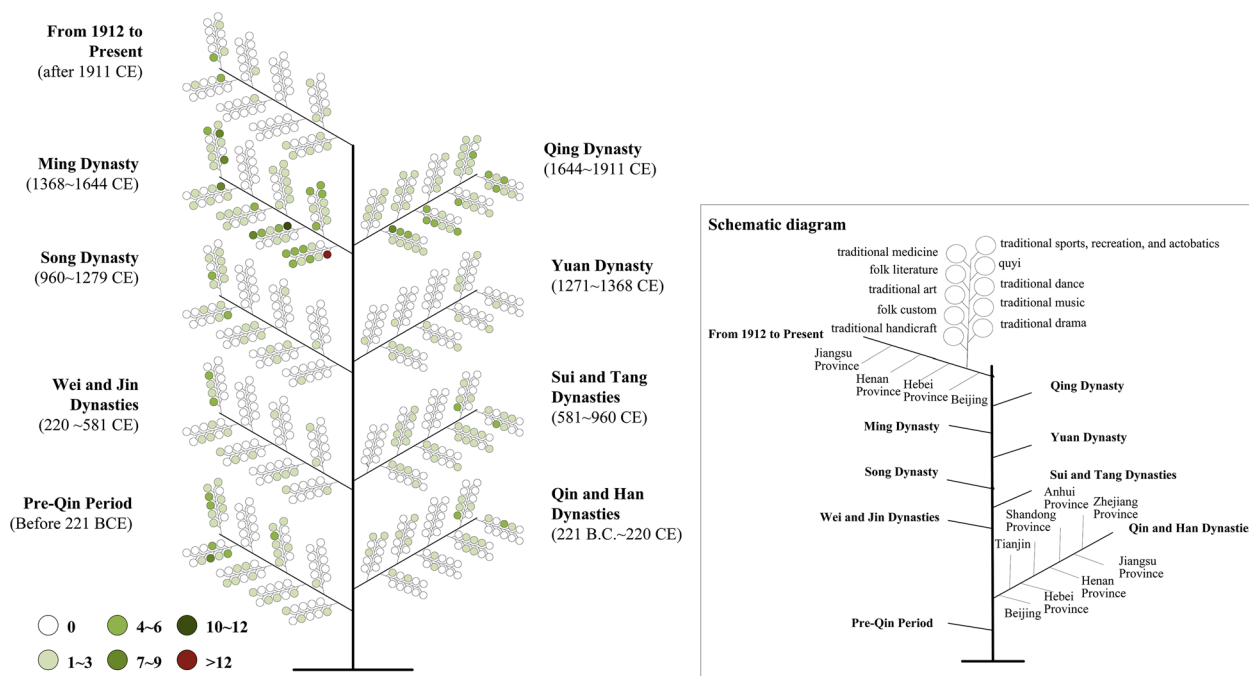
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Fig. 7 Evolution tree model of ICH along the Grand Canal

material and cultural foundation for the rise of ICH in Henan Province [5]. However, there were limited newly created ICH items during this period; only traditional arts from Jiangsu Province and traditional handicrafts from Zhejiang Province garnered attention. Due to frequent wars and an unstable social environment during the period from the Three Kingdoms to the Southern and Northern Dynasties, a large number of refugees from North China moved to South China [29]. The spatial center of ICH from this period shifted from the lower reaches of the Yellow River to the lower reaches of the Yangtze River, especially in Zhejiang and Jiangsu provinces. Traditional handicraft and folk literature remained the predominant types during this time. In the Sui and Tang Dynasties, the types of ICH were increasingly rich, and various forms of culture were inherited and developed. Quyi and traditional drama made their first appearances in Hebei, Shandong, and Henan provinces. The Song Dynasty witnessed another large-scale population migration to the south in Chinese history [29]. Under this background, East China, with Zhejiang and Jiangsu provinces as the center, once again became the main distribution area of ICH with further improvement in folk customs and traditional handicrafts. In addition, due to the decline of Luoyang's political status, the ICH originating from this period declined, which became a turning point for ICH in Luoyang. During the Yuan Dynasty, the political center of the country moved northward, while

the northern culture and ICH achieved new development. This situation continued until the Ming Dynasty when Beijing–Tianjin–Hebei became the core gathering area of ICH. In particular, Beijing's traditional handicrafts developed rapidly, becoming the largest ICH type among all provinces in various dynasties (over 12). Hebei's traditional drama, traditional sports, recreation, and acrobatics are also representative of that time period. In the Qing Dynasty, the number of ICH items along the canal further increased with more types. It is worth mentioning that ICH appeared for the first time in Anhui Province during this period. After 1912, although new ICH items were limited and no innovations were introduced in folk literature, folk customs, traditional dance, and traditional music, the dominant position of both ends of the canal were maintained.

The historical trends of different types of ICH vary among the cities along the Grand Canal (Table 5). Traditional handicrafts predominantly originated in Beijing, Suzhou (Jiangsu), Hangzhou, and Yangzhou, with 23 items created in Beijing during the Qing Dynasty. Luoyang in the Sui and Tang Dynasties was the sole city in the middle of the canal to invent traditional handicrafts, while Handan and Tianjin in the north made breakthroughs in the Ming and Qing dynasties, respectively. Traditional dramas can be traced back to Anyang in the Sui and Tang dynasties, gaining popularity in Handan, Xingtai, Jiaozuo, Cangzhou, and Jining during the Ming and Qing
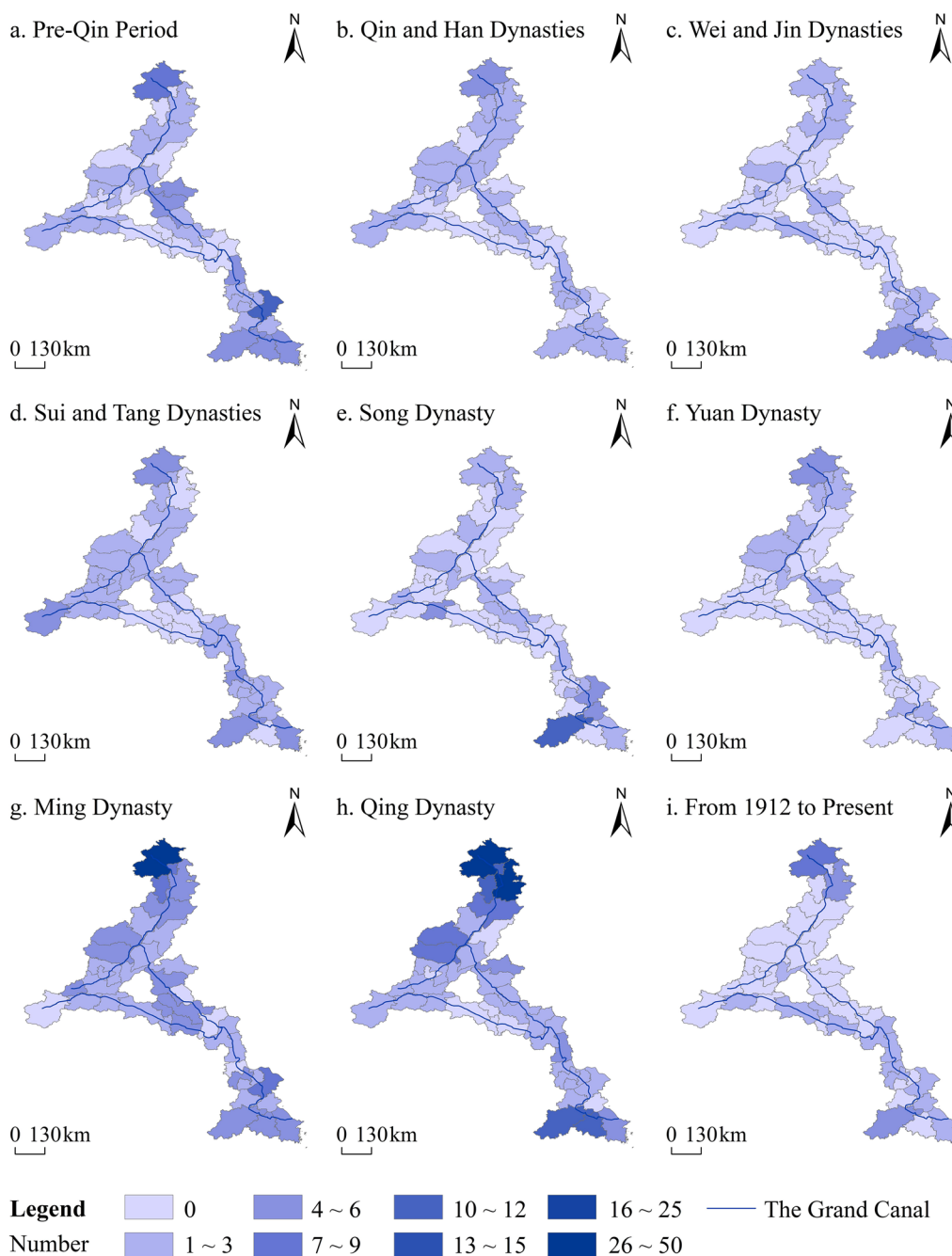
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Fig. 8 Spatial distribution of ICH originating from different historical periods

dynasties. Shaoxing located south of the canal was also a place of major concentration. Folk customs were mainly found in Suzhou (Jiangsu), Hangzhou, and Ningbo until Beijing developed its unique folk culture during the Ming Dynasty. Traditional music originated in Tai'an during the pre-Qin period and was primarily disseminated in Langfang and Tianjin during the Ming and Qing dynasties. Traditional art witnessed a continuous transfer

process from Suzhou (Jiangsu), Ningbo, and Yangzhou in the south of the canal to Beijing, Liaocheng, Kaifeng, and Cangzhou in the north of the canal. The regional concentration of traditional dance was limited, with Beijing being the main center during the Ming and Qing Dynasties, while in other periods, it was scattered in Jiaouzo, Changzhou, and Hangzhou. Quyi originated in Shaoxing during the Ming Dynasty and gained popularity in various

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Table 5 Historical trends of different types of ICH in cities along the Grand Canal

Historical period	Traditional handicraft	Traditional drama	Folk custom	Traditional music	Traditional art	Traditional dance	Folk literature	Quyi	Traditional medicine	Traditional sports, recreation, and acrobatics
Pre-Qin Period	Beijing (3); Suzhou (Jiangsu) (3); Yangzhou (2); Hangzhou (2)	–	Suzhou (Jiangsu) (2)	Tai'an (2)	Suzhou (Jiangsu) (3); Ningbo (2)	–	Jining (3); Ningbo (2)	–	–	Beijing (3); Cangzhou (2)
Qin and Han Dynasties	Beijing (2); Ningbo (2)	–	–	–	Beijing (2); Yangzhou (2); Liaocheng (2)	–	–	–	–	–
Wei and Jin Dynasties	Huzhou (2)	–	–	–	–	–	Hangzhou (3); Shaoxing (2)	–	–	–
Sui and Tang Dynasties	Hangzhou (4); Luoyang (2); Huzhou (2)	Anyang (2)	–	Zhenjiang (2)	Beijing (2)	Jiaozuo (2)	–	–	–	–
Song Dynasty	Suzhou (Jiangsu) (2); Wuxi (2); Hangzhou (2)	–	Hangzhou (3); Suzhou (Jiangsu) (2); Ningbo (2)	–	Kaifeng (2)	Hangzhou (2)	–	–	–	–
Yuan Dynasty	Beijing (2); Handan (2)	–	–	–	–	–	–	–	–	–
Ming Dynasty	Beijing (8); Suzhou (Jiangsu) (5); Langfang (2)	Handan (2); Xingtai (2); Jiaozuo (2)	Beijing (4)	Beijing (3); Langfang (3); Tianjin (2); Suzhou (Anhui) (2); Hangzhou (2)	Beijing (6); Langfang (2); Liaocheng (2)	Beijing (3); Changzhou (2)	–	Shaoxing (2)	–	Cangzhou (3); Xingtai (2); Jiaozuo (2)
Qing Dynasty	Beijing (23); Tianjin (5); Yangzhou (2); Hangzhou (2)	Handan (5); Shaoxing (4); Xingtai (3); Tianjin (2); Cangzhou (2); Anyang (2); Huai'an (2); Jining (2)	–	Langfang (5); Tianjin (3)	Beijing (5); Changzhou (2)	Beijing (4); Cangzhou (2)	–	Tianjin (6); Beijing (5); Hangzhou (4); Shaoxing (3); Cangzhou (2); Langfang (2); Yangzhou (2); Ningbo (2)	Beijing (6); Tianjin (4); Hangzhou (3)	Tianjin (6); Beijing (4); Langfang (3); Handan (2); Xingtai (2); Shaoxing (2)
From 1912 to Present	Hangzhou (3)	Beijing (2); Tianjin (2); Suzhou (Anhui) (2)	–	–	Beijing (2)	–	–	–	Beijing (2); Tianjin (2)	–

The number of ICH is indicated in parentheses

Only cities whose number of ICH is greater than or equal to 2 are shown

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regions including Tianjin, Beijing, Hangzhou, Cangzhou, and Yangzhou during the Qing Dynasty. Similarly, traditional medicine did not gain prominence in Beijing, Tianjin, and Hangzhou until after the Qing Dynasty. Traditional sports, recreation, and acrobatics experienced a long period of decline after the pre-Qin period but regained popularity during the Ming and Qing dynasties in cities like Cangzhou, Tianjin, Beijing, and Xingtai.

Influencing factors

Geographical environment characteristics of the densely distributed area of ICH in modern society

The influencing factors of ICH were identified as shown in Table 6. Culture(X11), economic development level (X7), and policy and financial support (X14, X15) have the most profound impact on the distribution of ICH along the Grand Canal. The explanatory power of government support, and human and society are stronger than those of natural geography. Regarding the natural environment, ICH items are mostly concentrated in warm and humid areas, and the temperature (X5) has the greatest impact with a *q* value of 0.398. The impact of the precipitation (X4) and distance (X6) factors is not prominent, with *q* value of 0.102 and 0.121. The *q* values of channel length (X1), water system (X2), and altitude (X3) are the lowest among all factors, below 0.1, indicating that these factors only slightly influence the ICH distribution. Furthermore, the influence of the factors belonging to human and society on the ICH distribution is quite different. Most notably, the value of culture (X11) and economic development level (X7) reached 0.861 and 0.820, which ranked the top two among all

factors. In addition, the tourism industry (X13), population (X10), and ethnicity (X12) also play important roles, while urbanization (X8) and transportation (X9) affects ICH distribution slightly with *q* values below 0.3. What attracts attention is that the support from the government, regardless of policy (X14) or funding (X15), is highly associated with the distribution of ICH along the Grand Canal, with high *q* values above 0.75.

The interaction detection results show that the interaction between natural geography, human and society, and government support mainly presents nonlinear synergistic and double synergistic effects, and the interaction between any two factors is greater than the influence degree of single factor, indicating that the factors affecting the spatial distribution of ICH may be the synergistic effect of natural geography, human and society, and government (Fig. 9). Most two-factor interactions have explanatory power of more than 60%. In particular, the interaction *q*-statistic values of government support, regardless of policy or funding, and any other factor, the explanatory strength exceeds 80%. Low *q*-statistic values appear in the internal interaction of natural geography factors (X1 ~ X4, X6) as well as the interaction with urbanization level (X8), traffic condition (X9), and population (X10), and most factor explanatory power less than 40%.

Factors influencing the changes of ICH spatial distribution during historical periods

Natural factors

Natural factors are the environmental basis for the survival and development of our ancestors, whose influence on the overall distribution characteristics of ICH was

Table 6 Results of factor detector

Dimension	Factor variable		*q* statistic	p value
Natural geography	X1	Channel length of the canal	0.092	0.814
	X2	Water system	0.058	0.805
	X3	Altitude	0.053	0.915
	X4	Precipitation	0.102	0.666
	X5	Temperature	0.398*	0.043
	X6	Distance	0.121	0.648
Human and society	X7	Economic development level	0.820**	0.000
	X8	Urbanization level	0.248	0.116
	X9	Traffic condition	0.189*	0.037
	X10	Population	0.449*	0.015
	X11	Culture	0.861**	0.000
	X12	Ethnicity	0.379	0.060
	X13	Tourism industry	0.531	0.054
Government support	X14	Policy support	0.752**	0.007
	X15	Financial support	0.775**	0.003

* Significance level of P ≤ 0.05

**Significance level of P ≤ 0.01

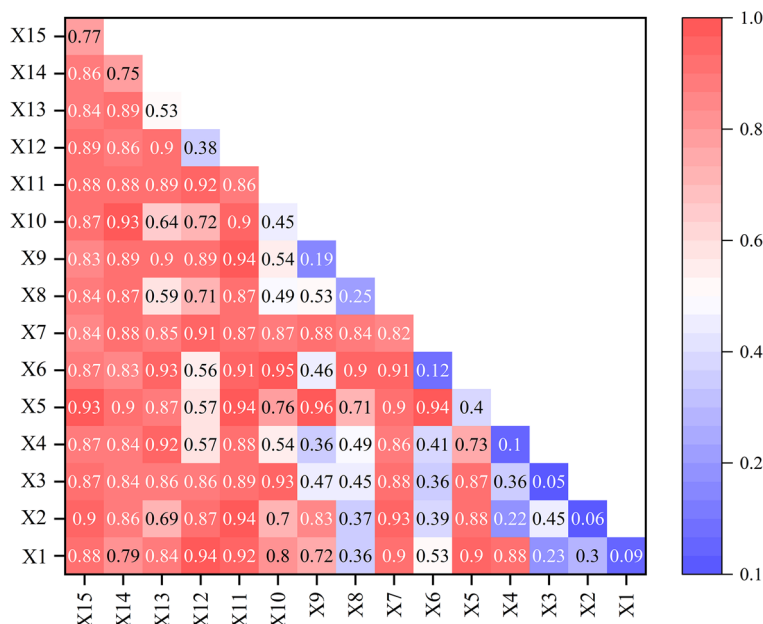Zhang *et al. Heritage Science* (2024) 12:246

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Fig. 9 Interaction results of the influencing factors

fundamental. The general trend of China's climate over the past two thousand years has been gradual cooling [30]. In the early period, the Yellow River Basin was a rich land with suitable climate, while the northern part of the Grand Canal was the center of population distribution with more prosperous cultural development and a higher civilization level [31]. Along with the climate cooling, the climate in the southern part of the Grand Canal became more hospitable to human habitation. In addition, frequent wars led to a large number of people moving south, and the distribution center of ICH also shifted from the north to the south of the Grand Canal.

Human factors

(1) *Population migration* There have been several large-scale migrations in Chinese history, which have caused changes in the distribution of ICH. In terms of the Grand Canal, Shandong and Jiangsu provinces, which are located in the middle and lower reaches of the Yellow River and the lower reaches of the Huai River, respectively, were population agglomeration areas in the pre-Qin period and also retained a large number of CH items. After the Wei and Jin Dynasties, the large-scale migration of population to the south of China increased the labor force and brought advanced production technology. According to modern researchers' estimation, about 5 million people migrated southwards

during the "Jingkang Southward Migration" at the end of the Northern Song Dynasty, with Hangzhou serving as the central region for northern immigrants [32]. The relatively stable social environment and large amount of arable land in southern China provided a more favorable setting for people's production and livelihoods [33], consequently fostering the development of ICH. Subsequently, the Yuan Dynasty was unified and established its capital in Beijing, with the political center gradually moving north. In the Yuan Dynasty, the population of southern China exceeded that of northern China. The number of ICH items in the south of the Grand Canal, represented by Jiangsu and Zhejiang provinces, increased, becoming the stable core area of ICH. During the Ming and Qing Dynasties, Beijing was still the capital. To consolidate political power and restore the economy, people migrated from southern China to Beijing, Hebei, Henan, Shandong, and other northern areas. With the increase in the population, the number of ICH items also increased. Therefore, the gathering and migration of population brought about the birth, exchange, and prosperity of ICH.

(2) *Economic development* Economic development is an important driving force for cultural prosperity. In the Qin and Han Dynasties, there were 27 economic centers in the whole country, mostly concentrated in the Yellow River basin [5]. By the Eastern Han Dynasty, a two-level urban system had been

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formed, of which 54% was distributed in the middle and lower reaches of the Yellow River and the Huai River basin [34]. During this period, Shandong and Jiangsu provinces were the core areas for the distribution of ICH items. In the Sui and Tang dynasties, a number of cities sprang up along the Grand Canal and the Yangtze River due to the convenience of water transportation, and the economic center moved southern China. Yangzhou gradually surpassed Luoyang in economic status [34], and the Yangtze River basin became a stable core area for the distribution of ICH items. The social stability and prosperity in the Ming and Qing dynasties provided the material basis for the prosperity and exchange of culture. Literature, drama, acrobatics, handicrafts, folk custom and other cultural forms emerged, and North China became another center of ICH.

(3) *Wars and disasters* First, the survival of people is difficult in historical periods with frequent wars and disasters, and the development of culture and ICH is also seriously hindered. The wars in the late Eastern Han Dynasty and the Wei and Jin Dynasties and the Yellow River floods in the Song Dynasty, seriously affected the social and economic development. Furthermore, the changes in the regimes and political centers also brought about the changes in the ICH spatial center. The main reason of political unrest was accompanied by changes in population distribution patterns. For example, after Beijing was established as the capital of the Ming Dynasty, a large number of bureaucrats, scholars, artists, and craftsmen immigrated from the south to the north of China, which made ICH develop rapidly.

(4) *Canal and shipping* Due to the huge size of the Grand Canal, it was built in sections. In 486 BCE, the channel of Hangou, located in Yangzhou, was opened to connect the Huai River and the Yangtze River, which is regarded as the beginning of the construction of the Grand Canal. In the following thousands of years, the canal facilitated the functions of irrigated agriculture, commodity trade, and transportation in the areas along the canal, spawning many towns that thrived because of its construction. For example, Liaocheng (Shandong Province) became a famous canal city in the Ming and Qing dynasties, and all industries prospered. People in successive dynasties have also attached importance to the maintenance and repair of canals. During the Sui Dynasty, the Jiangnan Canal was dredged and its navigability improved [35], which also facilitated the circulation of people, goods, and culture from the north and south, laying a material foundation

for the development and dissemination of intangible culture. At the end of the Qing Dynasty, the Yellow River broke its banks, and the Liaocheng Canal was silted up, which severely damaged the business environment and destroyed the canal. In the Ming and Qing dynasties when the canal flourished in Liaocheng, there were various ICH items, such as gourd carving (Dongchang gourd Carving), drum dance (Grahame Flower Drum), and elbow hammer, but none developed thereafter.

Discussion
Comparison with previous studies
As living cultural heritage, ICH is a testament to human creativity, whose formation and development constitute an integral part of the traditional cultural system. Unlike tangible resources, the intangible nature of this heritage allows for greater flexibility in spatial distribution yet presents challenges in accurately defining their spatial parameters. This study breaks through the thought in previous studies that regard ICH items as independent points in geographical space [4, 14], and carries out spatial deconstruction and pedigree age of the ICH along the Grand Canal based on the extent of spreading of ICH. This study provides a novel idea for methodological advancement of ICH spatial distribution, as well as the studies about local cultural identity and regional consistency from a macro scale.

This study found that northern and southern endpoints of the Grand Canal are generally more advantageous in terms of quantity of ICH items,whereas the central part shows a strong spatial aggregation among specific types. This finding is consistent with those of Yang et al. [36], and Chen et al. [37]. However, this study further explores the existence of spatial mismatch at the city and county level [5], which is also the innovation of this research. This finding revels that a large number of ICH distributed in county-level units still cannot break through the regional restrictions to be popularized in the city, province or even the whole country. In this situation, the southern region of the canal, especially the counties in Suzhou and Hangzhou, takes the leading position instead of Beijing. Following results about spatial autocorrelation analysis further illustrate the two ends of the canal are important gathering areas of ICH with high–high aggregation pattern, but the southern endpoint are obviously more competitive than the northern endpoint, indicating that the popularity of ICH and local identity are stronger.

Pedigree age of ICH essentially reflects the historical evolution and cultural changes. In this study, the evolution tree is drawn based on the time and regional differences, and the change of the spatial center of ICH in

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different times is analyzed. Indeed, previous studies have also traced the ICH along the Grand Canal [14, 38, 39], but also focusing on partial sections or specific heritage types, few studies have analyzed the historical evolution of the ICH along the entire canal as this study does. Therefore, this study shows the historical context and regional connection of the ICH along the Grand Canal, which plays an important role in in-depth understanding of cultural consistency.

ICH along the Grand Canal is mainly distributed in areas with a prosperous culture, a high level of economic development, and strong policy and financial support from government. Different from previous studies that address the importance of natural factors [37, 38], this study deems government support, and human and society have greater impact on current spatial distribution pattern of ICH. We do not deny the fundamental role of natural factors such as temperature, precipitation, and topography in ICH distribution, but the strong influence of human activities is more evident in modern society, which is consistent with the distribution rule of ICH in a wider space such as China [5]. In addition, this study adopts some indexes that are rarely covered in previous studies, such as culture industry value-added and financial expenditure for culture and media, both of which are very influential. To explore the influence of the evolution of the ICH spatial center in historical sequence time, this study traces the origin time of ICH, restores the historical scene, and summarizes the key factors of the change of natural environment, population migration, economic development, war disasters, and canal shipping.

Theoretical and practical implications
Theoretical implications
This study analyzes the spatial distribution and pedigree age of ICH based on knowledge concerning the extent of spreading of ICH, which provides a methodological model for understanding ICH from geographical spatial perspective. The methods used and the results produced in this study are of great significance to enrich the theoretical research of ICH.

Although the spatial distribution and space–time evolution of resources have been widely studied in academia, ICH remains distinct. First, the abundance and diversity of ICH are deeply intertwined with everyday life. Second, the intangible nature of this heritage necessitates its existence and transmission through human creative activities. Within the dual theoretical framework of the "cultural turn" in geography and the "spatial turn" in sociology, space increasingly serves as a significant means for producing and inhering ICH. The spatial analysis and visual representation of ICH in this study provide a profound reflection on the relationship between humanity and land, and provides a reference for the spatial research of other intangible resources.

Conventional studies on ICH spatial distribution regard ICH items as independent points in geographical space, ignoring the nature of the spread range of ICH. The method adopted is also nearest neighbor index, and kernel density analysis suitable for point distribution [14, 39]. This study introduces the spatial statistical method of ICH based on the extent of spreading, and adopts the spatial autocorrelation method that is more suitable for the analysis of planar spatial elements. It is the perspective of city-county mismatch that illustrates ICH distribution along the canal, which is methodological innovation of this study compared with others.

Furthermore, in the process of exploring the evolution of ICH, this study clarifies the pedigree age by constructing the evolution tree model, and successfully builds the connection between historical periods and ICH types. The evolution tree model proposed in this study can be directly promoted and applied in similar studies towards ICH.

In addition, our special setting for modern society and historical periods may explain the differences in the influence of time changes on the ICH distribution. Through analyzing factors influencing the ICH distribution in the present era, as well as the factors influencing the ICH spatial center in the historical periods, this study considers the changes of factors brought by social progress. The comparative analysis of different historical backgrounds is an urgent need to strengthen the research of huge or linear areas represented by canals.

Practical implications
The findings can provide ideas for the protection and management of ICH along the Grand Canal. First, through the publicity of the importance of ICH inheritance, the establishment of a reward system can improve the enthusiasm of local ICH item declaration. Appropriate policies should be implemented to strengthen the development and utilization of ICH resources in the middle of the Grand Canal. Second, it is necessary to strengthen the study of ICH along the Grand Canal in collaboration with universities and research institutions to explain the key role in the inheritance of Chinese civilization during different historical periods. Third, ICH is rooted in the geographical environment in which it originated. Different regions have different ways of life, forming different cultures and producing intangible cultural heritage with their own characteristics. The protection of ICH should adapt to the actual situation to protect the diversity of cultures in different regions.

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Conclusions

By analyzing the spatial structure and pedigree age of ICH resources along the Grand Canal, this study draws the following conclusions. (1) The two ends of the canal have obvious advantages in the number of ICH items, but the existence of spatial mismatch at the city–county level makes the southern endpoint occupy a dominant position in spatial deconstruction based on the distribution range. (2) Although there is a high–high aggregation pattern along the whole canal, there are 29.82% of counties distributed widely with low–low aggregation. The two ends of the canal are important gathering areas of ICH, but Suzhou, Jiaxing, and Hangzhou at the southern endpoint are obviously more competitive than Beijing at the northern endpoint, indicating the popularity of ICH and local identity are stronger. (3) The spatial distribution center of ICH items from different historical periods generally presents a changing path from north to south and returning north. (4) ICH items are mainly distributed in areas with a prosperous culture, a high level of economic development, strong policy and financial support from government. The change of natural environment, population migration, economic development, war disasters, and canal shipping have profound impact in historical periods. This study is beneficial to clarify the spatial pattern and pedigree age of ICH along the Grand Canal and offers feasible suggestions to protect and manage canal ICH in a sustainable manner.

Future studies should illustrate the correlation between ICH and the canal, so as to explore cultural integrity and historical continuity. First, the cultural correlation between ICH and the canal based on the specific types and practical applications of the ICH. On the other hand, the spatial correlation between ICH and the canal is analyzed by using the law of geographical attenuation. In addition, there are numerous ICH items distributed along the linear cultural heritage represented by the canal worldwide. However, the natural and human conditions in different regions are quite different, so the study of the influence of different geographical environment on the temporal and spatial distribution of ICH along linear cultural heritage is another direction for future research.

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