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Distribution Pattern and Influencing Factors of Highly Educated Talents in Guangdong Province from 2000 to 2020 based on GIS and GeoDetector Model

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Abstract— *Nowadays, in the context of globalization and informatization, highly educated talents (HET) have become an important driving force for the economic and social development of countries and regions. Therefore, analyzing the geographical factors related to talent can provide important references for the formulation of regional talent introduction policies and talent management. From this perspective, this study uses the data of the Chinese population census from 2000 to 2020, analyzes the distribution pattern and primary influencing factors of HET in Guangdong Province in the past 20 years through the Theil index, multiple linear regression model (MLR), and GeoDetector model, and proposes optimization suggestions on this basis. Study has shown that: (1) Guangdong's HET are concentrated in economically developed cities in the Pearl River Delta (PRD) region, presenting a spatial distribution pattern of "dense in the PRD region, sparse in other regions," with Guangzhou and Shenzhen having the highest talent density. (2) There was a significant difference in the change rate of high educated talent density among cities in the province before and after 2010. The growth rate was relatively fast before 2010, but slowed down after 2010. The change rate of talent proportion shows a trend of "fast growth in the PRD region and slow growth in other regions." (3) The imbalance between the density and proportion of HET among cities is on the rise. Through the analysis of the geographic detector model, it was found that administrative hierarchy, scientific research environment, and economic opportunities are the three main factors affecting the distribution pattern of HET in Guangdong Province.*

Keywords— ***Highly educated talents (HET), Pearl River Delta (PRD), Theil index, GeoDetector, Multiple linear regression model (MLR).***

I. INTRODUCTION

Highly educated talents (HET) usually refer to human resources with a higher level of education, often possessing rich professional knowledge and skills, capable of performing highly skilled and high-quality jobs. In this study, HET refer to human resources with a bachelor's degree or above who play an important role in promoting technological innovation, economic development, and social progress. As the main driving force of the knowledge economy era, the distribution pattern and influencing

factors of HET have important theoretical and practical significance for regional development. The study of the distribution pattern and influencing factors of HET in Guangdong Province, as a major economic province in China, has important practical significance.

In the study of the number and flow of highly qualified talent, scholars generally use statistical data analysis and survey study methods to examine the flow of talent. For example, Liu et al. (2023), using the national census data, conducted an in-depth analysis of the distribution pattern of Chinese highly educated talent between 2000 and 2020. The study found that the talent density was higher in the southeast and lower in the northwest, forming a distribution pattern of "southeast intensity, north-west scarce" [1]. By conducting a survey of the urban dimension, Wu et al. (2019) found that China's highly educated talent is highly concentrated in municipalities, provinces, and planned municipalities [2].

In the study of the driving factors of the distribution of highly educated talent, it has expanded from a single socio-economic factor to multiple influence factors. For example, Scholars such as Abel (2012) believe that economic factors play a crucial role in the capacity-gathering model of higher education [3]. Lu et al. (2024) pointed out that there were differences in the levels of gathering of different talents, which influenced the factors of gathering talents [4].

Therefore, by studying the distribution pattern and influencing factors of HET in Guangdong Province, the laws of talent flow and distribution can be revealed, providing new research perspectives and methods for population geography. Secondly, this study can provide reference and inspiration for the formulation of talent strategies, optimization of educational resources, and regional coordinated development in Guangdong Province. In addition, this study can provide experience and inspiration for the management of HET in other regions.

II. STUDY AREA AND DATA SOURCES

2.1 Study Area

Guangdong Province is located between latitude 20 ° 09 ′-25 ° 31 ′N and longitude 109 ° 45 ′-117 ° 20 ′E (Figure 1). Its gross domestic product (GDP) has consistently ranked first in the country, making it the largest economic province in China, accounting for 1/8 of the country's total economic output. In terms of administrative regions, it is divided into four major areas: the PRD, northern Guangdong, eastern Guangdong, and western Guangdong, with 21 prefecture-level cities under its jurisdiction. Its characteristics include a large population base, a high urbanization rate, population concentration in the PRD, and continuous improvement in education level.

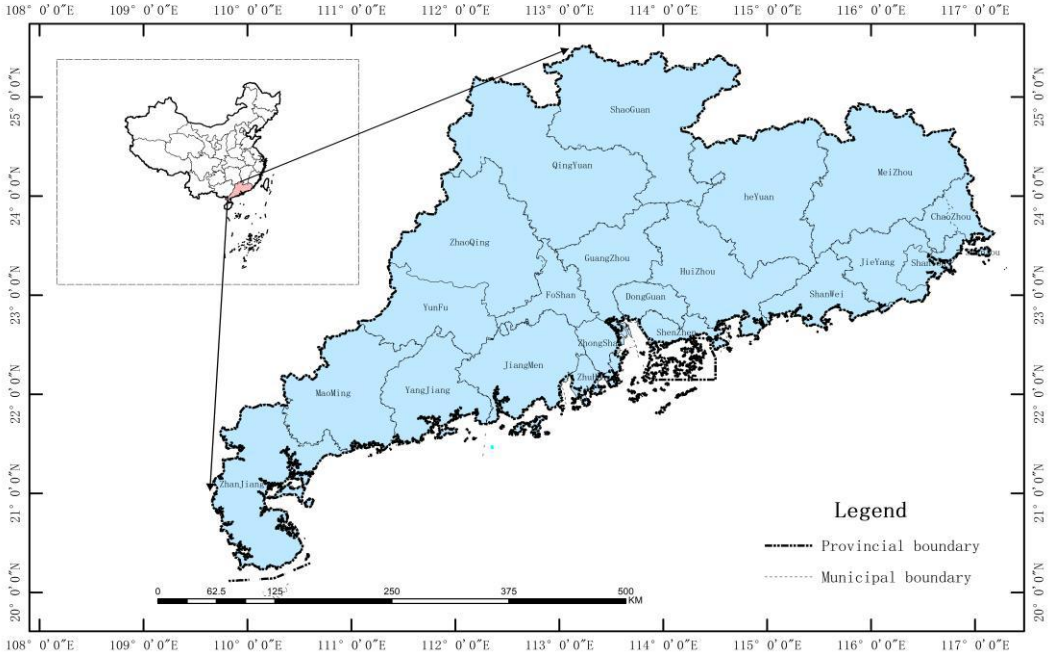

Fig.1 Location map of Guangdong Province

2.2 Data Sources

This article extracts data on HET in Guangdong Province based on the data from the 2000, 2010, and 2020 China Population Census data by county. The key indicators involved include the number of higher education talents, education level, occupational distribution, etc. Other socio-economic and cultural data are taken from the Guangdong Provincial Statistical Yearbook and the Guangdong Provincial Social Statistical Yearbook. The data sources and purposes are shown in Tables 1 to 4.

Table 1 Data sources list

Data Requirement	Data sources	Purpose
Virtual talent pool	2000 China census by county (www.zgtjnj.org)	Analyze the distribution of highly educated talents
	2010 China census by county (www.zgtjnj.org)	
	2020 China census by county (www.zgtjnj.org)	
Political, economic, and cultural data	《Guangdong statistical Yearbook》（www.zgtjnj.org）	The influencing factors of its distribution pattern were analyzed
	《Social statistics Yearbook of Guangdong Province》（www.zgtjnj.org）	

Table 2 Talent data for 2000 (Bachelor's degree or above)

	2000				
	Number of talents (people)	Area (km2)	Number of students above 6 years old (people)	Talent density (people/km2)	Proportion of talents
ShenZhen	564093	1998	6730702	282	8.38%
GuangZhou	926345	7436	9343161	125	9.91%
DongGuan	139125	2512	6207672	55	2.24%
ZhuHai	92684	1725	1153878	54	8.03%
FoShan	195717	3875	5011270	51	3.91%
ShanTou	103439	2123	4163064	49	2.48%
ZhongShan	62271	1770	2223841	35	2.80%
ZhanJiang	150215	11692	5376171	13	2.79%
ChaoZhou	38080	3098	2173248	12	1.75%
JiangMen	92430	9554	3669811	10	2.52%
MaoMing	99257	11345	4647692	9	2.14%
HuiZhou	81101	11159	2957389	7	2.74%
JieYang	34362	5269	4603280	7	0.75%
MeiZhou	88705	15925	3452387	6	2.57%
ShaoGuan	97501	18398	2519148	5	3.87%
ZhaoQing	76039	15006	3027286	5	2.51%
YangJiang	38656	8006	1985310	5	1.95%
ShanWei	23633	4957	2125218	5	1.11%

YunFu	31810	7778	1933183	4	1.65%
QingYuan	60583	19265	2858605	3	2.12%
HeYuan	35277	15644	2035619	2	1.73%

Table 3 Talent data for 2010 (Bachelor's degree or above)

	2010				
	Number of talents (people)	Area (km2)	Number of students above 6 years old (people)	Talent density (people / km2)	Proportion of talents
ShenZhen	1827627	1998	9865777	915	18.52%
GuangZhou	2491688	7436	12103857	335	20.59%
DongGuan	596079	2512	7934639	237	7.51%
FoShan	701158	3875	6853358	181	10.23%
ZhuHai	289837	1725	1478940	168	19.60%
ZhongShan	249970	1770	2977101	141	8.40%
ShanTou	230400	2123	5006963	109	4.60%
ChaoZhou	110041	3098	2488397	36	4.42%
ZhanJiang	356179	11692	6440811	30	5.53%
HuiZhou	293260	11159	4261832	26	6.88%
JiangMen	248858	9554	4217176	26	5.90%
MaoMing	267355	11345	5287984	24	5.06%
JieYang	110475	5269	5445169	21	2.03%
ShanWei	71079	4957	2719556	14	2.61%
YangJiang	114043	8006	2232694	14	5.11%
MeiZhou	205986	15925	3907483	13	5.27%
ZhaoQing	181704	15006	3611357	12	5.03%
ShaoGuan	201417	18398	2616591	11	7.70%
YunFu	76713	7778	2154694	10	3.56%
HeYuan	127968	15644	2640854	8	4.85%
QingYuan	153671	19265	3404265	8	4.51%

Table 4 Talent data for 2020 (Bachelor's degree or above)

	2020				
	Number of talents (people)	Area (km2)	Number of students above 6 years old (people)	Talent density (people / km2)	Proportion of talents
ShenZhen	5060813	1998	16310173	2533	31.03%
GuangZhou	5094467	7436	17471528	685	29.16%
DongGuan	1385885	2512	9906978	552	13.99%
FoShan	1533405	3875	8858452	396	17.31%
ZhuHai	628248	1725	2270837	364	27.67%
ZhongShan	590075	1770	4115594	333	14.34%

ShanTou	454176	2123	5027785	214	9.03%
HuiZhou	744619	11159	5563871	67	13.38%
ChaoZhou	196961	3098	2376239	64	8.29%
JiangMen	568059	9554	4475747	59	12.69%
ZhanJiang	615551	11692	6252873	53	9.84%
JieYang	246446	5269	4815372	47	5.12%
MaoMing	498487	11345	4615332	44	10.80%
YangJiang	236739	8006	2388989	30	9.91%
ShanWei	144075	4957	2475314	29	5.82%
ZhaoQing	361410	15006	3776715	24	9.57%
YunFu	163759	7778	2165676	21	7.56%
MeiZhou	320171	15925	3537955	20	9.05%
QingYuan	367366	19265	3606363	19	10.19%
ShaoGuan	331559	18398	2618275	18	12.66%
HeYuan	240638	15644	2595207	15	9.27%

III. RESEARCH METHODS

On the basis of population geographic spatial analysis, this study proposes an analytical framework for the spatial distribution pattern and influencing factors of HET in Guangdong Province (Figure 2). Firstly, key information such as the number of HET, educational level, and occupational distribution in various cities of Guangdong Province from 2000 to 2020 were collected, as well as data on the economy, culture, education, and other aspects of each city. After data acquisition, perform data cleaning to eliminate possible errors and outliers. Next, use ArcGIS software to process spatial data, analyze the spatial distribution pattern of HET, create a visual analysis map, and use the Theil coefficient to evaluate the uneven level of talents. Then, the driving factors were analyzed using a geographic detector model and a multiple linear regression model. Based on the analysis results, conclusions were drawn and relevant policy recommendations were proposed.

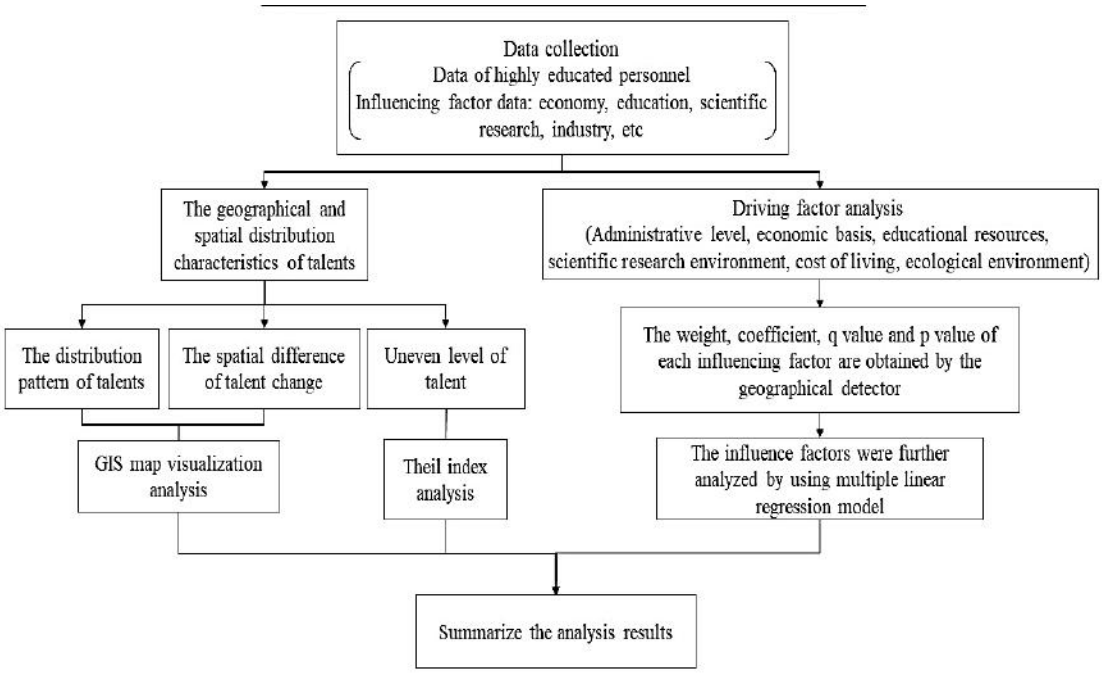

Fig.2 The schema of this study

(1) Talent density refers to the number of higher education talents per square kilometer of land, used to measure the degree of agglomeration of talents in spatial distribution. The specific calculation formula is shown in (1).

$$TD = \frac{Q}{A} \quad (1)$$

In the formula: TD represents talent density (people/square kilometer), Q represents the number of HET in the region (people), and A represents the area of the region (square kilometer).

The proportion of talents refers to the proportion of higher education talents to the total number of people aged 6 and above who receive education at all levels, reflecting the level of population quality in a region. The specific calculation formula is shown in (2).

$$PT = \frac{Q}{TQ} \quad (2)$$

In the formula, PT represents the proportion of talents (%), Q represents the number of HET in the region (people), and TQ represents the total number of people aged 6 and above in the regions who receive education at all levels (people).

(2) Talent density change rate: The talent density change rate of a city from 2000 to 2010 is equal to the talent density of the city in 2010 minus the talent density in 2000, divided by the talent density of the city in 2000, and finally multiplied by 100%. Similarly, extrapolate the data from 2010 to 2020.

The change rate of talent ratio: The relative growth rate of talent ratio in a certain city from 2000 to 2010 is equal to the difference between the talent ratio in 2010 and 2000, divided by the difference between the talent ratio in 2010 and 2000 nationwide. Similarly, extrapolate the data from 2010 to 2020.

(3) Theil index: By calculating the mean and variance of the number of HET, the imbalance is transformed into a specific value, allowing researchers to intuitively understand the degree of talent distribution differences between different urban areas. In addition, by decomposing the Theil index, further analysis is conducted on the contribution of each region to overall inequality in order to more accurately grasp the specific situation of each region [5]. The formula is as follows:

$$T = \frac{\left(\Sigma p_i^2 - \frac{[\Sigma p_i]^2}{n}\right)}{\left[\frac{(\Sigma i p_i)^2}{n}\right]} \quad (3)$$

Where pi represents the proportion of HET in the i-th city, and n represents the number of cities. The numerator of this formula represents the difference between the sum of squares of the proportion of HET in each city and the square of the average, while the denominator represents the mean of the sum of squares of the proportion of HET in each city. By calculating the Theil index, the equilibrium distribution of HET in various urban areas of Guangdong Province can be evaluated.

(4) Geodetector: is a spatial analysis tool used to explore spatial heterogeneity and its underlying drivers, widely used in driving force analysis and factor analysis [6]. Factor detection aims to detect the spatial differentiation of Y as well as the extent to which a certain factor X explains the spatial differentiation of attribute Y, measured by the q value, expressed as:

$$q = 1 - \frac{\sum_{h=1}^{L} N_h \sigma_h^2}{N\sigma^2} = 1 - \frac{SSW}{SST} \quad (4)$$

$$SSW = \sum_{h=1}^{L} N_h \sigma_h^2, SST = N\sigma^2 \quad (5)$$

In the formula: h = 1, L represents the stratification of variable Y or factor X, i.e., classification or partitioning; Nh and N represent the number of units in layer h and the entire region, respectively; σ2h and σ2 are the variances of the Y values for layer h and the entire region, respectively. SSW and SST are the Within Sum of Squares and the Total Sum of Squares, respectively.

(5) Multiple linear regression model: Further analysis can be conducted on driving factors [7], selecting some factors that may affect the distribution of HET, such as per capita GDP, average employee wages, urban forest coverage, etc., as independent variables. Through model fitting, the degree and direction of the impact of these factors on the distribution of HET can be evaluated. The expression is:

$$q = f(X1, X2, \ldots, Xn) \quad (6)$$

Among them, q is the distribution index of HET (density and proportion of HET), X1, X2,..., Xn are the influencing factors.

IV. DATA PROCESSING AND ANALYSIS

4.1 Spatial Distribution Pattern of Talent Density and Talent Proportion

Based on the indicator of "density of HET" and using data from 2000 as a benchmark, the natural breakpoint method was used to divide all urban areas in Guangdong Province into five categories: "low level," "lower level," "average level," "higher level," and "high level" (Table 5), in order to depict the spatial distribution pattern of talents. The Figures 3 and 4 shows the spatial differences in the density and proportion of HET in Guangdong Province from 2000 to 2020.

Table 5 Classification of talent density data range

Project	Label	Scope（per/km^2）
Talent density	Low Level	1-10
	Lower level	11-40
	Average level	41-180
	Higher level	181-350
	High level	351-2500

This study results show that: (1) Guangdong's HET are concentrated in developed cities such as the PRD economy, presenting a spatial distribution pattern of "dense in the PRD region and sparse in other regions." (2) The level of talent has generally improved: over the past 20 years, the number of HET in Guangdong Province has gradually decreased in low-level regions, while the number of high-level regions has gradually increased. (3) Dynamic trend: The spatial distribution pattern of HET in Guangdong Province is changing, showing a trend of diffusion from the PRD to the periphery.

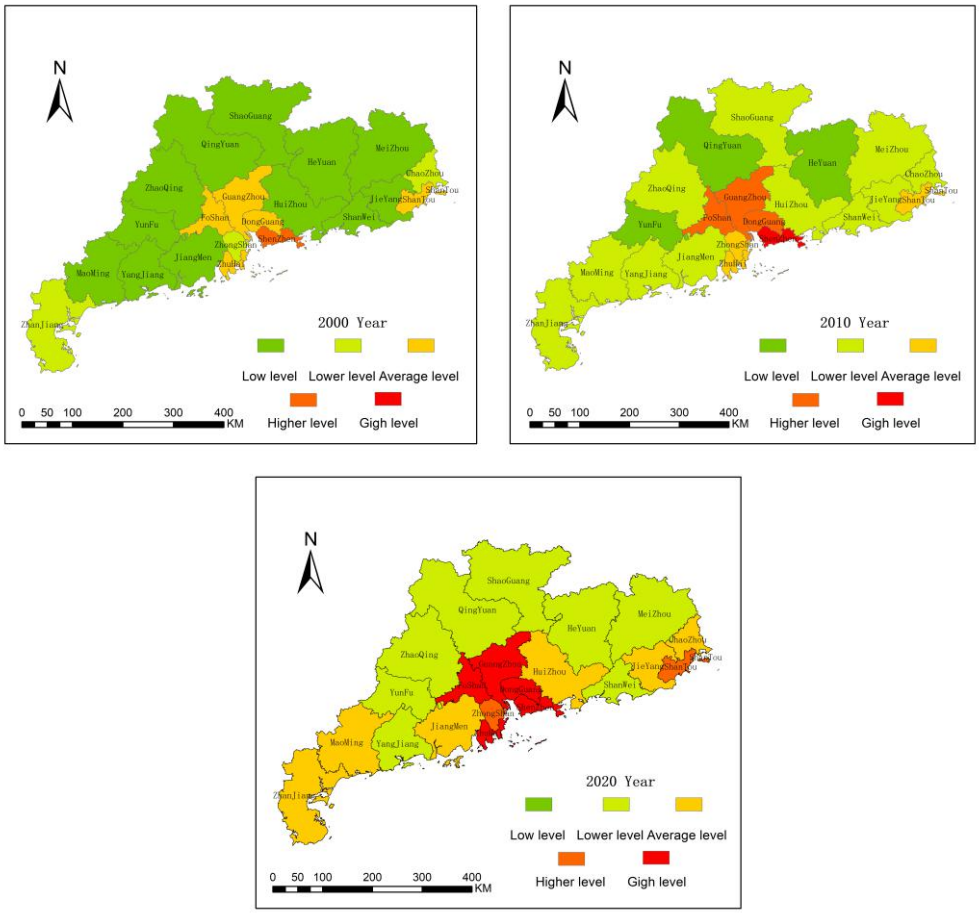

Fig.3. Density of HET by city in Guangdong Province from 2000 to 2020

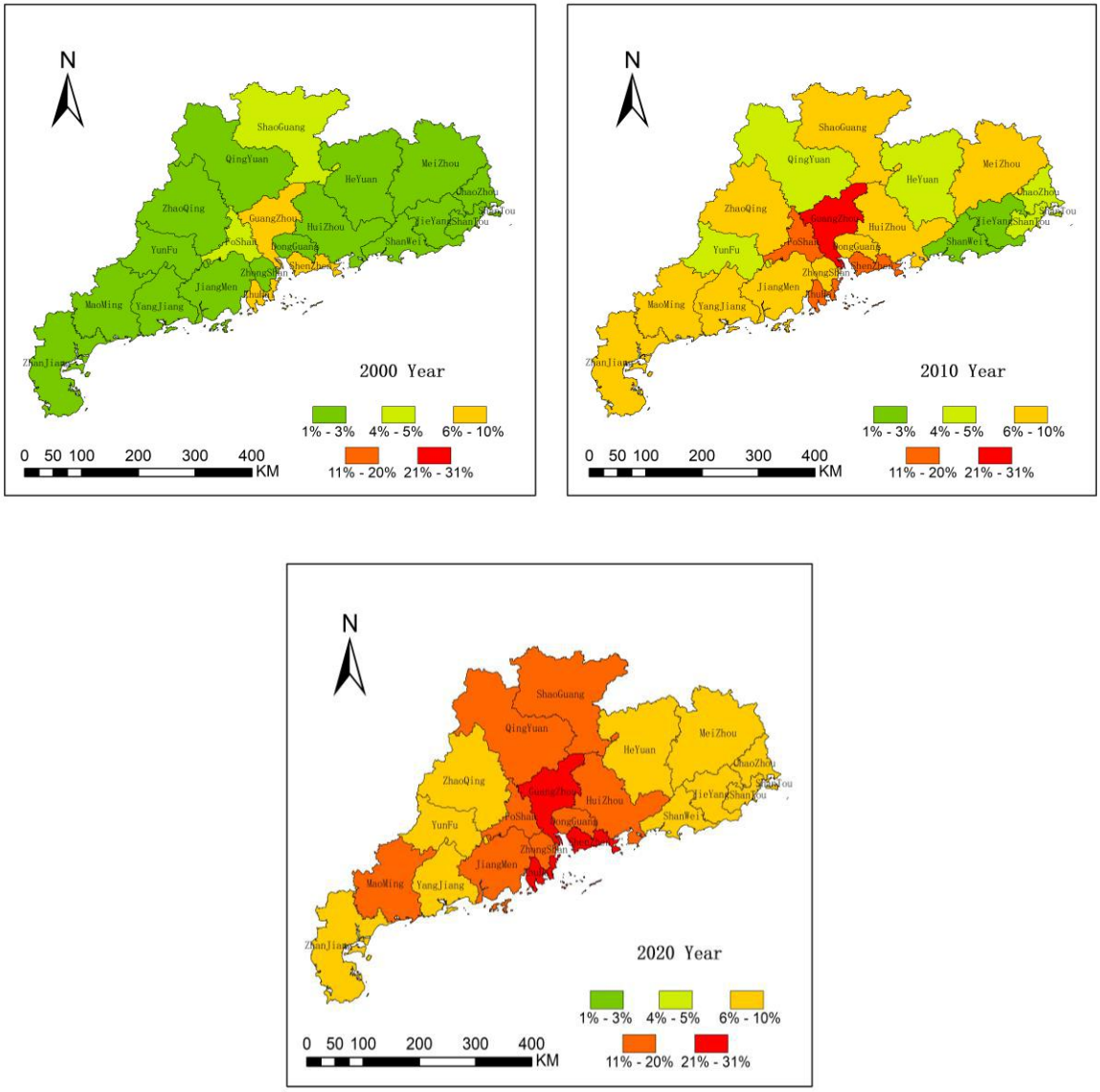

Fig.4 Proportion of HET by city in Guangdong Province from 2000 to 2020

4.2 Spatial Differences in Talent Density and Talent Proportion Changes

Calculate the change rates of talent density in each urban area from 2000 to 2010 and from 2010 to 2020, respectively. Divide all cities into five categories: "density reduction," "basic stability," "slow growth," "medium growth," and "high growth" (Table 6).

Table 6 Classification of talent density change rate

Project	Label	Scope（×100%）
Changing rate of talent density	Density reduction	0.01-0.65
	Basically stable	0.66-1.15
	Slow growth	1.16-1.65
	Medium growth	1.66-2.15
	High growth	2.15-3.32

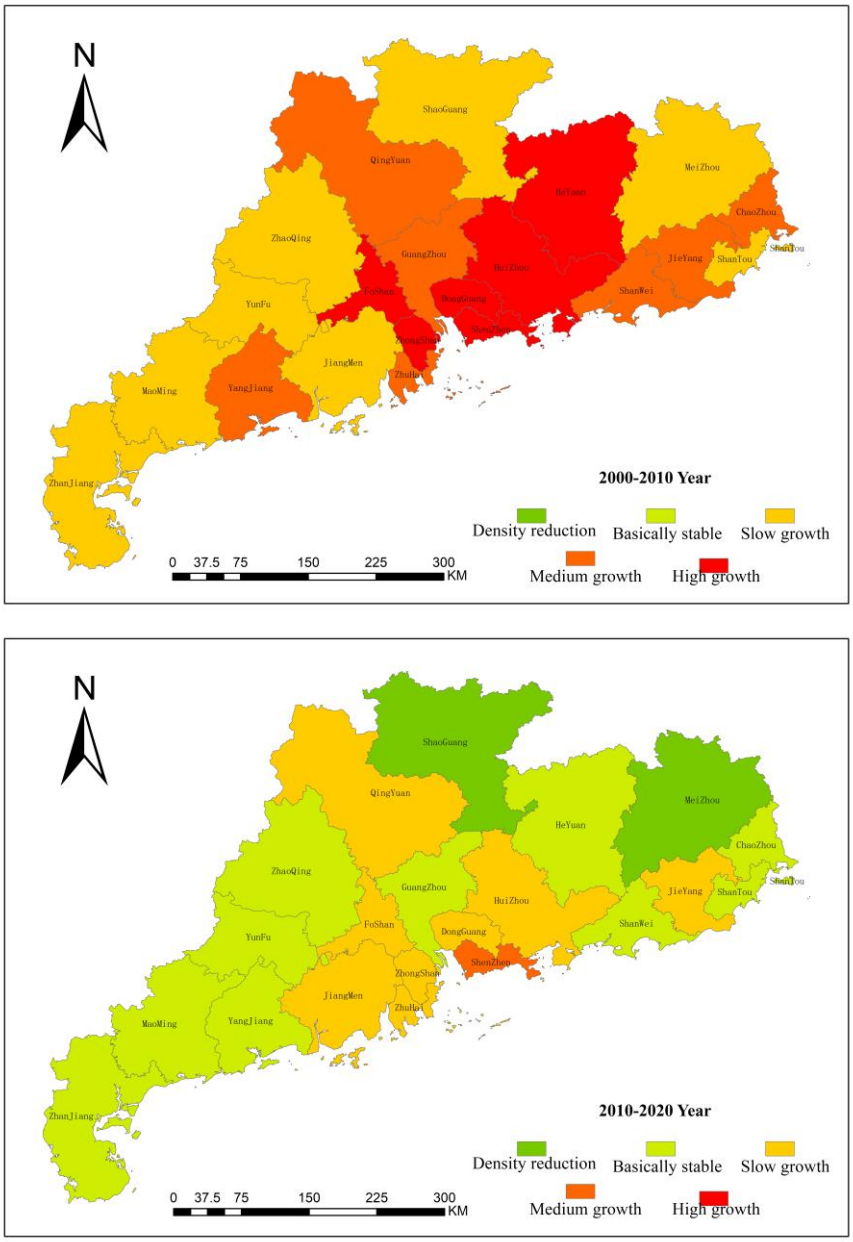

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Fig.5 Spatial variation pattern of the density of HET from 2000 to 2020

As shown in Figure 5, (1) the growth rate of talent density in Guangdong Province has slowed down over the past 20 years, and the talent density in the vast majority of regions has shifted from a growth type to a basically stable type. From 2000 to 2010, the PRD region experienced the fastest growth, especially in cities such as Guangzhou, Shenzhen, and Dongguan, while the eastern and western regions of Guangdong experienced slower growth. From 2010 to 2020, the growth rate of various cities in the province was slow, with most cities in western and northern Guangdong reaching the basically stable stage, while only some cities in the PRD region were in the slow growth stage. (2) Over the past 20 years, the density of HET in Guangzhou has maintained a steady growth rate, higher than the provincial average level; Shenzhen has a strong growth momentum, attracting numerous HET to come for employment and entrepreneurship

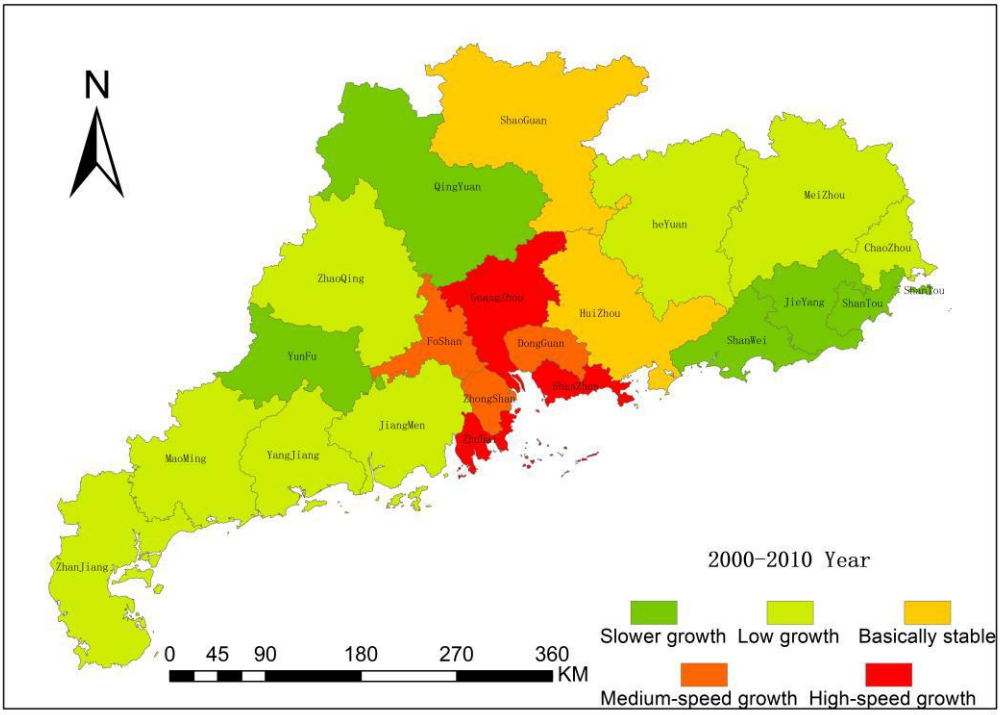
Calculate the relative growth rate of talent proportion in each urban area from 2000 to 2010 and from 2010 to 2020, respectively. Using the natural segment method, all cities are classified into five categories: "slower growth," "low growth," "basically stable," "medium growth," and "high

growth" (Table 7).

Table 7 Classification of talent ratio change rate

Project	Label	Scope（×100%）
Change rate of talents proportion	Slower growth	0.01-0.57
	Low growth	0.58-0.88
	Basically stable	0.89-0.96
	Medium growth	0.97-1.48
	High growth	1.49-2.70

As shown in Figure 6, (1) the change rate of the proportion of HET shows a trend of "fast growth in the PRD region and slow growth in other regions." The proportion of HET in cities such as Guangzhou, Shenzhen, and Zhuhai has a relatively high rate of change. However, economically underdeveloped areas such as Yangjiang, Yunfu, and Zhaoqing in western and northern Guangdong have lower rates of change. (2) The change rate of the proportion of HET shows a diversified characteristic. Some cities have been growing rapidly, and the rate of change in some cities has fluctuated. (3) The change rate of the proportion of HET in cities outside the PRD region, such as Huizhou and Jiangmen, has begun to surpass that of the PRD. These cities actively undertake the transfer of industries from the PRD, develop high-tech industries, and continuously expand the demand for HET.



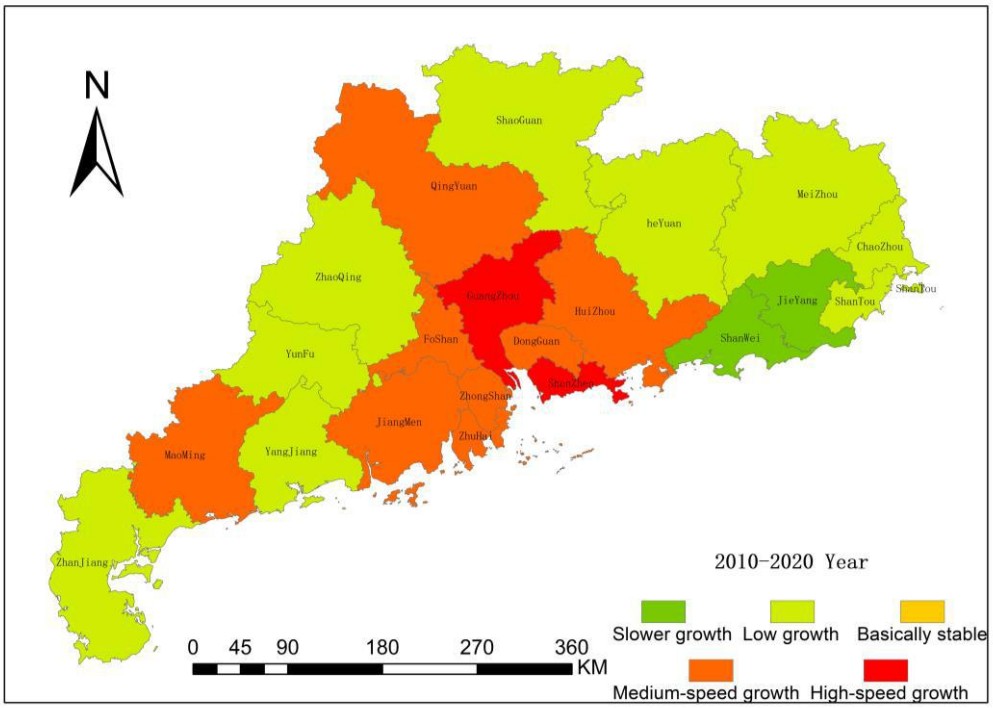


Fig.6 Spatial variation pattern of the proportion of HET from 2000 to 2020

4.3 Regional Imbalance Level between Talent Density and Talent Proportion

This study uses the Theil index to analyze regional differences in the density of HET and their proportion among talents in Guangdong Province from 2000 to 2020. The results show that the regional imbalance in the density and proportion of HET is on the rise.

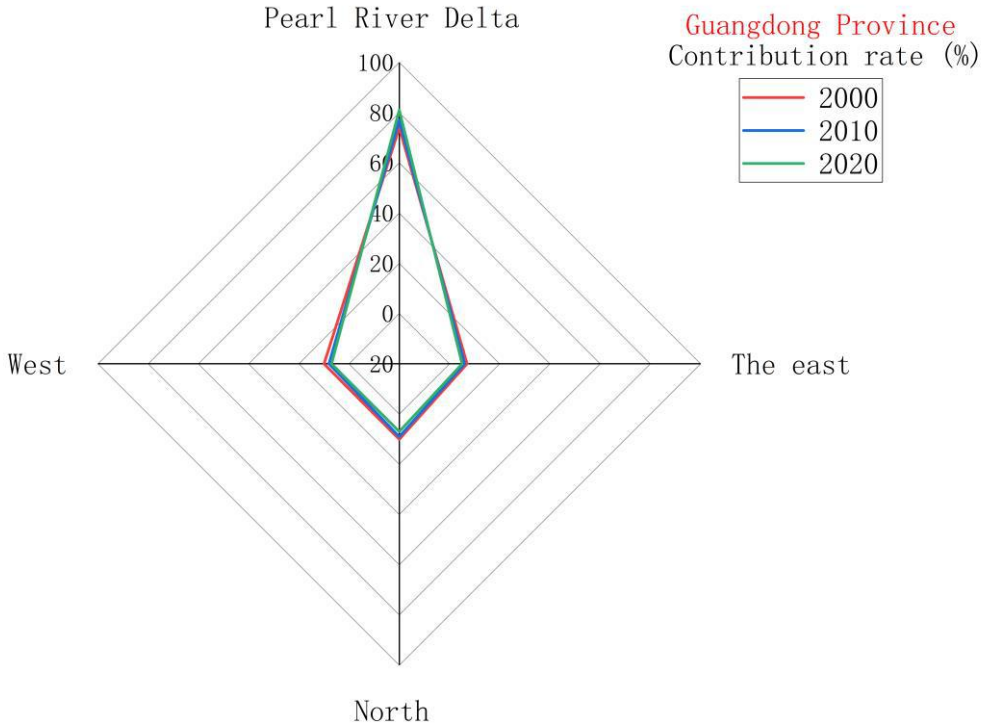
Divide the urban areas of Guangdong Province into four regions based on administrative regions and conduct Theil index analysis on the talent density and talent proportion in three different periods, revealing the overall differences in talent proportion and its contribution rate to the total difference (Table 8), as well as the radar chart of the Theil index contribution rate for each region (Figure 7).

The results indicate that:(1) In the PRD region, the overall difference in talent distribution is gradually increasing, indicating that the degree of imbalance in talent distribution is intensifying. The overall differences in the eastern, western, and northern regions of Guangdong are gradually decreasing. Specifically, the gap between Guangzhou and Shenzhen and other cities is becoming increasingly prominent. It can be seen that the main component of the difference in talent distribution in the PRD region is driven by the changes in Guangzhou and Shenzhen. (2) The contribution rate of HET in the PRD region is significantly higher than that in the eastern, western, and northern regions of Guangdong, and the gap is becoming larger and larger.

Table 8 Theil index and its decomposition of the proportion of HET

Decomposition of difference	2000		2010		2020	
	Theil coefficient	Contribution ratio（%）	Theil coefficient	Contribution ratio（%）	Theil coefficient	Contribution ratio（%）
Pearl River Delta	0.172	74	0.116	77	0.071	81
DongGuan	0.061	6	0.087	9	0.087	9
ZhongShan	0.028	3	0.036	4	0.037	4
FoShan	0.088	9	0.01	10	0.096	10
GuangZhou	0.415	42	0.362	36	0.319	32
HuiZhou	0.036	4	0.043	4	0.047	5

JiangMen	0.042	4	0.036	4	0.036	4
ShenZhen	0.253	25	0.266	27	0.317	32
ZhuHai	0.042	4	0.042	4	0.039	4
ZhaoQing	0.034	3	0.026	3	0.027	2
East	0.118	7	0.064	6	0.031	5
JieYang	0.172	17	0.209	21	0.238	24
ShanTou	0.522	52	0.442	44	0.442	44
ShanWei	0.122	12	0.143	14	0.143	14
ChaoZhou	0.183	19	0.205	21	0.186	19
North	0.047	10	0.029	9	0.012	7
MeiZhou	0.282	28	0.271	27	0.222	22
HeYuan	0.111	11	0.174	17	0.171	17
QingYuan	0.187	19	0.205	20	0.257	26
ShaoGuan	0.311	31	0.257	26	0.229	23
YunFu	0.099	10	0.101	10	0.098	10
West	0.011	10	0.001	8	0.001	7
ZhanJiang	0.523	52	0.483	48	0.463	46
MaoMing	0.341	34	0.357	36	0.271	37
YangJiang	0.126	13	0.153	15	0.177	18



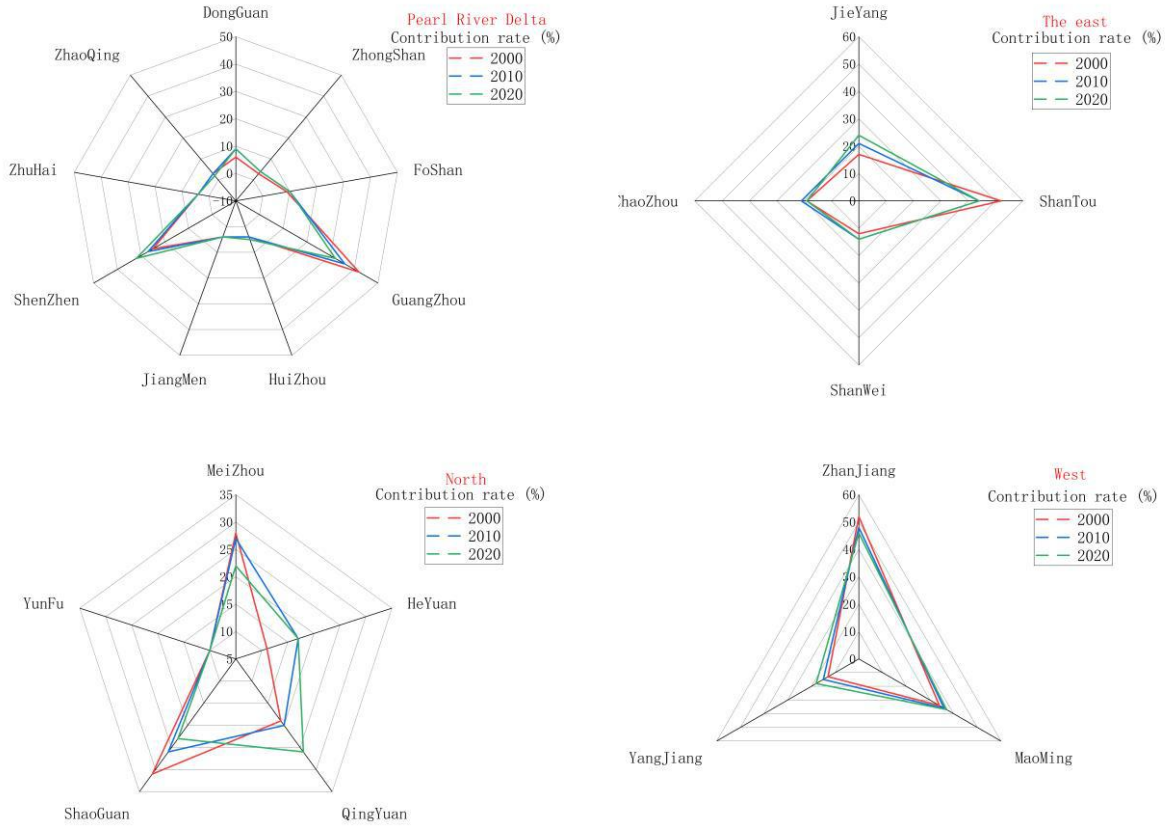


Fig.7 Contribution rate of Theil index in various regions

4.4 Analysis of Driving Factors for Talents

In the construction of a multiple linear regression model for the factors influencing talent density and talent proportion from 2000 to 2020, the statistical data of the independent and dependent variables involved are shown in Table 9. We selected talent density and talent proportion as dependent variables in order to identify the influencing factors of talent spatial distribution from the level of talent aggregation and quality.

Table 9 Basic statistics of variables

Variable Name	2000		2010		2020	
	Mean Standard	Deviation	Mean Standard	Deviation	Mean Standard	Deviation
Talent density (person /km²)	35	62	111	200	266	542
Talent ratio (%)	5.75	9.93	12.78	16.85	20.74	23.05
Gross domestic product per capita (Yuan)	13183	9851	35722	26557	47003	32242
Average urban wage (Yuan)	6127	2615	7168	2095	10312	1851
Scientific research funds (Yuan)	9824	35644	19049	68676	57339	203653
Teacher-student ratio	17	3	16	3	16	2
Number of cultural institutions (number)	149	87	677	470	803	723
Number of hospital beds per 10,000 people	32	35	28	26	28	9

Forest coverage (%)	49	16	56	11	60	9
Provincial capital, municipality (yes =1, no =0)	0.1	0.29	0.1	0.29	0.1	0.29
Tertiary industry increase index	112	4	113	3	107	1
Population density	578.46	426.9	688.3	501.59	853.92	695.14

This study based on literature, select influencing factors from six dimensions to analyze the trend factors of variable relationships. Such as:

(1) Administrative hierarchy [8]. Through comparative analysis, it was found that provincial capital cities and municipalities directly under the central government are far superior in terms of administrative resource allocation compared to other prefecture-level cities. These cities not only have higher levels of economic development, more modern industrial structures, stronger attraction of talent policies, and superior living environments, but also have unparalleled advantages in attracting population. Based on this understanding, this study will include whether the prefecture-level administrative unit is a provincial capital or municipality directly under the central government as a key dummy variable in the analysis model.

(2) Economic opportunities [9]. In economically developed regions, such as municipalities directly under the central government and provincial capital cities, due to providing a large number of employment opportunities, higher salary levels, and better living conditions, it is natural to attract many highly educated professionals. However, regions with insufficient economic development tend to have a lower proportion of HET. To accurately measure the economic opportunities provided by a region, this study uses two specific indicators: per capita GDP and average employee wages.

(3) Educational resources [10]. The richness and quality of educational resources directly affect the cultivation and aggregation of HET. If a region has a large number of high-quality higher education institutions, it has the ability to cultivate a large number of HET. Meanwhile, a good academic atmosphere and advanced research facilities also help attract and retain these talents. Therefore, we select the teacher-student ratio as two indicators to measure the scale of talent cultivation in a region.

(4) Research environment [11]. In areas with highly developed technology, the concentration of scientific researchers is often high, and the research funding is also relatively high, which reflects the degree of importance that the region places on scientific research investment. Therefore, scientific research expenditure is selected as an indicator to evaluate the scientific research investment situation in various regions.

(5) Cost of living and cultural level [12]. Over time, the level of public service has become one of the key factors in attracting talent. This study selects the number of hospital beds per 10,000 people and the number of cultural institutions as indicators to measure the medical and cultural level of a region.

(6) Ecological environment [13]. A good ecological environment can not only improve the quality of life of residents but is also an important factor in attracting talents to settle down. This study uses forest coverage to measure the degree of greening in a region, which also represents the ecological environment indicators of the region. By analyzing the above indicators, it is possible to accurately understand and predict the trend of talent mobility and the driving forces behind it.

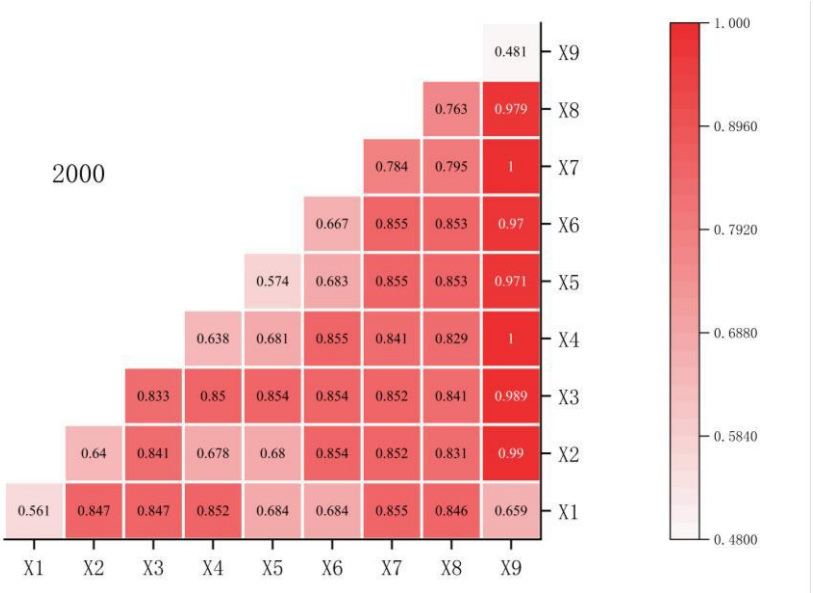
This study used a GeoDetector model to construct a factor detection model that affects the distribution of HET in Guangdong Province, and solved the model using GeoDetector software to obtain the q and p values of each influencing factor. Obtain the results of the GeoDetector model between talent density and various influencing factors in 2000, 2010, and 2020 (Table 10). The larger the q value, the stronger the explanatory power of the independent variable talent density on various influencing factors, and vice versa. The analysis results show that the main factors affecting the distribution of HET in Guangdong Province are administrative hierarchy, research environment, and economic opportunities in sequence. Among them, the influence of administrative hierarchy is the strongest, followed by the research environment, and the impact of economic opportunities is also more significant. The impact of cost of living and cultural level is relatively

weak, and the degree of influence of industrial structure is also relatively low, but it still has certain significance.

Next, further pairwise analysis was conducted on the various influencing factors, analyzing the interrelationships between the influencing factors of HET from 2000 to 2020 (Figure 8). X1 represents per capita GDP, X2 represents average employee salary, X3 represents research funding, X4 represents teacher-student ratio, X5 represents the number of cultural institutions, X6 represents hospital beds per 10,000 people, X7 represents forest coverage, X8 represents provincial capital, a municipality directly under the central government, and X9 represents the tertiary industry growth index. The results show that over time, the driving factors affecting the distribution of h HET are becoming increasingly diverse.

Table 10 The influence factors of HET distribution

	2000		2010		2020	
	q value	p value	q value	p value	q value	p value
Gross domestic product per capita	0.661	0.05	0.635	0.027	0.634	0.081
Average urban wage (Yuan)	0.64	0.025	0.666	0.017	0.686	0.027
Scientific research funds (Yuan)	0.833	0.003	0.802	0.008	0.879	0.005
Middle school teacher ratio	0.638	0.026	0.649	0.022	0.58	0.052
Number of cultural institutions (Number)	0.574	0.038	0.591	0.031	0.51	0.034
Number of hospital beds per 10,000 people	0.567	0.036	0.534	0.047	0.514	0.036
Forest coverage (%)	0.684	0.014	0.721	0.016	0.665	0.038
Provincial capital, municipality (yes =1, no =0)	0.863	0.001	0.891	0.005	0.846	0.001
Tertiary industry increase index	0.481	0.148	0.641	0.056	0.568	0.06



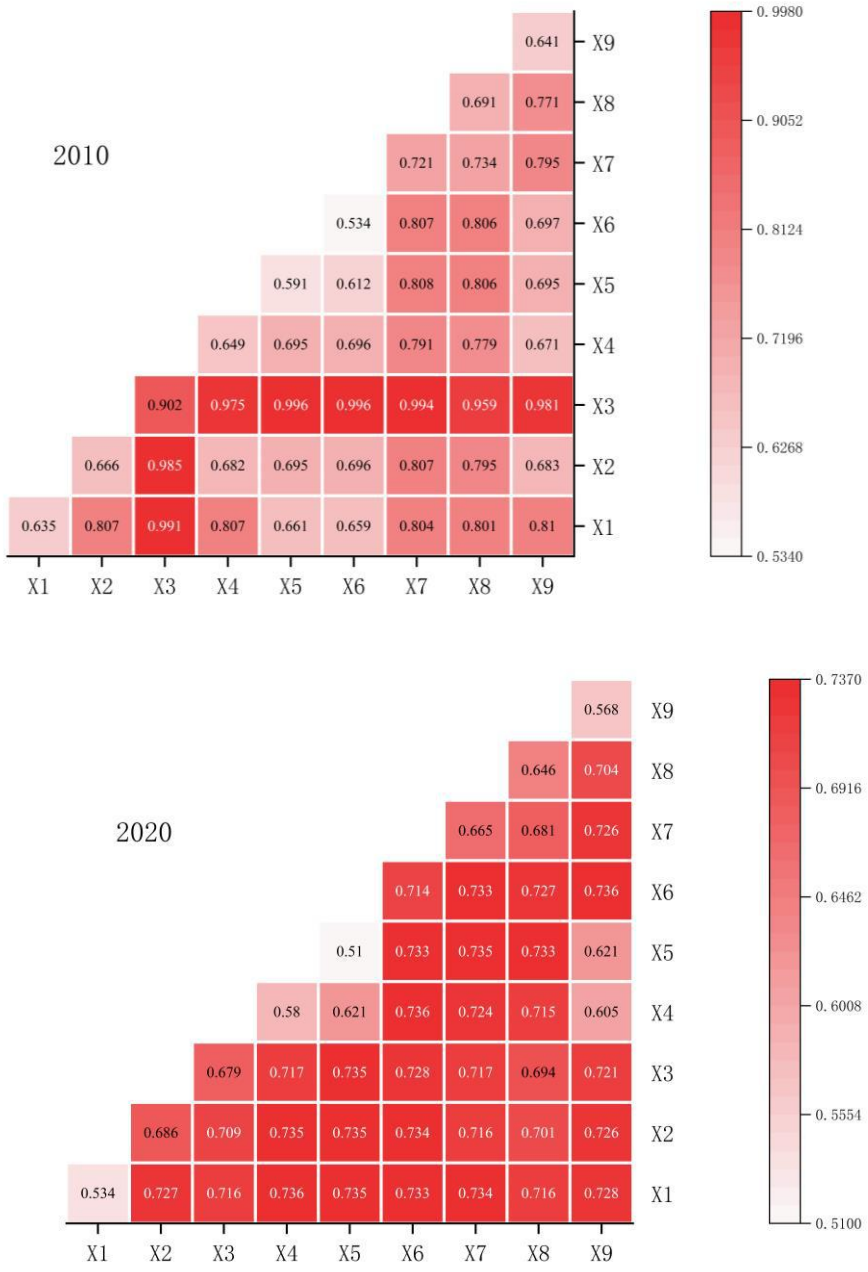


Fig.8 The relationship between the influencing factors of HET from 2000 to 2020

This study further conducted multiple linear regression analysis on various influencing factors, revealing the correlation coefficients of the factors affecting the distribution of HET from 2000 to 2020 (Table 8).

Table 8 Correlation coefficient between talent density and talent proportion

Variable name	Talent density			Proportion of talents		
	2000	2010	202	2000	2010	2020
GDP per capita (Yuan)	0.048**	0.036**	0.018**	0.046**	0.028**	0.018**
	(2.253)	(1.889）	(1.235)	(2.242)	(1.746)	(1.218)
Average urban wage (Yuan)	0.048**	0.066*	0.047**	0.035**(2	0.042*	0.020**
	(2.533)	(3.089）	(2.435)	.242)	(1.746)	(0.918)
Scientific research funds (Yuan)	0.058*	0.039**	0.034**	0.041**(0	0.039**	0.034**

	(0.658)	(1.787)	(0.911)	.658)	(1.787)	(0.911)
Teacher-student ratio	0.058*	0.62*	0.057*	0.054*	0.058*	0.054*
	(0.658)	(0.330)	(0.634)	(0.538)	(0.420)	(0.586)
Number of cultural institutions	0.034**	0.035**	0.032**	0.032**(0	0.030**	0.028**
(Number)	(0.261)	(0.581)	(0.184)	.165)	(0.581)	(0.184)
Number of hospital beds per	0.055*	0.048**	0.054*	0.052*	0.058*	0.054*
10,000 people (Number)	(0.181)	(0.581)	(1.264)	(2.181)	(1.856)	(1.964)
Forest coverage (%)	0.058*	0.066*	0.068*	0.066*	0.078*	0.068*
	(2.253)	(1.889）	(2.564)	(1.564)	(1.716)	(1.615)
Provincial capital, municipality	0.048**	0.052*	0.032**	0.064*	0.041**	0.022**
(yes =1, no =0)	(2.253)	(2.465)	(0.114)	(2.025)	(1.164)	(0.902)
Tertiary industry increase index	0.052*	0.041*	0.037**	0.031**(0	0.024**	0.008***
	(0.474)	(1.250)	(1.684)	.511)	(1.434)	(2.814)
Population density	0.014**	0.008***	0.003***	0.014**(0	0.007***(	0.003***(
	(0.856)	(0.011)	(0.032)	.856)	0.011)	0.032)
Constant	110.099	0.364	181.941	0.264	266.481	0.358
	(1.741)	(3.171)	(0.885)	(2.171)	(0.178)	(0.939)
Observed number	21	21	21	21	21	21
Adjust R^2	0.9723	0.964	0.922	0.982	0.945	0.962

Note: Use robust standard error t values in parentheses:*p<0.1, **p<0.05, ***p<0.01

The data shows a significant positive correlation between administrative hierarchy, talent density, and talent proportion over three different periods. The higher the administrative level of a prefecture-level administrative unit, the stronger its ability to attract talents. Over time, the impact of administrative hierarchy on talent density weakens, but its impact on the proportion of talent increases. HET tend to migrate to areas that provide more employment opportunities and higher salaries. The average salary and per capita GDP of various urban areas in Guangdong Province have significantly increased between 2000 and 2020, and the positive correlation between salary levels, talent density, and talent proportion has increased over time.

There is a significant positive correlation between the number of universities and the density and proportion of talents, while the correlation between the proportion of middle school students and teachers and the proportion of talents is increasing year by year. The impact of research environment on talent density and proportion is gradually increasing. Medical and cultural atmosphere have a certain impact on talent density and proportion, and the number of cultural institutions is significantly correlated with talent density and proportion. The forest coverage rate maintains a significant positive correlation with the density and proportion of talents. However, HET are more affected by economic, social, and cultural factors and are concentrated in the PRD, while there are fewer in eastern and western Guangdong.

V. CONCLUSION

This study uses China's census data from 2000 to 2020 and analyzes the distribution pattern of highly educated talents in Guangdong Province and its main influencing factors in the past 20 years through the Theil index, multiple linear regression model, and geodetector model. On this basis, make optimization suggestions.

Research shows that: (1) Guangdong's highly educated talents are concentrated in economically developed cities in the PRD region, showing a spatial distribution pattern of "dense in the PRD and sparse in other regions," with Guangzhou and Shenzhen having the highest concentration of talents. (2) Before and after 2010, there was a clear gap in the change rate of the density of highly educated talents in various cities in the province. The growth rate was faster

before 2010, but the growth rate slowed down after 2010. The change rate of the proportion of talents shows a trend of "fast growth in the PRD region and slow growth in other regions." (3) The imbalance in the density and proportion of highly educated talents among cities is on the rise. Through geodetector model analysis, it was found that administrative level, scientific research environment, and economic opportunities are the three main factors affecting the distribution pattern of highly educated talents in Guangdong Province.

Based on the above, this article will propose relevant policy optimization suggestions for optimizing administrative levels, scientific research environments, economic opportunities, and other aspects to enhance talent aggregation. Firstly, in terms of administrative hierarchy, a hierarchical talent management mechanism should be established. Provincial governments should formulate macro talent policies, while governments below the city level should develop specific talent introduction and training plans based on their own characteristics and needs. Establish talent mobility incentive policies: Encourage highly educated talents to move from developed regions to underdeveloped regions, such as recommending talents from the Pearl River Delta region to other regions for job support. Secondly, in terms of the scientific research environment: enhance the construction of scientific research platforms, increase investment in scientific research projects, and provide sufficient scientific research projects and financial support for scientific research institutions at different administrative levels. Thirdly, in terms of economic opportunities: developing regional characteristic industries, cultivating and strengthening regional characteristic industries based on local resource endowments, and providing more employment and entrepreneurial opportunities for highly educated talents. At the same time, strengthen support for higher education, especially for universities in poverty-stricken areas, to optimize talent distribution.

The analysis results of this study not only reveal the patterns of talent mobility and distribution, providing new research perspectives and methods for population geography, but also provide reference and inspiration for the formulation of talent strategies, optimization of educational resources, and regional coordinated development in Guangdong Province.

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