Spatial Distribution Pattern and Prediction of Pension Pressure in Provinces of China

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ABSTRACT: Along with China stepping into the aging society, pension pressure has become a social livelihood issue. This paper firstly defines the concept of pension pressure standing on the employment. On this basis, the research uses the spatial autocorrelation and standard deviation ellipse to study the spatial distribution pattern and evolution characteristics of pension pressure. Furthermore, the study constructs the GM (1,1) model to predict the trend of pension pressure. Based on the data collected from 31 provinces from 1995 to 2016, it found out that the pension pressure in China shows a slow upward trend generally. The growth of the pension pressure has a spatial agglomeration effect, and the pension pressure is characterized by a general pattern of divergent spatial distribution, mainly in the East-West direction and supplemented by the North-South direction. In addition, the future distribution pattern of pension pressure in China will shift from "Northeast to Southwest" to "North to South", and it will basically become stable in the future.

1. INTRODUCTION

According to the latest United Nations standards, more than 7% of population in a region is aged. By the end of 2017, the number of the elderly aged over 65 in China was 150 million, accounting for 10.8% of the total population. The aging situation in China is quite serious, causing high pension pressure. According to the Bloomberg Sunset Index released by the United States in 2017, there’s an average of 3.5 on-the-job employees supporting one elderly person, which ranks fifth among the most aging countries in the world. The heavy pension pressure not only restricts the development of the national pension cause, but also adversely affects the economic and social development. Influenced by the uneven geographical distribution of factors such as the degree of aging and endowment resources in China, the pension pressure shows regional differences. Therefore, it is of great practical significance to know and predict the spatial distribution pattern of pension pressure in China, to understand the regional differences and evolution trends of pension pressure, and to formulate targeted pension policies in different regions.

Scholars have carried out a lot of research on the pension pressure. It mainly focused on pension, pension system, old-age security, the level and source of pension pressure. For example, Sambt et al. and Fu [1,2] think that the change of population structure is an important factor hindering the
development of public pension system through the analysis of the present situation of population aging in China. Tim et al. [3] prove the negative effect of fiscal shortage and government pressure on pension plans. Gui [4] finds out that the endowment insurance in China will face pressure of economic development lagging behind population aging and family size miniaturization. Chen [5] proposes that the pension pressure is mainly concentrated on the elderly through the construction of "long-term" and "short-term" family life-course, and the "421" family structure hypothesis exaggerate the pension pressure. Lanzieri et al. [6] compare and predict pension pressure in each European country, which shows that the pension pressure in Europe will increase in the future. Xiong [7] researches on the only-child family, finding out that the main pressure of the only-child pension focus on the life care and spiritual support of the elderly.

In recent years, many scholars have carried out in-depth research on the influencing factors and alleviation countermeasures of pension pressure. For example, Wang et al. [8] use questionnaires to study the pension dilemma of empty nesters in cities, proving that the lack of social pension services is an important cause of pension pressure. Jin et al. [9] construct linear regression to study the influencing factors of pension pressure of urban and rural residents, which proves that economic income has a significant impact on pension pressure. However, Lee et al. [10] find out that pension pressure has a negative impediment to economic development. In addition, Lin [11] believes that it is an important way to alleviate the pension pressure of the empty-nest elderly by changing the land using pattern and improving the land circulation management, and providing funds for the family and institutional pension of the elderly.

Existing studies have explored the problem of pension pressure from the perspectives of manifestations, sources, influencing factors and coping measures. However, there is no clear definition of the pension pressure, neither the spatial distribution pattern of pension pressure at county level. Therefore, this paper firstly defines the concept of pension pressure standing on the employment. Then, it uses spatial autocorrelation and standard deviation ellipse to study the spatial distribution pattern and evolution characteristics of pension pressure. Furthermore, based on the data results of standard deviation ellipse, this paper structures GM (1,1) model to predict the trend of pension pressure. The results will establish the theoretical basis for government departments formulating effective regional pension policies.

2. CONCEPT DEFINITION AND DATA SOURCES

2.1 Definition of Pension Pressure
The pension pressure in this paper refers to the number of elderly that an employed need to support within a closed economic region, which standing on the needs of economic support, spiritual comfort, life care and medical care for elderly. The employed people refer to who aged 16 or above, engaged in certain work or business income and obtain labor remuneration or economic income. The elderly people refer to who aged 65 or over in this economic region.

2.2 Data Sources
The data needed in this paper include the population, household registration population, elderly population and employment population of 31 provinces in China from 1995 to 2016. It comes from China Statistical Yearbook, China Population and Employment Statistical Yearbook, provincial statistical yearbooks, the fifth and sixth census data. In addition, the GIS graphics data are collected from the 1:4000000 database of the National Basic Geographic Information Center.
3. METHOD INTRODUCTION

3.1 Spatial Autocorrelation
The spatial distribution pattern of pension pressure mainly refers to its spatial agglomeration. This paper uses exploratory spatial data analysis to study the spatial agglomeration of pension pressure, mainly including global and local spatial autocorrelation analysis.

3.1.1 Global Spatial Autocorrelation
The global Moran's I exponential formula is:

$$I = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij} (X_i - \bar{X})(X_j - \bar{X})}{\sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij} \sum_{i=1}^{n} (X_i - \bar{X})^2}$$

(1)

In formula (1), \(n\) is the number of units studied; \(X_i\) and \(X_j\) are the attribute values of different spatial units \(i\) and \(j\); \(\bar{X}\) is the average of attributes \(X\); \(S\) is the variance of values \(X\) and mean values \(\bar{X}\); \(W_{ij}\) is the spatial weight matrix. The range of Moran's I is \([-1,1]\). When the global Moran's I is greater than 0, it indicates that there is a positive spatial correlation; the global Moran's I is less than 0, indicating that there is a negative spatial correlation; and the global Moran's I is equal to 0, indicating that there is no spatial correlation and belongs to random distribution.

3.1.2 Local Spatial Autocorrelation
The local Moran's I exponential formula is:

$$I_i = \frac{(X_i - \bar{X}) \sum_{j=1}^{n} W_{ij} (X_j - \bar{X})}{S}$$

(2)

In formula (2), \(W_{ij}\) is the spatial weight matrix, \(X_i\) is the attribute value of the spatial unit \(i\), \(S\) is the standard deviation. When the index is positive, it indicates the existence of high-value agglomeration; when the index is negative, it indicates low-value agglomeration. The clustering results can be visualized in ArcGIS software, HH type represents high value clustering, HL type represents high value surrounded by low value, LH type represents low value surrounded by high value, LL type represents low value clustering.

3.2 Standard Deviation Ellipse
Li et al. [12] point out that the standard deviation ellipse is an important method for measuring the direction trend of data. It consists mainly of four elements: the center of the circle, the corner \(\theta\), and the standard deviation along the \(X\)-axis and \(Y\)-axis. The center of the ellipse is the center of the arithmetic mean, and the corner \(\theta\) is calculated as follows:

$$\tan \theta = \frac{\sum_{i=1}^{n} (X_i - \bar{X})^2 - \sum_{i=1}^{n} (Y_i - \bar{Y})^2}{2 \sum_{i=1}^{n} X_i Y_i}$$

(3)

In equation (3), \(\theta\) is the rotation angle, \(\bar{X}\) and \(\bar{Y}\) is the center of the coordinates \(X\) and average. \(\sigma_x\) and \(\sigma_y\) is the standard deviation of \(-\text{axis}\) and \(-\text{axis}\), which is:

$$\sigma_x = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n}}$$

$$\sigma_y = \sqrt{\frac{\sum_{i=1}^{n} (Y_i - \bar{Y})^2}{n}}$$

(4)

4. EMPIRICAL ANALYSIS

4.1 Spatial Distribution Characteristics of pension Pressure
The value of pension pressure of 31 provinces in China from 1995 to 2016 is obtained by using ratio with number of the elder to employed. In 1995, the national average pension pressure was 0.1207, of which the top 5 were Shanghai, Beijing, Tianjin, Zhejiang and Liaoning. The last rankings were Guizhou, Tibet, Ningxia, Gansu and Qinghai. In 2016, the national average pension pressure was 0.1710. The top 5 were Sichuan, Shanghai, Jiangsu, and Liaoning, and the last were Fujian, Xinjiang, Guangdong, Qinghai and Tibet.
This study divides the pension pressure of various provinces in 5 levels visualizing in ArcGIS software according to the 1995 and 2016 pension pressure values (Figs. 1 and 2). It can be seen that the pension pressure in various provinces are increasing. Heilongjiang, Liaoning, Jilin, Shanxi, Sichuan and Anhui have been a significant increase in the ranking of pension pressure. The trend of pension pressure has shifted from south to north. It’s because the rapid development of the economy in eastern coastal cities has attracted a large influx of talents from the northeast and central-western regions, which has become the main gathering place for the floating population. The immigration of labor will accelerate economic development and improve service facilities such as old-age care, which has led to the rise in the ranking of urban pension pressure. It is worth mentioning that Sichuan and Chongqing are areas with the most serious population loss except three provinces in northeast of China. However, there’s no actions on the introduction of talents, it should be highly involved with local government.

4.2 Spatial Agglomeration Effect of Pension Pressure

4.2.1 Spatial Agglomeration of Pension Pressure Level

Using the spatial analysis function in ArcGIS software to calculate the global and local Moran’s I of pension pressure in 1995, 2000, 2005, 2010 and 2016 (Table 1). It shows that there was a spatial agglomeration in Chinese provincial pension pressure in 1995 and 2000, but the agglomeration effect decreased with time. However, in 2005, 2010 and 2016, there was no spatial agglomeration in the pension pressure, and the degree of dispersion gradually was increasing. The local Moran’s I clustering results shows that the agglomeration effect of the pension pressure space in China was gradually weakened, and the HH and LL type were gradually less. From 1995 to 2016, the HH type shifted from the southeast of Anhui, Jiangsu, Shanghai, Zhejiang, etc. to the northeast direction of Liaoning, Jilin and Shangdong. The pension pressure in China shows a "Northeast-Western" polarization.

| Year | 1995 | 2000 | 2005 | 2010 |
|------|------|------|------|------|
| Global Moran’s I | 0.2241 | 0.1828 | 0.0489 | 0.0514 |
| Sig | 0.0005 | 0.0037 | 0.2790 | 0.4742 |
4.2.2  Spatial Agglomeration of Pension Pressure Growth
This paper calculates the global and local Moran's I of the growth rate of pension pressure from 1995 to 2000, 2000 to 2005, 2005 to 2010, 2010 to 2016 (Tables 2). It can be seen that there is spatial agglomeration in the growth rate of pension pressure in China, the agglomeration effect is also weakening. Compared to the clustering results of pension pressure, the HH type shift from northeast to southwest, while the growth rate is faster in Sichuan, Chongqing, Shanxi and Ningxia. LL types are mainly distributed in Zhejiang, Fujian, Anhui, Guangxi and Guangdong. Different from the distribution of pension pressure, the growth rate of pension pressure presents a multipolar distribution.

| Year       | 1995~2000 | 2000~2005 | 2005~2010 | 2010~2016 |
|------------|-----------|-----------|-----------|-----------|
| Global Moran’s I | 0.2178    | 0.1651    | 0.1421    | 0.1408    |
| Sig        | 0.0011    | 0.0117    | 0.0004    | 0.0236    |

4.3  Evolution Characteristics of Spatial Pattern of Pension Pressure
This paper structures the standard deviation ellipse model based on data of pension pressure in 1995, 2000, 2010 and 2016, and the ellipse center is marked on the map (Figs. 3 and 4). It can be seen that the standard deviation elliptical coverage areas are mainly concentrated in the eastern and central areas of China, including Beijing, Tianjin, Hebei, Shanxi, Shandong, Shanghai, Zhejiang, Sichuan, Chongqing, Hunan, Anhui, Jiangxi, Hubei and Henan.

Figure 3. Discrete trend of spatial pattern of pension pressure

Figure 4. The center of Standard deviation ellipse transfer
The ellipse gradually moved from southeast to northeast during the period from 1995 to 2016, the area decrease slowly, indicating that the pension pressure in China gradually and steadily increases from the perspective of ellipse area. The center of the standard deviation ellipse mainly concentrates in Nanzhao County, Nanyang City, Henan Province, it moves slowly from south to north. In the view of elliptical half-axis, the standard deviation the X-axis and Y-axis are gradually smaller, X-axis fluctuates between 13.1955 and 13.8876, and Y-axis fluctuates between 8.8021 and 9.2804. It shows that pension pressure in China is characterized by a general pattern of divergent spatial distribution, mainly in the East-West direction, supplemented by the North-South direction, and both directions are gradually
increasing the overall pattern characteristics. From the perspective of angle range $\theta$, it changes from 68.4172 degrees to 74.0035 degrees, tends to decrease gradually. The spatial distribution of pension pressure in China generally presents a pattern of "Northeast to Southwest" and it has a trend to "South to North" pattern.

### 4.4 Prediction of Spatial Distribution Pattern of Pension Pressure

The Grey Prediction Model has the characteristics of high forecasting accuracy, which is suitable for short-term and medium-term forecasting. According to the data characteristics of elliptic parameters with standard deviation, this paper combines standard deviation ellipse with GM (1,1) model to forecast the direction trend of pension pressure in China. The prediction accuracy of GM(1,1) model is shown in Table 3, the forecast results of standard deviation parameters from 2017 to 2021 are shown in Table 4. As can be seen from Table II, there is a great forecasting results with the accuracy above 92%.

**Table 3. Prediction of elliptic parameter prediction model with standard deviation**

| Model prediction accuracy | Central coordinates $(x,y)$ | Standard deviation along X-axis /km | Standard deviation along Y-axis /km | corner $\theta$/° |
|---------------------------|-----------------------------|-----------------------------------|-----------------------------------|-------------------|
| (0.9984,0.9991)           | 0.9943                      | 0.9588                            | 0.9290                            |

**Table 4. Standard deviation elliptic parameter prediction**

| Year | Central coordinates $(x,y)$ | Standard deviation along X-axis /km | Standard deviation along Y-axis /km | corner $\theta$/° |
|------|-----------------------------|-----------------------------------|-----------------------------------|-------------------|
| 2017 | (112.1981° E, 33.9422° N)   | 13.3583                           | 8.9326                            | 70.4492           |
| 2018 | (112.1739° E, 33.9718° N)   | 13.3429                           | 8.9157                            | 70.3292           |
| 2019 | (112.1497° E, 34.0015° N)   | 13.3275                           | 8.8987                            | 70.2094           |
| 2020 | (112.1013° E, 34.0312° N)   | 13.3121                           | 8.8818                            | 70.0899           |
| 2021 | (112.0771° E, 34.0610° N)   | 13.2968                           | 8.8649                            | 69.9705           |

It can be seen from Table 4 that the standard deviation along the X-axis varies from 13.2968 to 13.3583, along the Y-axis varies from 8.8649 to 8.9326, and the concentration trend along Y-axis is slightly higher than that along X-axis. It proves that the pension pressure in China will continue to grow in the future, and the center of pension pressure will move from south to north. The elliptical center moves from south to Chongxian County, Luoyang City, Henan Province. As can be seen from the angle of rotation, the range is from 69.9705 degree to 70.4492 degree. It can be seen that pension pressure in China is still characterized by the overall pattern of East-West orientation, supplemented by North-South orientation in the future, and the distribution pattern tends to be stable, with a gradual northward trend.

### 5. CONCLUSION

This paper defines the concept of pension pressure, studies and predicts the spatial distribution pattern of pension pressure by spatial autocorrelation, standard deviation ellipse and GM(1,1) model. The results show that the pension pressure is mainly concentrated in the northeast of China, and there is a slow upward trend in Sichuan and Chongqing. There is no spatial agglomeration of pension pressure in the global area, but there is spatial agglomeration in the local area. The HH area is mainly concentrated in Heilongjiang, Jilin, Liaoning, Shandong, while LL type is mainly concentrated in Xinjiang, Tibet and Qinghai. The pension pressure is characterized by a general pattern of divergent spatial distribution, mainly in the East-West direction and supplemented by the North-South direction. In addition,
distribution pattern of pension pressure in China will shift from "Northeast to Southwest" to "North to South" the future, and it will basically become stable. The problem of pension pressure in China is structural at present. Unbalanced population migration makes the aging difference between the net inflow area and the net outflow area larger, which brings spatial differences and agglomeration to pension pressure. However, the pension pressure is also influenced by other factors, such as economy, society and culture. Those reasons should be further explored in the future.

ACKNOWLEDGMENTS
This research was financially supported by Zhijiang Youth Project of Zhejiang Province Social Science Planning (Grant Nos. 16ZJQN017YB), Key Project of State Statistical Bureau (Grant Nos. 2015LZ14), Science and Technology Innovation Program for College Students in Zhejiang Province (Grant No. 2018R407065), Foundation for Fostering Excellent Dissertations of Postgraduates of Hangzhou Dianzi University (Grant No. yxlw2018019).

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