Analysis and prediction of China's future pension industry based on fitting algorithm and BP neural network

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Abstract. In this paper, we analyze and forecast China's future pension industry. We first use the fitting algorithm to predict the number of elderly population in the future. Then BP neural network is used to predict the willingness of the elderly at all levels to stay in pension institutions, and then the market demand scale of the number of elderly service beds in China in the future is obtained. Finally, we get that in 2023, the demand for elderly care beds in China is expected to reach 16.7 million, and urban beds will dominate, accounting for 86.83% of all beds.

Keywords: Fitting algorithm BP neural network Elderly care beds.

1. Introduction
As the saying goes, one old man is like one treasure. Now China has entered an aging society, and the degree of aging is becoming more and more serious [1,2]. A young family often has to provide for four old people, so nursing homes and related industries are favored by many young and old people [3]. Although China's pension industry is booming, there are still many deficiencies to be improved. Due to China's large population and different levels of pension demand, it is urgent to solve the problem of pension service [4]. China's current pension model is mainly family pension, community pension and institutional pension, among which the types of institutional pension are public nursing homes, private nursing homes, public nursing homes, etc [5]. However, the existing supply of elderly service beds can not meet the needs of the society, increasing the number of elderly service beds is an urgent practical problem to be solved [6].

Based on the population, structure and consumption level of China, this paper forecasts the market demand scale of the number of elderly care beds [7].

2. Fit past data and predict future data
This paper will forecast the market demand scale and structure of the number of elderly care beds. We use the fitting method to predict the elderly population in the next five years with the number of the elderly population in the past few years, and use the urban population rate in the past few years to predict the population distribution of urban and rural areas in the next five years.

First of all, we build a fitting model based on the elderly population in China from 2011 to 2018, and predict the elderly population in the next five years. We get the following data and figures 1.
\[ x_1 = 930.2a - 2852000 \]  

(1)

Where \( x_1 \) is the number of elderly population (10000), \( a \) is the year.

It can be seen from \( R^2 \) that the fitting degree of this linear fitting model is very high, and it can accurately predict the elderly population of China in the next five years.

According to the fitting curve, we predict the population of the elderly in China in the next five years, as shown as table 1.

| particular year | Elderly population (10000) |
|-----------------|---------------------------|
| 2019            | 26073.8                   |
| 2020            | 27004.0                   |
| 2021            | 27934.2                   |
| 2022            | 28864.4                   |
| 2023            | 29794.6                   |

Similarly, we use the urban population rate of the past decade to predict the proportion of urban and rural population in the next five years. And use the fitting method to predict the residents’ per capita disposable income, per capita consumption expenditure, per capita pension and dependency ratio of the elderly in the next five years. The fitting formula, chart and data are as follows.

The fitting results of urban population rate are as follows figures 2:

\[ x_2 = 0.01188a - 23.36 \]  

(2)

Where \( x_2 \) is the urban population rate.
The fitting results of per capita disposable income of residents are as follows figures 3:

\[ x_3 = 1967a - 3942000 \]  

(3)

![Fig.3 Fitting chart of per capita disposable income of residents](image)

\[ R^2 = 0.9977 \]

Where \( x_3 \) is the per capita disposable income of residents (yuan).

The fitting results of per capita consumption expenditure of residents are as follows figures 4.

\[ x_4 = 1316a - 2636000 \]  

(4)

![Fig.4 Fitting chart of per capita consumption expenditure of residents](image)

\[ R^2 = 0.9989 \]

Among them, per capita consumption expenditure of residents (yuan).

The fitting results of per capita pension are as follows figures 5:

\[ x_5 = 3141a - 6299000 \]  

(5)

![Fig.5 Fitting chart of per capita pension](image)

\[ R^2 = 0.9980 \]

Where \( Z \) is the per capita pension of residents (yuan).

The fitting results of dependency ratio of the elderly were as follows figures 6:

\[ x_6 = 0.005679a - 11.3 \]  

(6)
Where $x_6$ is the dependency ratio of the elderly.

Through the above fitting results, we find that the fitting curves are linear functions, and the goodness of fit of $R^2$ is close to 1. We can think that the fitting results of linear function are good, and we can predict the data in the next five years, as shown in the table 2 below:

### Table 2. Data forecast for the next five years

| Particular year | Urban population rate | Per capita disposable income of residents (yuan) | Per capita consumption expenditure of residents (yuan) | Pension per capita (yuan) | Dependency ratio for the elderly |
|-----------------|-----------------------|--------------------------------------------------|------------------------------------------------------|---------------------------|----------------------------------|
| 2019            | 62.57%                | 29373.00                                         | 21004.00                                            | 42679.00                  | 16.59%                           |
| 2020            | 63.76%                | 31340.00                                         | 22320.00                                            | 45820.00                  | 17.16%                           |
| 2021            | 64.95%                | 33307.00                                         | 23636.00                                            | 48961.00                  | 17.73%                           |
| 2022            | 66.14%                | 35274.00                                         | 24952.00                                            | 52102.00                  | 18.29%                           |
| 2023            | 67.32%                | 37241.00                                         | 26268.00                                            | 55243.00                  | 18.86%                           |

3. **BP neural network prediction**

This paper establishes a BP neural network model based on the relationship between the willingness of the elderly to stay in pension institutions ($\beta_1$~$\beta_6$) and the per capita disposable income, per capita consumption expenditure, per capita pension and dependency ratio of the elderly ($x_5$~$x_6$).

Among them, $\beta_1$ is the willingness of the urban elderly to move into the pension institutions, $\beta_2$ is the willingness of the rural elderly to move into the pension institutions, $\beta_3$ is the willingness of the urban high-income elderly to move into the pension institutions, $\beta_4$ is the willingness of the urban middle-income elderly to move into the pension institutions, $\beta_5$ is the willingness of the urban low-income elderly to move into the pension institutions, $\beta_6$ is the willingness of the rural high-income elderly to move into the pension institutions, $\beta_7$ is the willingness of the rural middle-income elderly to move into the pension institutions, and $\beta_8$ is the willingness of The willingness of rural low-income old people to live in pension institutions.

According to the above BP neural network fitting, we predict the data in the next five years:

### Table 3. Forecast of willingness rate in the next five years

| Particular year | city | country | Urban high income | Income in the city | Urban low income | High income in rural areas | Rural middle income | Rural low income |
|-----------------|------|---------|-------------------|-------------------|-----------------|---------------------------|-----------------|-----------------|
| 2019            | 7.68%| 2.29%   | 16.14%            | 11.59%            | 3.42%           | 3.14%                     | 2.79%           | 1.25%           |
| 2020            | 7.59%| 2.32%   | 16.41%            | 11.51%            | 3.39%           | 3.09%                     | 2.79%           | 1.30%           |
| 2021            | 7.49%| 2.28%   | 16.52%            | 11.31%            | 3.38%           | 3.07%                     | 2.75%           | 1.33%           |
| 2022            | 7.36%| 2.26%   | 16.56%            | 11.18%            | 3.37%           | 3.06%                     | 2.70%           | 1.35%           |
| 2023            | 7.23%| 2.26%   | 16.57%            | 11.14%            | 3.37%           | 3.06%                     | 2.67%           | 1.37%           |
So far, we have predicted the number of elderly population, urban population rate and various willingness rates in the next five years. We have given the calculation formula of the market demand scale of the number of elderly service beds.

\[ y_1 = x_1 \times x_2 \times \beta_1 + x_1 \times (1 - x_2) \times \beta_2 \]  

(7)

Among them, \( y_1 \) is the total number of elderly care beds in China (10000 beds).

We forecast the market demand scale of the number of elderly care beds in the next five years, as shown in Table 4 and Figure 7.

| particular year | Urban beds (10000) | Rural beds (10000) | Total (10000 sheets) |
|-----------------|--------------------|--------------------|----------------------|
| 2019            | 1252.98            | 223.48             | 1476.46              |
| 2020            | 1306.83            | 227.04             | 1533.87              |
| 2021            | 1358.89            | 223.25             | 1582.13              |
| 2022            | 1405.01            | 220.91             | 1625.91              |
| 2023            | 1450.26            | 220.03             | 1670.29              |

Fig.7 Market demand forecast chart for the next five years

4. Conclusion
Through the fitting algorithm, we predict that the number of urban elderly beds and rural elderly beds from 2019 to 2023 will be 1252.98, 1306.83, 1358.89, 1405.01, 1450.26 and 223.48, 227.04, 223.25, 220.91, 220.03 respectively. In 2023, the total demand for elderly care beds in China is expected to reach 16.7 million, and urban beds will dominate, accounting for 86.83% of all beds. This shows that most of the pension pressure in China is still concentrated in cities.

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