ISSN 2616-5783 Vol.4, Issue 6: 99-108, DOI: 10.25236/AJHSS.2021.040616

Operation forecast and influencing factors analysis of pension market based on grey correlation analysis

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Abstract: *Aiming at the operation problem of pension market, this paper establishes multiple linear model, auto-regressive integral moving average model and other prediction models through data analysis of nursing service beds, multiple linear regression and grey correlation analysis, etc. programming software such as SPSS and MATLAB are used to make the prediction model of pension market, and the grey correlation degree is used to discuss the influence variables Through the research of population factor and economic factor, it is concluded that the most important factor affecting the number of nursing beds is per capita GDP.*

Keywords: *Nursing bed, multiple linear regression, grey correlation analysis, GDP per capita, forecast, MATLAB*

1. Introduction

With the passage of time, China's elderly population has gradually increased, and the social problem of aging has become increasingly prominent year by year. Because China has a large population base and different levels of old-age needs, it is extremely urgent to solve the problem of old-age services, especially the problem of old-age beds in the operation of the old-age market.At present, China's pension models are mainly family pension, community pension and institution pension, and various pension models have made different contributions to pension service. Different pension models have different demands for pension beds, and the existing pension service beds supply is far from meeting the needs of society, so it is urgent to increase the number of pension service beds.In this paper, from the perspective of enterprises, the profit points in the old-age service beds are explored. By means of data analysis, on the premise of forecasting the operation of the old-age market, the programming model is comprehensively used, various effective variables are selected, and the influencing factors are classified and processed by means of the internal relations among variables, and the most important factors affecting the old-age beds are obtained. Forecast the operation of the future pension market and analyze the influencing factors.

At present, domestic scholars have begun to increase their research on old-age services. Yin Yaping studied the planning strategy of urban old-age facilities under the balance of supply and demand, put forward the problems related to the construction of old-age facilities, defined the concept of urban old-age facilities, expounded a large number of relevant theoretical studies, and analyzed the current trends and characteristics of urban social and economic development.Summarize the main contradictions and study the countermeasures [1]; Li Dongmei and others have studied the application of PPP mode to promote the development of old-age service institutions. According to the theory of public goods and the theory of project differentiation, it is feasible to provide social old-age service through PPP mode when the government cooperates with social capital [2]; Lin Lei et al. studied the institutional pension needs in Beijing.Based on the life table of China Life Insurance, this paper calculates the age structure of the elderly population in Beijing under a certain number of years, and at the same time, calculates the demand quantity of the old-age market, finds out the contradictory problems existing in the supply and demand of the old-age market in Beijing, and puts forward relevant suggestions such as speeding up the construction of the old-age service system in turn [3];Wang Yirun and others explored the market demand and path of the "combination of medical care and nursing" old-age care model under the new situation, and concluded that under the current social and economic development, the combination of medical care and nursing has quickly become the direction of the transformation of old-age care models in various places. However, due to the late start of China's old-age care market, there are many problems such as

ISSN 2616-5783 Vol.4, Issue 6: 99-108, DOI: 10.25236/AJHSS.2021.040616

shortage of professionals and lack of medical insurance payment.Although local governments have issued policies to promote the development of the combination of medical care and nursing, the road to development is still rugged. Based on summarizing the current situation of supply and demand of the combination of medical care and nursing under the new situation, this paper discusses the future development path of this model from three major factors: state, institution and market [4]. Li Na analyzed the demand and supply of aged care services,In order to investigate the supply and demand situation of China's old-age service resources, this paper comprehensively calculates the supply and demand situation of three old-age services and other aspects by using CHARLS (China Health and Old-age Tracking Survey Database) data, and puts forward policy recommendations [5]; The prediction of China's urban residents' old-age insurance participation rate under the aging population of Zhu Jiaming is based on the participation rate data of previous years.The ARIMA model is used to predict the participation rate in the next three years, and relevant suggestions are put forward for the development of endowment insurance [6]. Ma Guihua and others predicted the demand of commercial health insurance under the background of population aging based on the combination forecasting model, and concluded that from 2018 to 2027, the average growth rate of commercial health insurance premiums in China was 43.4%, and the market potential of commercial health insurance was huge, which reflected the huge pension market demand [7]. Based on the population and economic factors, this paper explores the maximization of profits, finds out the influencing factors of the existing market on the old-age beds, and puts forward some suggestions for the development of China's old-age market.

2. Data sources and assumptions

The data are derived from the data of the proportion and quantity of the population of different ages in China from 2003 to 2018, combined with the statistical bulletin of China's population life table from 2017 to now, and the statistical yearbook of China's fifth census, so as to ensure the authenticity and reliability of the data sources. And collected and collated the survey data and results of some third-party organizations, A statistical survey of the willingness of the elderly to stay in old-age care institutions shows that around the world, about 5% of the elderly are willing to stay in old-age care institutions, and the willingness rate of some developed countries in Europe and America even reaches 35%; In China, the willingness to stay in old-age care institutions is higher than the global average, about 10%. According to the occupancy rate in China, The demand for old-age care institutions in China is about 17 million people. With the continuous development of China's social and economic level and the development process of China's aging, the demand for old-age beds in China will increase year by year in the future. Combined with the survey of residents' consumption ability, since 2013, the consumption level of residents in China has been continuously improved.However, according to the statistical bulletin on the development of human resources and social security in 2018, the total income of the basic old-age insurance fund is 5.5005 billion yuan, and the total expenditure of the fund is 4.755 billion yuan; At the end of the year, the accumulated balance of the basic old-age insurance fund was 5.8152 trillion yuan; The accumulated balance of basic old-age insurance and enterprise annuity is 7,292.2 billion yuan. Accumulated balance of endowment insurance plus enterprise annuity, China's pension reserve is only enough for one year, which is quite different from developed countries.

In order to facilitate the research, the following assumptions are put forward: (1) It is assumed that all factors representing and affecting the number of old-age beds are determined in the average sense of the whole society, and the selected indicators can quantify the bed demand within the acceptable error range. (2) During the forecast period, the society developed steadily, and there were no unpredictable natural disasters, political factors and other systematic influences on the indicators.Each index is relatively stable, even if there are changes, it is relatively regular. (3) The indicators used for forecasting are national statistical data, and their values do not change with the change of statistical methods.

3. Forecasting the market demand scale of the number of old-age service beds

3.1 Research ideas

To forecast the market demand scale of the number of old-age service beds, we first consider many factors such as population size, structure and consumption level in China, and on the basis of establishing a mathematical model, predict the market demand scale and classification of the number of old-age service beds. Therefore, this paper first analyzes the population system structure of the data,And find out the characteristics of the data and the laws reflected by these data, put forward a multivariate linear

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regression prediction model, and test the sensitivity of the constructed model, and use the time series model to correct the results.

3.2 Research methods

As a social system index, the number of old-age service beds is affected by many factors, such as population, economy and nature. In order to achieve the balance between supply and demand, it is necessary to make systematic analysis, such as variance analysis, ordinary regression analysis, GM(1,1) model [8, 9], etc., but it is often required to have a large amount of data and obey a typical probability distribution to find out its statistical law.Further analysis of grey relational grade shows that since urban population and rural population, female population and male population are the same group of grouped data on population, under the principle of minimizing parameters, this paper selects five factors as independent variables in multiple linear regression model to predict the size of old-age beds in China.

(1) Model establishment

Multivariate Logarithmic Linear Regression Model [10-14] is used to study the quantitative problem between the dependent variable (explained variable) and multiple independent variables (explained variables). The model can be used to predict and control the relationship between diversified variables. If the dependent variable is y, the independent variable is $x_1, x_2, ..., x_m$, the multivariate logarithmic linear regression model can be expressed as:

$$\boldsymbol{\hat{y} = b_0 + b_1 x_1 + b_2 x_2 + \cdots b_m x_m} \quad (1)$$

In which b0is a constant; B*i*is the partial regression coefficient, which represents the independent variable when controlling the linear influence of other variables on the dependent variable $x_i (i = 1, 2, 3...m)$ The linear regression model can be expressed as:

$$\begin{cases} y_1 = \beta_0 + \beta_1 x_{11} + \beta_2 x_{12} + \cdots + \beta_m x_{1m} + \varepsilon_1 \\ y_2 = \beta_0 + \beta_1 x_{21} + \beta_2 x_{22} + \cdots + \beta_m x_{2m} + \varepsilon_2 \\ \vdots \\ y_n = \beta_0 + \beta_1 x_{n1} + \beta_2 x_{n2} + \cdots + \beta_n x_{nm} + \varepsilon_n \end{cases} \quad (2)$$

The matrix form is$y = \beta x + \varepsilon$, where:

$$y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix}, x = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix}, \ \beta = \begin{bmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_n \end{bmatrix}, \varepsilon = \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_n \end{bmatrix} \quad (3)$$

According to the principle of calculus, when$Q$right$\hat{\beta}$ When the derivative is equal to 0, the solution can be obtained, namely$Q = 0$. among them,$Y(t)$Indicates the number of old-age service beds in China at a certain time point;$X_i(t)$It indicates the influencing factors of the number of beds in old-age service.

(2) Model solution

According to the above analysis, taking the size of the old-age service bed in China as the explained variable and the influencing factors as the explained variable, the linear diagram is drawn as shown in Figure 1.

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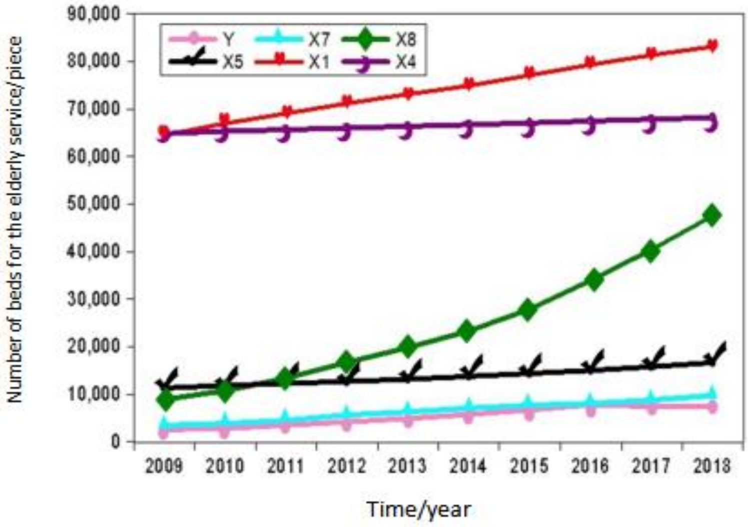

Figure 1: Data graph of old-age service beds and their influencing factors

It can be seen that there are obvious differences among the influencing factors, but the changing directions are basically the same, so we try to establish multiple linear regression functions. The number of beds in 2009-2018 is analyzed by using Eviews software, and the regression results of the linear regression model obtained by using ordinary least square method are shown in Figure 2.

Dependent Variable: Y
Method: Least Squares
Date: 05/23/20 Time: 19:34
Sample: 2009 2018
Included observations: 10

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	513363.3	439937.0	1.166902	0.3081
X7	-0.853891	0.906721	-0.941735	0.3996
X8	-0.056281	0.301792	-0.186490	0.8611
X5	0.393248	3.880888	0.101329	0.9242
X1	2.459767	1.393655	1.764975	0.1523
X4	-10.34955	8.548049	-1.210750	0.2926

R-squared	0.976852	Mean dependent var	5324.800
Adjusted R-squared	0.947916	S.D. dependent var	1997.624
S.E. of regression	455.8952	Akaike info criterion	15.36611
Sum squared resid	831361.6	Schwarz criterion	15.54766
Log likelihood	-70.83056	Hannan-Quinn criter.	15.16695
F-statistic	33.75969	Durbin-Watson stat	1.568151
Prob(F-statistic)	0.002290		

Figure 2: Fitting results of multiple linear regression model

Among $R^2 = 0.976852, F = 33.75969, P = 0.002290$, the model estimation results are as follows:

$$Y = C(1) + C(2) * X_7 + C(3) * X_8 + C(4) * X5 + C(5) * X_1 + C(6) * X_4 \tag{4}$$

$$= 513363.34 - 0.85 * X_7 - 0.06 * X_8 + 0.39 * X_5 + 2.46 * X_1 - 10.35 * X_4$$

(3) Residual test

After solving the above model, in order to further obtain the fitting effect of the model, the parameters of the above model are tested according to the residual analysis.

Figure 3 shows the fitting results of the actual scale of the old-age service beds and the residual results of the fitting model.

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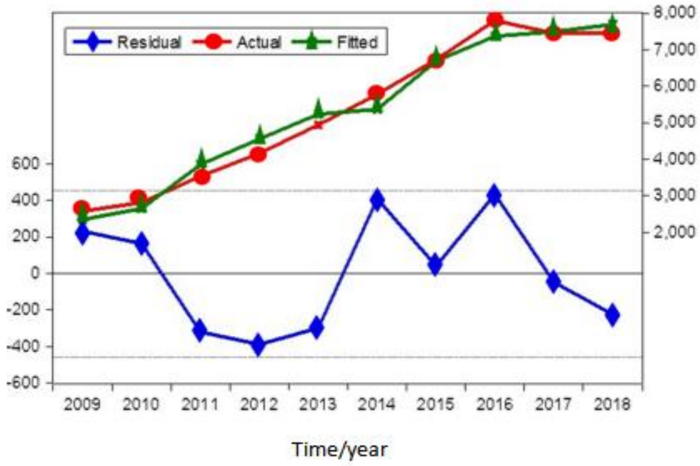

Figure 3: Actual scale fitting results and model residual results

It can be seen from Figure 3 that the prediction results of the actual old-age service bed size are basically consistent with the actual production trend, and the abnormal values of residual samples are few and fluctuate around zero. The model is verified by the known relevant data in 2018, and the verification results show that the accuracy of the multiple linear regression model is 81.06%, and the fitting results have good accuracy.

(4) $ARIMA$ Model solving

According to the time series analysis of the number of beds in old-age care institutions from 2009 to 2018, this paper preliminarily estimates the number of beds in old-age care institutions in 2019, which shows that the number of beds in old-age care institutions in 2019 is slightly less than 8 million, compared with the actual statistical data of 7.324 million in the first quarterly report of civil affairs statistics in 2019, with an accuracy rate of 91.55%, which verifies the correctness of the model.

In the establishment of multivariate linear regression equation, the original sample sequence has a certain degree of stability after feature analysis, which can be established$ARIMA(p,q)$Model [15-18], after inputting sample data into SPSS, the time series of the number of old-age service beds is shown in Figure 4.

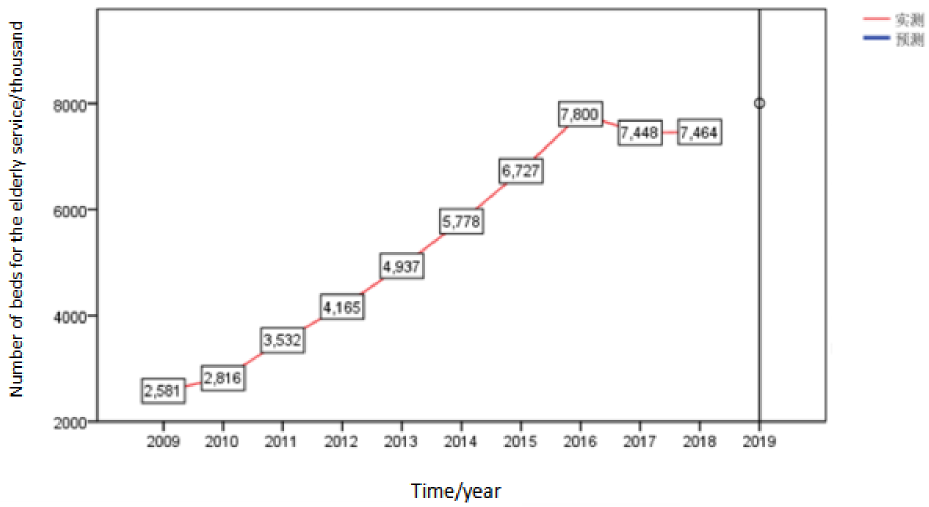

Figure 4: Simple time series analysis of the number of beds in old-age care institutions

4. Analysis of influencing factors of pension market

4.1 Research ideas

Based on the theory and method of public goods supply, this paper preliminarily determines the main factors affecting the number of old-age beds in China through the data given in the title and consulting

ISSN 2616-5783 Vol.4, Issue 6: 99-108, DOI: 10.25236/AJHSS.2021.040616

relevant literature. It mainly selects indicators from two aspects: population factors and economic factors to study the influence of each factor on the supply of home-based old-age services. Each major factor contains several sub-factors.Among them, population factors include urban populationx_1Number of rural population x_2 Number of men x_3 Number of women x_4 The number of elderly people x_5, the total population x_6 Economic factors cover per capita GDP x_7 Expenditure on financial basic old-age insurancex_8Two factors, such as the above eight indicators as explanatory variables, and the number of beds in urban and rural home care service institutions as explanatory variables.

4.2 Research methods

(1) Data preprocessing

Through sorting out the data in the ten years from 2009 to 2018, preliminary screening and classification are carried out, and the specific data are determined as shown in Table 1.

Table 1: Main factors affecting the number of old-age beds in China from 2009 to 2018

Year/ year	elderly care service Number of beds/thousand beds	Divided by urban and rural areas		Divided by sex		Elderly population/ 10,000 (over 65 years old)	Total population Several/ ten thousand people	per capita GDP/ USD	Financial basic pension Insurance expenditure/ 100 million yuan
		Urban population /10,000	Rural population /10,000	Male/10,000 people	Female/ ten thousand people				
2009	2 581	64 512	68 938	68 647	64 803	11 307	133 450	3 468.30	8 894.43
2010	2 816	66 978	67 113	68 748	65 343	11 894	134 091	3 822.24	10 755.32
2011	3 532	69 079	65 656	69 068	65 667	12 288	134 735	4 550.45	13 363.21
2012	4 165	71 182	64 222	69 395	66 009	12 714	135 404	5 618.13	16 711.53
2013	4 937	73 111	62 961	69 728	66 344	13 161	136 072	6 316.92	19 818.71
2014	5 778	74 916	61 866	70 079	66 703	13 755	136 782	7 050.65	23 325.81
2015	6 727	77 116	60 346	70 414	67 048	14 386	137 462	7 651.37	27 929.43
2016	7 800	79 298	58 973	70 815	67 456	15 003	138 271	8 078.79	34 004.29
2017	7 448	81 347	57 661	71 137	67 871	15 831	139 008	8 759.04	40 423.75
2018	7 464	83 137	56 401	71 351	68 187	16 658	139 538	9 770.85	47 550.41

According to the visual description statistics of sample data, as shown in fig. 5, all the influencing factors have changed steadily in the sampling time, showing an upward trend in different degrees, so it is reasonable to include the above eight indicators into the independent variables of the model.

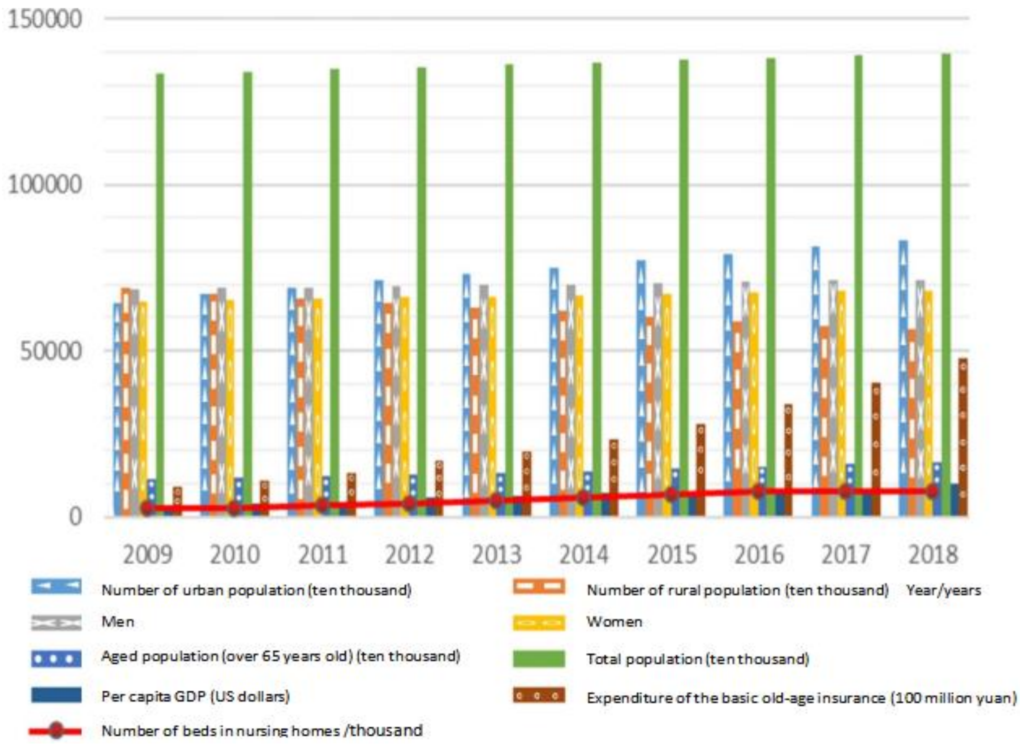

Figure 5: Statistical analysis of the main influencing factors of the number of old-age beds from 2009 to 2018

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(2) Determine that data sequence to be analyzed

Set a mother sequence and several subsequences$X_i(t)$Composition matrix:

$$Z=\begin{bmatrix} Y(1)Y(2)Y(3)\cdots Y(m) \\ x_1(1)x_1(2)x_1(3)\cdots x_1(m) \\ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\ x_n(1)x_n(2)x_n(3)\cdots x_n(m) \end{bmatrix} \tag{5}$$

In which the mother sequence$Y(t)$It represents the dependent variable of the sample, that is, the number of beds in the aged care service from 2009 to 2018, reflecting the system characteristics of the number of beds in the aged care institutions; subsequence$X_i(t)$Indicates the dependent variable of the sample, that is, the same period $[X1, X2, X3, X4, X5, X6, X7, X8]$ The value of, reflecting the main influencing factors of the number of beds in old-age care institutions, n=8,t=10 in this study.

(3) Dimensionless treatment

Because the units of each matrix are different and the data meanings are different, in order to enhance the comparability of data, it is necessary to eliminate the influence of dimension. In this paper, the mother sequence is obtained first Y_t and subsequences X_t the mean value of each index is divided by the mean value of each element in the index, and the dimensionless mother sequence is obtained $Y_t(k)$ and subsequence $X_t(k)$ the calculation formula is:

$$Y_t(k)=\frac{nY_t}{\sum Y_t}, X_i(k)=\frac{nX_i(t)}{\sum X_i(t)} \tag{6}$$

See Table 2 for sample data processing after de-dimensioning.

Table 2: The main factors affecting the number of old-age beds in China from 2009 to 2018

Year/ year	elderly care service Bed number	Divided by urban and rural areas		Divided by sex		Number of elderly population (over 65 years old)	Total population	Per capita GDP	Financial basic pension Insurance expenditure
		Number of urban population	Number of rural population	male	woman				
2009	0.484 7	0.871 0	1.104 5	0.981 5	0.973 9	0.823 5	0.977 8	0.532 9	0.366 4
2010	0.528 8	0.904 3	1.075 3	0.983 0	0.982 0	0.868 2	0.982 5	0.587 2	0.443 0
2011	0.663 3	0.932 6	1.051 9	0.987 6	0.986 8	0.897 0	0.987 2	0.698 9	0,550 4
2012	0.782 2	0.961 0	1.029 0	0.992 2	0.992 0	0.928 0	0.992 1	0.862 8	0.688 3
2013	0.927 2	0.987 1	1.008 8	0.997 0	0.997 0	0.960 7	0.997 0	0.969 9	0.812 6
2014	1.085 1	1.011 5	0.991 2	1.002 0	1.002 4	1.004 0	1.002 2	1.082 4	0.960 6
2015	1.263 3	1.041 2	0.966 9	1.006 8	1.007 6	1.050 1	1.007 1	1.174 5	1.150 1
2016	1.464 8	1.070 6	0.944 9	1.012 5	1.013 7	1.095 1	1.013 1	1.239 9	1.400 2
2017	1.398 7	1.098 3	0.923 9	1.017 1	1.020 0	1.155 6	1.018 5	1.344 1	1.664 5
2018	1.407 1	1.122 4	0.903 7	1.020 2	1.024 7	1.215 9	1.022 3	1.499 1	1.957 9
average/ mean value	5 324.8	74 067.6	62 413.7	69 938.2	66 543.1	13 699.7	136 481.3	6 508.674	24 277.687 9

(4) Calculate the correlation coefficient

First, calculate the mother sequence$Y_t(k)$And subsequence$X_t(k)$ the absolute difference between the series, calculated as follows:

$$a=\min(i)\,min(k)|Y_t(k)-X_i(k)| \tag{7}$$

$$b=max(i)\,max(k)|Y_t(k)-X_i(k)| \tag{8}$$

among$i$ =1,2,3,...,8; K=1,2,...,10. After MATLAB operation, it is obtained$a=$ 0.0018, $b=$ 0.6198.

Then calculate the mother sequence$Y_t(k)$And subsequence$X_t(k)$Correlation coefficient between, the calculation formula is:

$$y(Y_t(k),X_i(k))=\frac{a+\beta b}{|Y_t(k)-X_i(k)|+\beta b} \tag{9}$$

Here'sβTo resolve the coefficient,$\beta\in(0,1)$And its value does not affect the correlation analysis of parent sequence and subsequence.βThe larger the resolution is, the greater the resolution is. This paper takes 0.5 (i =1,2,3,...,8;k=1,2,...,10).

(5) Calculate the correlation degree

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The calculation formula is:

$$y(Y_t, X_i) = \frac{1}{n}\sum_{k=1}^{n} y(Y_t(k), X_i(k)) \tag{10}$$

The calculated result is the correlation degree between the values of the variables in the parent sequence and subsequence. The correlation degree of each subsequence to the parent sequence is arranged in order of size to form the correlation sequence, which directly reflects the importance and influence of each index to the parent sequence variables, and confirms the fitting degree between the parent sequence and each subsequence.

(6) Model solution

After the above analysis, we use MATLAB software to comprehensively solve the problem, and get the correlation coefficient between each influencing factor and the number of old-age beds, as shown in Figure 6.

	X1	X2	X3	X4	X5	X6	X7	X8
Y-2009	0.4477	0.3353	0.3864	0.3901	0.4792	0.3882	0.8694	0.7281
Y-2010	0.4548	0.3640	0.4080	0.4085	0.4801	0.4082	0.8453	0.7880
Y-2011	0.5382	0.4463	0.4915	0.4922	0.5734	0.4918	0.9008	0.7375
Y-2012	0.6379	0.5600	0.5996	0.5998	0.6841	0.5997	0.7968	0.7723
Y-2013	0.8430	0.7963	0.8210	0.8210	0.9078	0.8210	0.8821	0.7409
Y-2014	0.8128	0.7719	0.7932	0.7939	0.7972	0.7936	1.0000	0.7179
Y-2015	0.5859	0.5141	0.5503	0.5511	0.5959	0.5506	0.7837	0.7372
Y-2016	0.4427	0.3756	0.4090	0.4096	0.4587	0.4093	0.5840	0.8330
Y-2017	0.5107	0.3972	0.4508	0.4527	0.5637	0.4517	0.8578	0.5411
Y-2018	0.5290	0.3858	0.4508	0.4538	0.6288	0.4522	0.7631	0.3597

Figure 6: Correlation coefficient between various influencing factors and the number of old-age beds

The larger the number of diamonds, the more important the index is to the number of old-age service beds. The greater the influence, the more triangles, the smaller the influence. It can be preliminarily judged from this figure that all factors have different degrees of influence on the number of old-age service beds, and further quantitative analysis will be made next.

Each subsequence is X_i the correlation coefficient is further calculated as the arithmetic mean and the influencing factors $[X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8]$ See table 3 for details of grey correlation degree.

Table 3: Grey correlation degree of each influencing factor

factor	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
Grey correlation degree	0.5803	0.4946	0.5361	0.5373	0.6169	0.5366	0.8283	0.6956

From this, we can clearly draw the conclusion that the correlation order of each factor is: X_7 (GDP per capita) > X_8 (Financial basic endowment insurance expenditure) > X_5 (population over 65 years old) > X_1 (urban population) > X_4 (female population) > X_6 (total population) > X_3 (male population) > X_2 (rural population), among which the most important factor affecting the number of old-age beds is per capita GDP.

ISSN 2616-5783 Vol.4, Issue 6: 99-108, DOI: 10.25236/AJHSS.2021.040616

5. Conclusions and suggestions

5.1 Conclusion

With the increasing popularity of the old-age market, the demand for old-age beds is an important quantitative indicator of the development trend of the old-age market. From the research results of this paper, it can be seen that the demand for old-age beds tends to be precise. By forecasting the demand for old-age beds, it is concluded that the number of old-age beds in 2019 is slightly less than 8 million.According to the research on the influence of the number of old-age service beds, the most important factor affecting the number of old-age service beds is per capita GDP.

5.2 Suggestions

First, pay attention to economic development and promote local economy according to local conditions. As the main factor affecting the number of old-age beds, per capita GDP is the key to fundamentally improve the present situation of China's old-age market economy and alleviate the pressure of old-age care in various places. Promoting economic development and increasing the per capita GDP are the fundamental methods and measures to improve the present situation of old-age care in China.

Second, government departments should complete practical projects of the municipal government on time and with good quality. Public resources should be invested in individuals. Construction subsidies and bed subsidies play a vital role in promoting the development of old-age care institutions. From the perspective of the goal of old-age care services for sustainable development and social employment,In the future, the focus of the construction of old-age care institutions should gradually change from increasing the number and expanding the scale to adjusting the structure and improving the service to promote the supply-side reform of old-age care institutions.

Third, implement the bed subsidy strategy to guide the old-age care institutions to upgrade the bed function and improve the service level. From the implementation of the bed subsidy in China, the two allocation strategies of subsidizing according to the nursing level of the elderly and subsidizing according to the occupancy rate have certain universality and advantages.It can play a role in promoting the nursing level of old-age beds and meeting the market demand.

Fourth, promote the construction of aged care service team, guide the identification and training of aged care workers, study and establish the salary system of aged care workers, publish the monitoring results of market wages of aged care workers, and establish a unified information management system of aged care workers in the whole city.

Fifth, promote the development of private pension service industry. In the new era, the foundation of the development of China's pension industry revolves around private pension service industry, which is a powerful guarantee for vigorously promoting the market-oriented development of pension service.

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