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The Impact of Population Aging on GDP and Medical Expenditure in China

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Abstract: Population aging is a major social problem in the 21st century, which is also the main feature of human social development in the new century. Since the reform and opening up in China, with the significant development of social economy and the rapid progress of medical level, the average life expectancy has been improved to a large extend, which cause that the problem of population aging has become increasingly serious. This paper takes the proportion of elderly population in China as research object, applies VAR model to analyze and forecast the data with the aim to study its impact on GDP and medical expenditure. As is well-known, it is inevitable that proportion aging will inhibit economic growth and increase healthcare spending. This paper finds that this kind of effect is not immediate. Based on this lag, in order to reduce the negative impact of population aging, suggestions for the future work of government leaders and medical practitioners can be put forward.

Keywords: aging of population, GDP, medical expenditure, VAR model

1. Introduction

Population aging refers to the trend of continuous increase in the proportion of the elderly population (65 years old and above) in the total population compared with the percentage of the young people. In 1982, when China's National Bureau of Statistics first published data on aging, the proportion of elderly people in China was 4.9%. The following years witnessed a dramatic increase in the proportion of the elderly population, which exceeded 10% in 2014 and almost approached 15% in 2022.

Population aging is an inevitable trend in the development of human society. On the one hand, it is a sign of social progress. On the other hand, it also brings many problems to the society. The aging of the population will increase the financial burden of the younger generation, while the state should also allocate more money to pension funds, which includes the medical expenses. In addition, the relatively high age of the working population will seriously affect the labour production efficiency, while the consumption desire of the elderly is normally much lower than that of the young and middle-aged. Therefore, the aging of population reduced the accumulation of capital from both production and consumption, and restricts the sustainable development of economy [1].

The aging of the population began in France. In the end of 19th century, after entering the industrial society, there was a dramatic decline in the birth rate of France, and it became the most significant aging country in Europe, which caused an exploration wave of aging [2]. The early research on population aging was mainly carried out from the perspective of demography, but it was not until the

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last three decades that demographers began to pay attention to the study of geography. Represented by American scientists, who focused on the regional differences in the distribution of elderly population. They concluded that the elderly population in America is obviously concentrated in the core areas and remote tribes. Although Chinese scholars have only studied the aging of population for a relatively short time, they have achieved quite fruitful achievements, such as studying the characteristics, development rend and possbile problems in the future brought by the aging of population in China, which provided theoretical support for the policies of Chinese government [3,4].

At present, China is in the development stage to complete the building of a moderately prosperous society and accelerating socialist modernization. This is an important period for institutional transformation, structural adjustment and social reform. It is also a crucial period for dealing with the aging population. At present, China's aging population has become a very serious situation, facing the double pressure of aging population and overpopulation.

There are a great number of reasons contribute to this situation. First and foremost, the extension of average life expectancy. After the founding of New China, as a result of social stability, economic development and the improvement of medical conditions, the average life expectancy has been greatly increased, and the proportion of elderly population has soared. This is an inevitable trend caused by economic development [5]. Moreover, China's family planning policy is also a significant dominant. In recent decades, China has successfully implemented the family planning policy and carried out the principle of fewer and better births with the aim to control the sharp increase of population. With the persist effort, Chinese government succeeded in reducing the fertility rate. However, they ignored drawback of this policy and finally led to a relative rise in the proportion of elderly people [6]. In addition, economic development is always accompanied by population flow and migration. The young and middle-aged people in the economically underdeveloped areas tend to flow to the economically developed areas in order to earn more money and live a better life, resulting in the aging of population in the economically disadvantaged areas [7].

In comparison with developed countries, there are three characteristics about China's population aging process. Firstly, this process is extremely fast. It took Swedan 85 years, which has the biggest proportion of elderly people in the world, to increased its percentage from 7% to 14%, while China only spent 27 years to finish this goal. Its growth rate has surprised that of Japan, which is the country with fasted aging speed [8]. Secondly, the scale is enormous. China's population has exceeded 1.4 billion by 2022, which is the second largest country in the world. The large population base determines that China will experience the largest increase of the figure for elderly population in the world history. Thirdly, China's economic development is relatively backward. Even though it has become one of the largest economies in the world, per capita economic level is still low.

The rest of this article is structured as follows: Part 2 covers information about the data sources, data stability and the introduction of the model used in this article. Then it is followed by part 3, which makes a comprehensive discussion on the fitting results of VAR model, predicts the future trend of population aging, GDP and medical expenditure, with the analysis about the influence of the increase of population aging on GDP and healthcare spending in future periods. After that, there is a discussion about the focus, goals and importance of this article. Eventually, the fifth part briefly restates the final conclusions, and puts forward reasonable suggestions for government agencies and medical practitioners according to the results of this research.

2. Research Design

2.1. Data Source

The National Bureau of Statistics of the People's Republic of China (NBS), founded in August 1952, is an organ directly under the State council. It is not only in charge of national statistics and national

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economic accounting, but also the largest and most accurate database in China. Since the government did not lay emphasis on population and medical industry in the early years of the founding of New China, the accurate data of population aging and medical expenditure is failed to reach. Hence, this research only studies the years in which had all these three types of data, namely the period after 1990.Specially, because the population has been increasing every year since the founding of New China in 1949, undoubtedly that is not practical to only take the elderly population into consideration. Therefore, the total number of elderly people is divided by the total figure of population, with the aim to analyze the phenomenon more intuitively, and the resulting proportion of elderly people is use to analyze the data and study the impact of aging on GDP and healthcare spending.

2.2. Augmented Dickey–Fuller (ADF) Unit Root Test

Before completing the model construction, we first need to carry out unit root test on the model, which means to test its stationarity [9]. The original assumptions is that the model has unit root and is not smooth. According to the ADF test conducted by STATA, it can be seen from the Table 1 that the p-value of unprocessed GDP data is 0.0094, which is less than 0.01, Therefore, the original hypothesis can be rejected and consider that the data is stable. However, the p-value of the raw elderly population data and medical fund expenditure data is 1.0000 and 0.8847 respectively, which are greater than 0.01. Hence, the original hypothesis cannot be rejected and believe that the data is unstable. Modeling requires the use of stable data. With the aim to obtain the stable data, the data of proportion of the elderly and medical expenditure is differenced, and the p-value after the difference is 0.0001 and 0.0000 respectively, which are less than 0.01. Similarly, the original hypothesis can be rejected and believe that the data is stable.

Table 1: ADF test.

Variables	t-statistic	p-value
Raw		
GDP	-3.978	0.0094***
Proportion of 65+	1.831	1.0000
Expenditure	-1.313	0.8847
Difference		
Proportion of 65+	-5.121	0.0001***
Expenditure	-6.160	0.0000***

2.3. Vector Autoregression (VAR) Model

VAR model, whose full name is vector autoregressive model, was proposed by Sims[10] in 1980.Simply put, it is to use the model to describe the quantitative relationship between vectors. There are two applicable premises of VAR model. Firstly, can carry out regression, which means that the data should be stable. Secondly, regression occurs between vectors, and some relationships are in need between vectors.

In this paper, there are three time series variables $\{x_{t,1},x_{t,2},x_{t,3}\}$, which are respectively the response variables of the three regression equations, and the explanatory variables are the p-order lag values of these three variables, forming a ternary VAR(p) system:

$$x_{t,1} = a_1 + \emptyset_{11}x_{t-1,1} + \cdots + \emptyset_{1p}x_{t-p,1} + \beta_{11}x_{t-1,2} + \cdots + \beta_{1p}x_{t-p,2} + \delta_{11}x_{t-1,3} + \cdots + \delta_{1p}x_{t-p,3} + e_{1t}. \quad (1)$$

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$$x_{t,2} = a_2 + \emptyset_{21}x_{t-1,1} + \cdots + \emptyset_{2p}x_{t-p,1} + \beta_{21}x_{t-1,2} + \cdots + \beta_{2p}x_{t-p,2} + \delta_{21}x_{t-1,3} + \cdots + \delta_{2p}x_{t-p,3} + e_{2t}. \quad (2)$$

$$x_{t,3} = a_3 + \emptyset_{31}x_{t-1,1} + \cdots + \emptyset_{3p}x_{t-p,1} + \beta_{31}x_{t-1,2} + \cdots + \beta_{3p}x_{t-p,2} + \delta_{31}x_{t-1,3} + \cdots + \delta_{3p}x_{t-p,3} + e_{3t}. \quad (3)$$

Equation (1), (2) and (3) represent GDP, the proportion of aging population and medical expenditure respectively. Write the three equations together to get the matrix form (4).

$$\begin{bmatrix} x_{t,1} \\ x_{t,2} \\ x_{t,3} \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} + \begin{bmatrix} \emptyset_{11} & \cdots & \emptyset_{1p} \\ \emptyset_{21} & \cdots & \emptyset_{2p} \\ \emptyset_{31} & \cdots & \emptyset_{3p} \end{bmatrix} \begin{bmatrix} x_{t-1,1} \\ \cdots \\ x_{t-p,1} \end{bmatrix} + \begin{bmatrix} \delta_{11} & \cdots & \delta_{1p} \\ \delta_{21} & \cdots & \delta_{2p} \\ \delta_{31} & \cdots & \delta_{3p} \end{bmatrix} \begin{bmatrix} x_{t-1,3} \\ \cdots \\ x_{t-p,3} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{bmatrix}. \quad (4)$$

In particular, in equation (1), $a_1 + \emptyset_{11}x_{t-1,1} + \cdots + \emptyset_{1p}x_{t-p,1}$represents the linear function of past lags of GDP, while $\beta_{11}x_{t-1,2} + \cdots + \beta_{1p}x_{t-p,2}$ and $\delta_{11}x_{t-1,3} + \cdots + \delta_{1p}x_{t-p,3}$are past lags of the elderly and the medical spendin.Apart from them, e_{1t} is the error term. To sum up, GDP is modeled by its variable and the other two variables. Similarly, the equation (2) and (3) can be obtained [11].

3. Empirical Results and Analysis

3.1. Order of VAR Model

With the aim to find out the optimal lag order of the VAR model, the information criteria of LR likelihood, AIC statistics and other statistics are used to determine the order, whose purpose is to find the minimum statistic. The sign (*) after the figure represents the optimal order under the certain criterion.

Table 2:VAR model identification.

Lag	LL	LR	p	FPE	AIC	HQIC	SBIC
0	68.832		0.00	2.0e-07	-6.93085	-6.90561	-6.78172
1	133.033	128.38	0.601	6.0e-10	-12.7404	-12.6394	-12.1439
2	136.706	7.3451	0.029	1.1e-09	-12.1796	-12.0029	-11.1357
3	146.007	18.602	0.000	1.4e-09	-12.2113	-11.9589	-10.7201
4	163.611	35.207	0.000	1.0e-09	-13.1169	-12.7888	-11.1783
5	234.626	142.03	0.000	6.0e-12*	-19.6448	-19.241	-17.2589
6	1628.52	2787.8	0.000		-165.424	-164.944	-162.59
7	1652.18	47.303	0.000		-167.913	-167.434	-165.08
8	1681.56	58.776	0.000		-171.007	-170.527	-168.173
9	1675.92	-11.278	.		-170.413	-169.934	-167.58
10	1687.3	22.753	0.007		-171.611	-171.131	-168.777
11	1674.59	-25.415	.		-170.273	-169.794	-167.44
12	1725.56	101.94*	0.000		-175.638*	-175.159*	-172.805*

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As can be seen from the Table 2, the PRE statistic of order 5 lag is the smallest, which is 6.0e-12, while the LR, AIC, HQIC and SBIC statistic of order 12 lag are the smallest, which are 101.94, -175.638, -175.159 and -172.805 respectively. Therefore, according to the information criterion, we should take 12 as the optimal order. However, the degree of freedom of the model is only 9, which is lower than the optimal order of 12. The order is too high and the parameters are too many, while the data length is not enough. Hence, 5 is selected as the optimal order of VAR model.

After the model is constructed, it is still necessary to test whether this model is operable, which means that whether the VAR model is a stable process. The workability is tested by the unit root test and by drawing a unit circle with the roots. The sufficient and necessary condition for stability of VAR model is that all the eigenvalues of the coefficient matrix fall within the unit circle.

From figure 1, it can be seen that all roots are in the unit circle, which means that there is no need to re-estimate the order of lag, and the three-variable VAR (5) is a stable model.

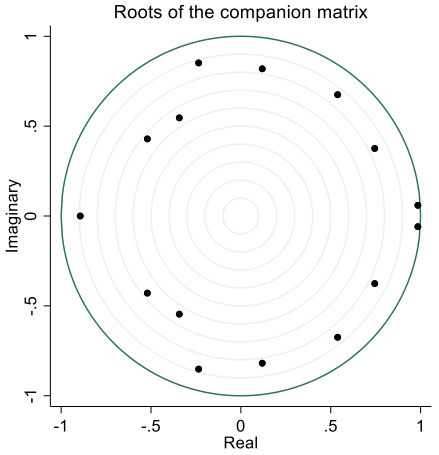

Figure 1:Unit circle test. Photo credit: Original.

3.2. Impulse Response

This paper studies the effects of the proportion of the elderly population on GDP and medical expenditure. Since the beginning of the 21st century, the proportion of elderly people has gradually increased, and all parts of the world are facing the problem of population aging degree. It can be seen from the forecast graph that the degree of population aging will not only continue to increase, but also rise at a significantly faster rate after 2022 (Figure 2).

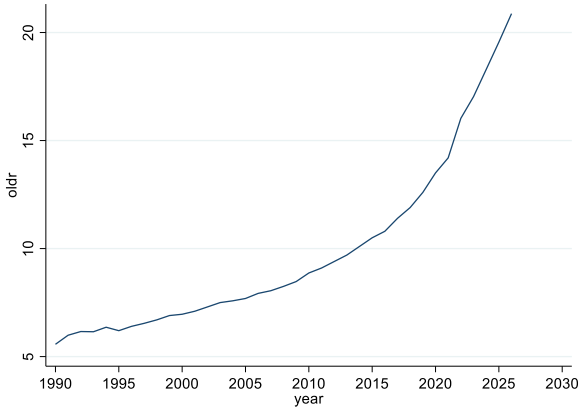

Figure 2:Forecast, old ratio. Photo credit: Original

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Because most of the elderly are unable to work, which means that the government needs to allocate resources to support them, undoubtedly that the ratio of the elderly population is a brake on national economic growth [12]. As one of the fasted developing countries in the past 30 years, China's GDP has shown an increasing trend year by year. However, in the future, its growth rate will gradually slow and be near stagnation between 2025 and 2026 (Figure 3).

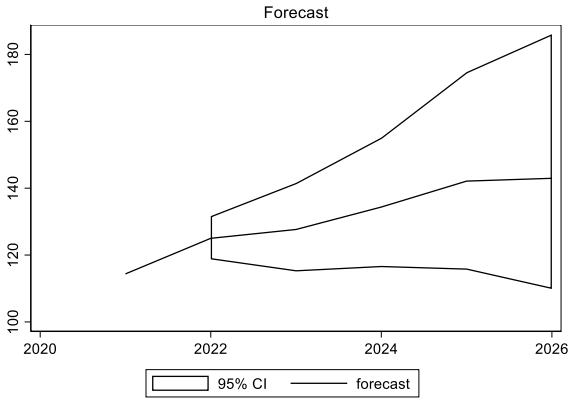

Figure 3:Forecast, GDP. Photo credit: Original.

With the increase of age, human organs will gradually deteriortate, causing various diseases such as heart disease and high blood pressure, which are inevitable [13]. Therefore, it is of necessity that the elderly are always the biggest contributor to health expenditure in order to treat their own diseases. Due to the increasing proportion of the elderly population and the improvement of the national economic situation, China's medical spending has shown a rising trend year by year. It is predicted that the increased percentage will reach the maximum in 2023 (Figure 4).

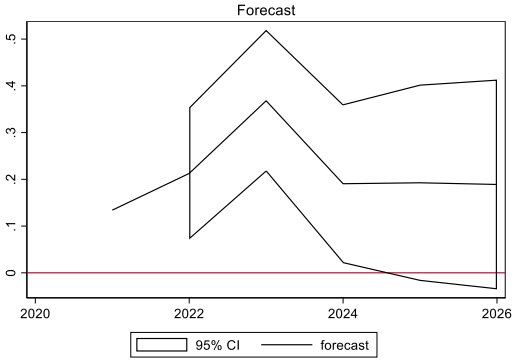

Figure 4:Forecast, medical expenditure growth rate. Photo credit: Original.

The first impulse response diagram (Figure 5) takes the proportion of elderly population as the pulse variable and GDP as the response variable. This chart illustrates the impact of increasing the degree of aging by one unit at t=0 on GDP in the future periods. As can be seen from the figure, the increase in the proportion of aging population has little impact on GDP in the first and second periods, and GDP still presents a gradually accelerating growth trend. However, in the third period and after, the GDP growth rate slow down and show negative growth, which is approximate -0.5%, -1% and -2% in the third, fourth and sixth period respectively. Therefore, it can be considered that the influence of aging on GDP is mainly reflected in the third and later periods.

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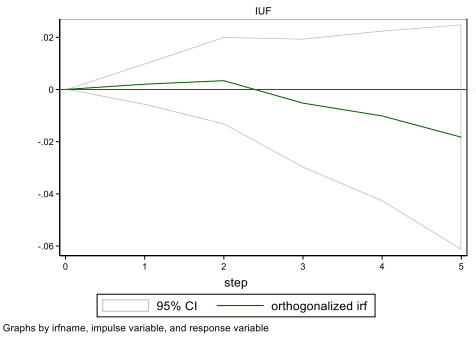
GDP



Expenditure

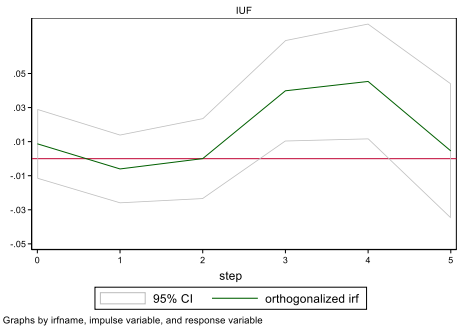


Figure 5:Impulse response. Photo credit: Original.

The second impulse response diagram (Figure 5) takes the proportion of elderly population as the pulse vector and the medical spending as the response vector. This picture shows the impact of increasing the degree of aging by one unit at t=0 on medical expenditure in the future phases. As is shown in the diagram, the increase in the degree of aging has little effect in the first and second stages, but rises sharply to 3% in the following stage and peaks at 4% in the fourth stage. Since the impulse response diagram reflects only static changes, the rate of increase in medical spending gradually slow after the fifth phase, which possibly due to the recovery or death of elderly patients.

4. Discussion

In comparison with other studies, this paper lays emphasis on the influence of the degree of population aging on GDP and health expenditure in China. Whereas, most of the existing papers relate population aging to national policies, family burden and labor shortage, and rarely discuss the relationship between population aging and medical spending [14,15]. Although there are some articles investigating the impact of population aging on the medical system, a majority of them focus on the shortage of medical resources and the increased social burden brought by the elderly people, or research the innovation and price disputes in the medical industry [16,17]. However, in the process of data processing, analysis and research, the methods are quite common, such as difference and VAR model. This paper also refers to the scientific research done by many predecessors, with the aim to ensure the universality and practicability of the data, analysis method and conclusions. In fact, even though population aging is so common, not all governments take this situation seriously, especially in parts of the developing countries. The speed of GDP growth in these countries has led leaders to ignore potential demographic and other factors that may hold back their economies. For developed countries, the social burden brought by the problem o population aging has already become the bottleneck restricting its further development. This study finds that the degree of aging will soar in the next 3-4 years, the slowdown of GDP growth indicates that economic development is inhibited, and the increase of medical points indicates that the social demand for medical resources will increase dramatically. According to this article, leaders of various countries should pay more attention to the problem of labor shortage, social depression and economic recession brought by population aging, and take measures such as encouraging birth to curb the continuous aggravation of population aging. In addition, relevant practitioners in the medical industry should also make preparations in advance to cope with the future wave of population aging, such as purchasing medical equipment and drugs in advance to avoid the shortage of medical resources.

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5. Conclusion

The object of this article is to study the impact of China's aging population on GDP and healthcare expenditure, predict the future trend of these three indicators and put forward some related suggestions for the development direction of the government and relevant practitioners. This paper mainly uses VAR model to explore impulse response to analyze and integrate relevant data. The study is based on modeling, mapping and empirical investigations.

By analysing the data and examining it, the paper shows that the ageing population has a significant impact on GDP and medical expenditure. Over the next five years, the population will continue to age more rapidly, and GDP growth will slow or even decline while the spending on national health care will keep climbing. Among them, the increase of the aging degree of population will not immediately have a obvious impact on these two indicators. There is a lag of three to four years, which means that it will significantly inhibit the growth of GDP and the increase rate of medical expenditure will reach its peak after three to four years. Therefore, Chinese government needs to prepare in advance in order to deal with various problems brought by the aging population, take measures to curb the deterioration of the aging population and prepare enough funds to cope with the sharp increase in medical expenditure.

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