# Research on Population Aging and Economy Based on GDP Threshold Model

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**Abstract:** Firstly, this article provides a detailed analysis of the evolution process of aging in both spatial and temporal dimensions. By comparing and analyzing the aging population situation in different regions, this article finds that the aging degree in the economically developed eastern regions of China is particularly significant, while the aging degree in the western regions is relatively mild. However, overall, the issue of aging is becoming increasingly prominent in various parts of China and requires high attention and active response. Furthermore, this article delves deeper into the causes behind the phenomenon of aging, and clearly points out that the decline in fertility willingness, fertility rate, and mortality rate are the core factors that trigger aging. Based on the above reasons, it is predicted through data that the number of elderly population in China will continue to grow in the coming years, and it is expected that China will enter a stage of moderate aging around 2025. Finally, this article found through research that aging has multiple impacts on GDP, both positive and negative. This article uses the threshold model and VAR model, combined with the Delphi entropy weight method to calculate the comprehensive aging index. It deeply explores the impact of aging on industrial structure and how this impact affects GDP changes. In summary, this article provides theoretical basis and practical suggestions for addressing the challenges of population aging in China by studying the impact of population aging on GDP and its composition, which is of great significance for promoting sustained and healthy economic development in China.

## 1. Introduction

With the deepening of China's aging population, its impact on China's GDP and its composition is becoming increasingly significant. In the past few decades, China's economy has achieved remarkable results, with sustained high-speed GDP growth. However, with the intensification of population aging, China is facing various challenges such as reduced labor supply, decreased consumer demand, and increased social security pressure. These factors will have a profound impact on China's GDP and its composition. Therefore, studying the impact of population aging on China's GDP and its composition can help us better respond to this challenge and achieve sustained and healthy economic development. Some scholars believe that with the formation of an aging population society, the "silver economy" is expected to evolve into a new track with great development potential in the aging society that may worsen in the future[1].

The connection between aging and the economy, the economy is an important indicator for measuring a country's development. In Gao Zehao's "Research on the Impact of Population Aging on Economic Growth in China", a model was constructed to study the threshold effect and spatial spillover effect of population aging on economic growth[2].

Nie Dan's "Research on the Impact of Aging on Industrial Structure Servitization: Based on Empirical Evidence from OECD Countries" explores the theoretical mechanism of the impact of aging on industrial structure servitization. The aging population leads to the expansion of consumption scale, which in turn leads to investment in human capital and promotes the service-oriented industrial structure[3].

Huang Shisong and Hu Qing mentioned in their "Strategic Design, Focus and Difficulties, and

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Path Optimization for Developing the Silver Hair Economy". In an aging society, accurately grasp the characteristics of this transformation and development, and develop a silver haired economy[4]. Subdivide the silver hair industry, analyze the difficulties in the current development of China's silver hair economy, and optimize the path for high-quality development of China's silver hair economy.

In Chen Yaner and Zhao Fuxin's "Population Aging, Digital Transformation, and the Real Economy," it is mentioned that "although the sustained and rapid deepening of China's population aging has become an irreversible trend, hindering economic growth, digital transformation can improve economic resource allocation capacity and offset the adverse effects of the decrease in mobile population on potential economic growth rate and social innovation vitality through the processing and analysis of massive data and effective utilization in combination with other industries[5]."The article proposes an innovative approach to smart elderly care, which involves the collaboration between artificial intelligence and an aging society to address the challenges of aging and provide a new perspective for related research.(Data sources :http://www.china-cssc.org/list-57-1.html)

## 2. The Causes and Prediction of Population Aging

When studying the development of population aging in China, this article believes that population aging is mainly influenced by population structure. "Fewer children" and decreasing mortality rates are the main factors affecting population structure[6].

### 2.1 The influence of fertility intention on population aging

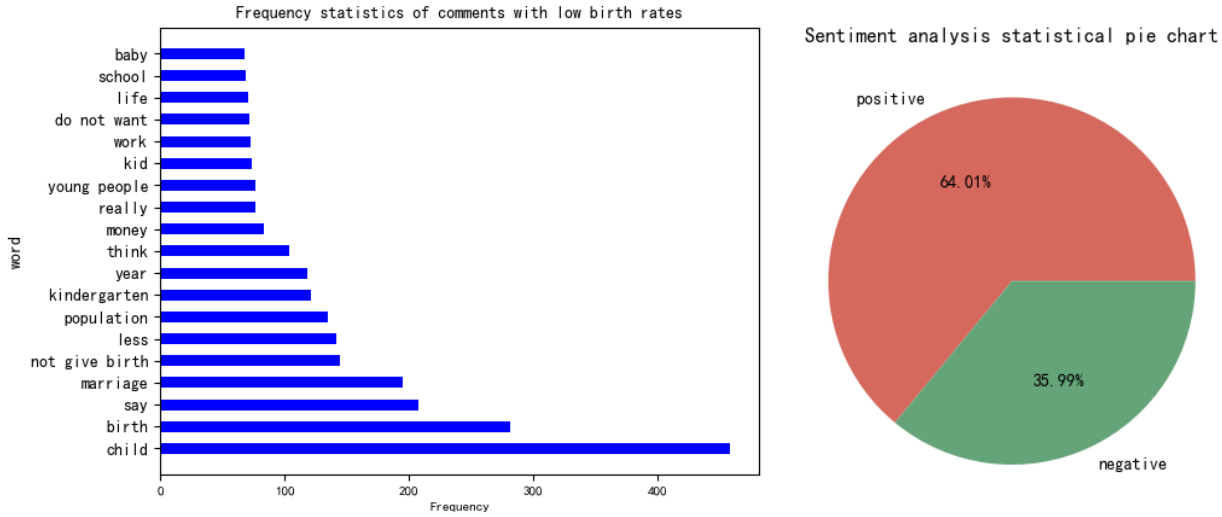


Figure 1: Statistical chart of fewer comments and pie chart of fertility intention

Due to the phenomenon of declining population, the population of our country is constantly decreasing. As shown in Figure 1, in the comment section on the topic of "fertility", "child" has become the most frequently mentioned word. In the comment section of online videos, the majority of people's views tend to lean towards not wanting to have children. Some people believe that the pressure of having children in modern society is too heavy, involving not only economic costs but also educational costs. With the rapid development of the economy and the updating of people's concepts, the willingness to have children is also constantly changing. Analysis shows that 64.01% of people have a positive intention to have children, while 35.99% have a negative intention. The classic theory of population transition tells us that with the advancement of modernization, the population transition led by the decline in fertility rate objectively promotes the development of population reduction and thus affects population structure.

### 2.2 Fertility rate and mortality rate affect population aging

The population problem in China in the 21st century is a structural issue and a core issue in the population structure. The issue of population aging is influenced by factors such as long-term decline

in fertility levels and extended average life expectancy. The population mortality rate and birth rate from 1990 to 2022 are shown in Figure 2.

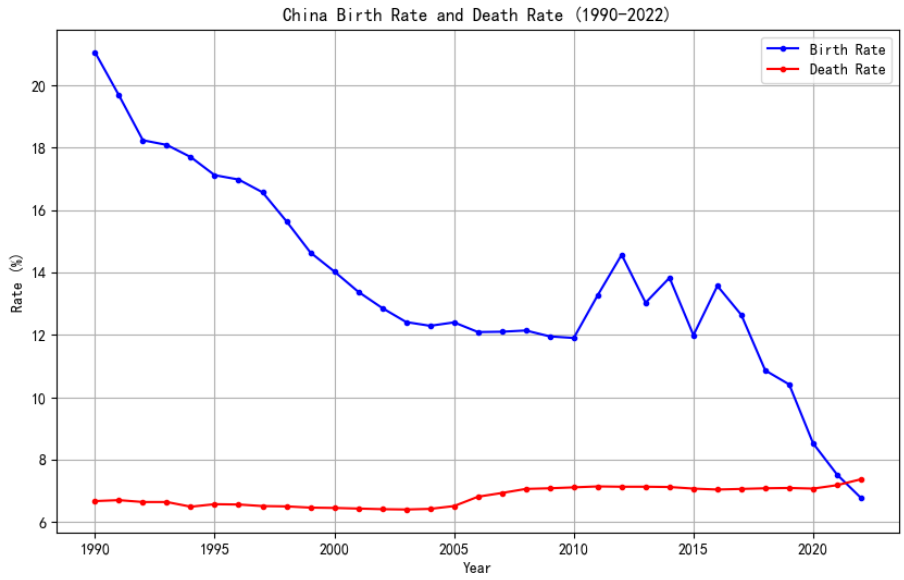


Figure 2 Population mortality rate and birth rate from 1990 to 2022

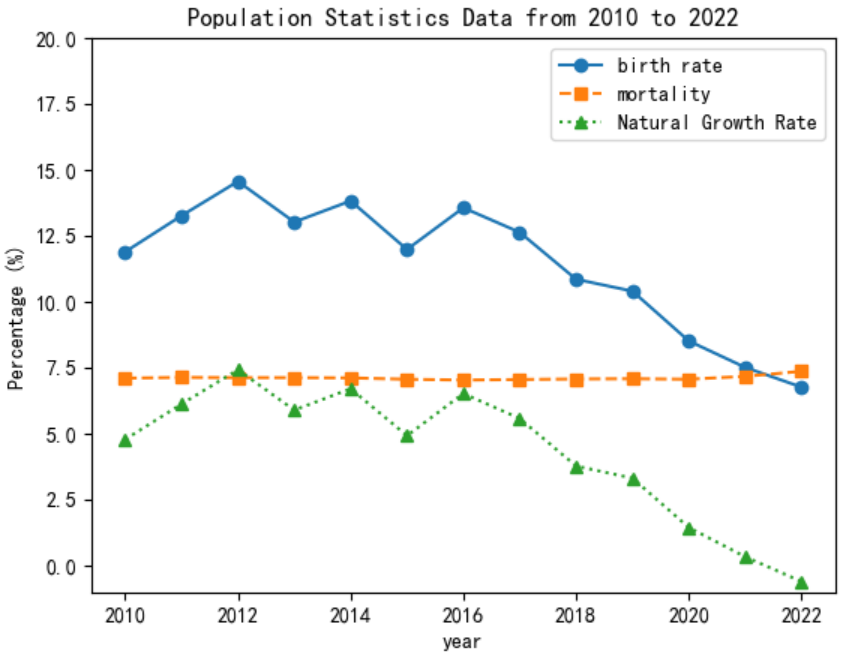


Figure 3 Birth rate, mortality rate, and natural growth rate from 2010 to 2022

As shown in Figure 3, the birth rate in China fluctuates greatly and has shown a downward trend since 2016. From 2010 to 2022, the mortality rate of China's population remained around 7.5%, and by 2022, the fertility rate of China's population was lower than the mortality rate. With the growth of the economy, advancement of technology, improvement of medical facilities, and improvement of residents' living standards, people have become healthier and longer, significantly extending the average life expectancy in China, leading to a continuous increase in the number of elderly people. In summary, China's population transition has rapidly occurred under the dual effects of the family planning policy and modern economic development.

### 2.3 National Aging Population Forecast

Based on the comprehensive analysis of fertility intention, birth rate and mortality rate, as well as population age structure, the predicted trend of national population aging in Figure 4 is obtained. By

using ARIMA time series prediction method to predict and analyze real data from 2023 and before, preliminary judgments can be made on the future trend of population aging in China. According to reliable prediction data, it is expected that the number of elderly people in China will exceed 300 million by around 2025, marking the transition of Chinese society from a mild aging stage to a moderate aging stage. Faced with the challenge of demographic changes, we must carefully consider how to promote the development of the silver economy under this trend. By formulating scientifically reasonable policy measures and tapping into the potential of the elderly market, we can inject new vitality into the sustainable development of the social economy.

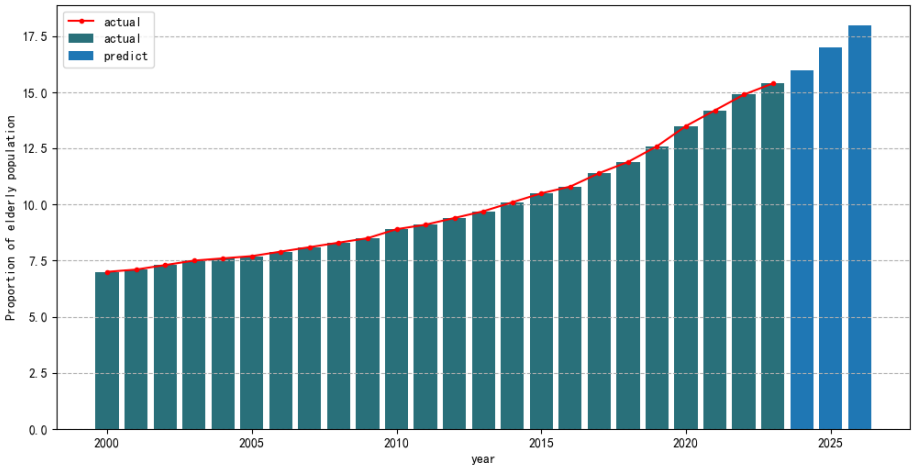


Figure 4 National Population Aging Prediction Trend Chart

## 3. The impact of aging

Based on Liu Xiaoyong's research on the inverted U-shaped relationship between aging and inter provincial economic growth, it is found that aging has a dual positive and negative impact on GDP growth[7]. This article explores in depth the positive and negative effects of aging based on four dimensions: industrial employment, consumption scale, industrial structure, and fiscal expenditure, and emphasizes the importance of developing a "silver economy" as a response strategy. The phenomenon of aging poses both challenges and opportunities for the country. In order to effectively address the negative impact of aging and further expand its positive effects, the country actively advocates the development of a "silver economy". The implementation of this strategy can not only stimulate the potential for economic growth, promote employment opportunities, but also meet the diverse needs of the elderly, thereby improving their quality of life. The theoretical basis of the silver haired economy lies in the profound and inherent systemic impact of population aging on the economy.

### 3.1 Aging affects the supply of industrial labor force

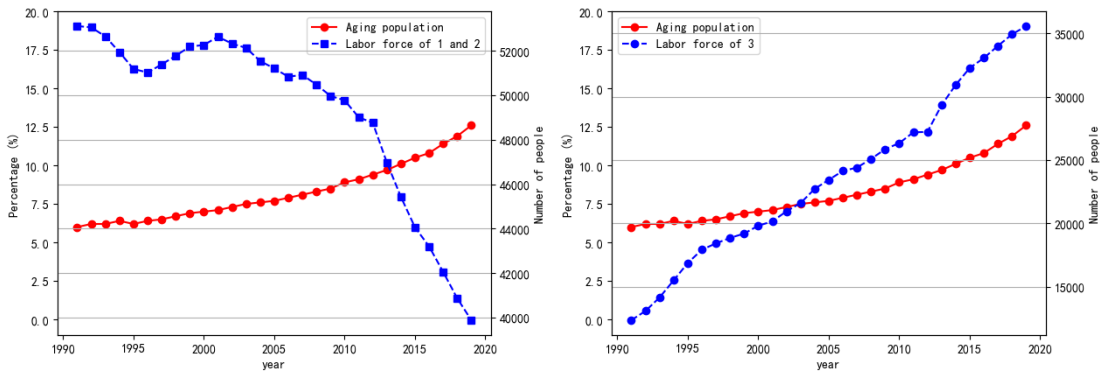


Figure 5: The proportion of aging population and the proportion of labor force in the tertiary industry from 1990 to 2020

As shown in Figure 5, from 1990 to 2020, the labor force in the primary and secondary industries showed a downward trend, while the labor force in the tertiary industry showed an upward trend. From 1990 to 1995, there was a significant decline in the labor force in the primary and secondary industries, while at the same time, the labor force in the tertiary industry increased rapidly. Over time, from 1995 to 2005, the proportion of labor force in the primary and secondary industries increased slightly and returned to its original proportion, while the number of people in the tertiary industry continued to rise, doubling from 1995 to 10%, indicating a continuous upgrading of the industrial structure. By 2012, the proportion of labor force in the tertiary industry was on par with that of the primary and secondary industries, and the focus of economic development continued to shift towards the tertiary industry.

With the aging population leading to a decrease in the number of young people, the overall labor participation rate has decreased. With the changes in the age structure of China's population, the degree of decline in the labor force has shifted from mild to severe[8]. According to the above analysis, population aging has an impact on the improvement of industrial structure by affecting the supply structure of the labor market and the demand structure of the product market.

### 3.2 Aging affects the upgrading of industrial structure

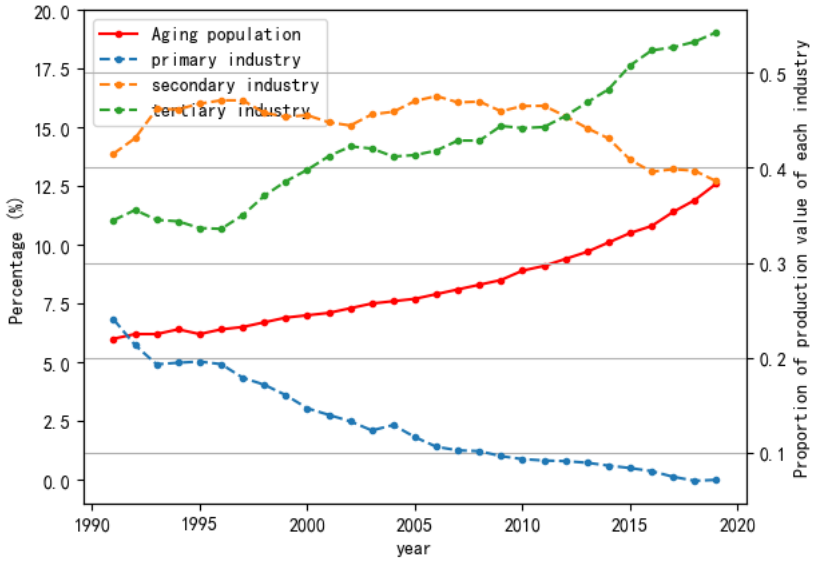


Figure 6: The proportion of production value and aging population in various industries from 1990 to 2020

By analyzing the industrial input table, observe the contribution of an industry to the entire national economy from the perspective of industrial production value. The proportion of the structure of the three industries (primary industry, secondary industry, and tertiary industry) is used to measure the level of economic development. GDP is the sum of industrial added value, which affects the total value of GDP by influencing the proportion of three industries. From Figure 6, it can be seen that from 1990 to 2020, the proportion of GDP and aging in various industries showed a synchronous upward trend with the increase of aging, while the proportion of output in the tertiary industry gradually decreased.

The mechanism of population aging affecting industrial structure through total demand is mainly reflected in two aspects[9]: firstly, because the proportion of service industry in the consumption of the elderly is greater than that of young people, the aggravation of population aging will weaken the proportion of industry in consumption and increase the proportion of service industry. Therefore, under the same consumption rate, the higher the degree of population aging, the lower the proportion of industry, and the higher the proportion of service industry, which is called intensive marginal effect; Secondly, the deepening of population aging will increase the consumption rate and reduce the investment rate, while the proportion of service industry in the consumption structure is significantly higher than that of investment. Therefore, population aging will reduce the proportion of industry and

increase the proportion of service industry, which is called the extensive marginal effect.

## 4. The threshold effect of population aging on GDP changes

When conducting threshold regression analysis in this article, ARIMA filling method was used to interpolate missing data. When constructing the model, we selected per capita Gross Regional Product (PGDP) as the dependent variable to measure economic growth, while using the proportion of people aged 65 and above (PPO) as the core explanatory variable to represent the level of aging. However, considering that the proportion of people aged 65 and above may not fully reflect the age structure of the region as an explanatory variable alone, we further introduced the proportion of elderly to young people (Roy), elderly dependency ratio (OFR), proportion of social pension fund recipients (PFRP), and proportion of elderly people in the employed population (EER). We used a comprehensive evaluation method combining the Delphi entropy weight method to calculate the comprehensive aging index (Old), in order to improve the explanatory power and accuracy of the model[10].

By adopting expert opinions, establishing a judgment matrix and conducting consistency checks on it, CR<0.1 is calculated, indicating that the consistency check has been passed, thereby further calculating the weight matrix. According to the entropy weight method, the weights of each indicator are determined. Firstly, the data is processed to form the following data matrix.

$$R = (r_{ij})_{\mathrm{m\times n}} \tag{1}$$

The basic idea is to establish an information entropy model by measuring the information entropy between indicators, and then calculate the weight of indicators based on their information entropy values. The calculation formula is as follows:

$$\omega_i^{(2)} = \frac{(1-E_j)}{(\sum_{j=1}^{n}(1-E_j))} \tag{2}$$

Among them, $\omega_i^{(2)}$ represents the weight of the i-th indicator, $\mathrm{E}_j$ represents the information entropy of indicator J, and $n$ represents the number of indicators.

Information entropy can be expressed using the following formula:

$$E_j = -\frac{1}{lnm}\sum_{i=1}^{m} p_{ij} lnp_{ij} \tag{3}$$

Among them, $p_{ij}$ represents the proportion of the score of sample $j$ on indicator $i$ compared to the total score of that indicator, and $m$ represents the number of samples.

$$p_{ij} = \frac{r_{ij}}{\sum_{j=1}^{n} r_{ij}} \tag{4}$$

The so-called information entropy refers to the uncertainty size of a dataset. The smaller the information entropy, the smaller the uncertainty of the dataset, that is, the purer the dataset; On the contrary, the larger the information entropy, the greater the uncertainty of the dataset, that is, the more cluttered the dataset.

Therefore, in the entropy weight method, for each indicator, we first need to calculate its information entropy value, and then use the above formula to calculate the corresponding weight.

Finally, normalize the weights of each indicator obtained by dividing each weight by the sum of all weights to obtain the normalized new weight $\omega_i^{(2)}$.

The final weight is:

$$\omega_i = \frac{\alpha\omega_i^{(1)} + \beta\omega_i^{(2)}}{\sum_{i=1}^{n} \alpha\omega_i^{(1)} + \beta\omega_i^{(2)}} \tag{5}$$

The threshold threshold test is shown in Table 1.

Table 1 Threshold Test

| threshold | threshold | Confidence interval at 95% level |
|---|---|---|
| $\gamma_1$ | 7900 | [7505,8295] |
| $\gamma_2$ | 20500 | [19475,21525] |

Table 2 Threshold effect of population aging on economic growth in China

| variable | symbol | coefficient | t | P |
|---|---|---|---|---|
| Aging level(per capitaGDP $\leq \gamma_1$) | $\ln old(pgdp \leq \gamma_1)$ | -0.083 | -1.78 | 0.069 |
| Aging level($\gamma_1 \leq$ per capitaGDP $\leq \gamma_2$) | $\ln old(\gamma_1 < pgdp \leq \gamma_2)$ | -0.012 | -0.027 | 0.7609 |
| Aging level(per capitaGDP $> \gamma_2$) | $\ln old(pgdp > \gamma_2)$ | 0.013 | 0.30 | 0.738 |

Table 3 Estimated Coefficients

| symbol | Model 1 coefficient estimate | P | Model 2 coefficient estimate | P |
|---|---|---|---|---|
| $\ln old(pgdp \leq \gamma_1)$ | -0.086* | 0.069 | -0.059** | 0.035 |
| $\ln old(\gamma_1 < pgdp \leq \gamma_2)$ | -0.014* | 0.796 | 0.013 | 0.605 |
| $\ln old(pgdp > \gamma_2)$ | 0.016 | 0.738 | 0.043* | 0.093 |

According to Tables 2 and 3, it can be seen that there is a threshold effect of the level of aging on economic growth, that is, the direction and degree of the impact of aging on economic growth vary at different levels of per capita GDP.

### 4.1 Establishing mathematical models to explain phenomena

$$y_{GDP} = \sum S_i J_i \tag{6}$$

S technology level (per capita production value of the tertiary industry): J employment number (employment number of the tertiary industry)

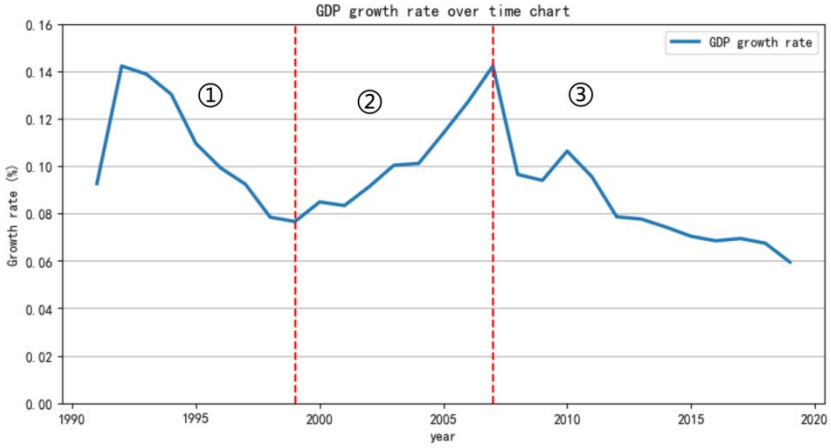


Figure 7: Trend of China's GDP Growth Rate from 1990 to 2019

This article studies the dual threshold effect of aging on economic growth, which means that the direction and degree of aging's impact on economic growth vary at different levels of per capita GDP.

According to Figure 7, the per capita GDP growth rate is analyzed over three time periods: 1999 is the first threshold, and 2007 is the second threshold. The first stage was a slowdown in per capita GDP growth from 1991 to 1999, the second stage was an increase in per capita GDP growth from 1999 to 2007, and the third stage was a decrease in per capita GDP growth from 2007 to 2019.

Since the reform and opening up, China's economy has experienced rapid development, and the per capita GDP growth rate has also shown certain fluctuations. This article will explore the relationship between the fluctuation of China's per capita GDP growth rate and aging based on data from 1991 to 2019, and analyze the reasons behind it.

### 4.2 Analyzing the phenomenon of GDP growth rate

From Figure 7, it can be seen that the per capita GDP growth rate in China decreased from 0.015437 to 0.011104 from 1991 to 1999. The main reasons for the decline in its growth rate are the decrease in employment in the primary and secondary industries and the decrease in output value. In the early stage of aging, China's economy still relies mainly on the production of the primary and secondary industries, and the development of the tertiary industry is slow. Therefore, the increase in aging will cause serious damage to the primary and secondary industries in the early stage of technological immaturity, making it difficult to make adjustments in a short period of time.

The primary and secondary industries are mainly agriculture and industry. China is a large agricultural country, and industrial production is an important driving force for GDP growth. The significant decline in its growth rate has led to a slow and declining trend in GDP growth. The insufficient external demand in the first and second industries leads to an increase in enterprise costs, and under the guidance of product demand structure and factor supply structure, their growth rate will decline. Although the tertiary industry has made initial progress, due to technological limitations, its growth rate is still insufficient to compensate for the output loss caused by the decrease in labor force in the primary and secondary industries, resulting in a slowdown in per capita GDP growth rate.

Taking into account the phenomenon of the decline in per capita GDP growth rate in China from 1991 to 1999, it is mainly attributed to the economic structural adjustment pressure brought about by the early stage of aging, as well as factors such as the slowdown in the growth rate of the primary and secondary industries and insufficient development of the tertiary industry. To address this complex situation, practical and effective measures such as technological innovation and market opening must be taken to promote sustained economic growth and achieve sustainable development goals.

## 5. Conclusions

Population aging poses both challenges and opportunities for China’s economic development. While it leads to a decline in the labor force and potential economic growth, it also drives the development of the service sector, expands the scale of consumption, and promotes industrial structure upgrading. This paper explored the complex relationship between aging and the economy, demonstrating the existence of a threshold effect. The impact of aging on economic growth varies with the level of per capita GDP. In regions with lower per capita GDP, aging tends to have a negative impact because of the lack of technological and industrial development to offset the labor force loss. However, in regions with higher per capita GDP, the development of the service sector and the expansion of consumption can offset the negative impact of aging, leading to a positive effect on economic growth. Therefore, it is crucial for China to formulate targeted policies to address the challenges and leverage the opportunities brought by population aging, ensuring sustainable and healthy economic development.

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