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The Impact of Population Aging on Regional Economy

Taking Yunnan Province as an Example*

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***Abstract*—According to surveys and researches, there is certain correlation between population aging and regional economic development. This research aims at finding out the action mechanism and mode in which population aging affects the regional economy in Yunnan Province, to objectively evaluate the impact of population aging on regional economy. A country's GDP is equivalent to the sum of consumption, investment and net export. Production and consumption are important parts of regional economy. Therefore, this paper analyzes the impact of population aging on household consumption, fixed asset investment, and net export and other aspects by gray correlation degree on the basis of the current aging status in Yunnan Province, and tries to make clear the relations between population aging and the said aspects and further find the way of aging affecting Yunnan's regional economy. It is concluded that the gray correlation degree between population aging proportion and household consumption, investment and net export is greater than that between the aging proportion and other factors. This indicates that the population aging in Yunnan Province affects regional economic growth by affecting the elements that promote economic growth such as household consumption, fixed investment, and net exports.**

Keywords—Yunnan Province; population aging; gray correlation degree; regional economic growth

I. INTRODUCTION

Population aging refers to a dynamic state in which the proportion of aged people is increased among the total population of a region due to reduction of people's birth rate and increase of people's life time. It is a stage that must be experienced due to the rapid development of the economy and society. On the one hand, it refers to a process in which the population of aged people is constantly increasing among total population of a region; on the other hand, it refers to a state in which the population structure is aging and entering an aging society. When the proportion of elderly population over 60 years old in a region or country to the total population is up to 10%, or that over 65 years old is up to 7%, it indicates that the population of the country or region has entered an aging society. Since the reform and opening up, the social development and national economic income has entered a rapid development stage; along with it, Yunnan Province's economic strength has been gradually increased. Of course, compared with the developed regions, Yunnan Province's economic strength is still relatively backward. This shows that the population aging in Yunnan comes earlier than its urbanization and industrialization and it has become a fact that Yunnan has got old before getting rich [1].

Foreign scholars have made a large number of researches on population aging. Italian economist Modigliani was the person who made discussion on the relation between population age structure and consumption the earliest. He pointed out that population aging ratio is negatively correlated with people's average consumption awareness, and increasing the population aging ratio may lead to lowering of the total population consumption level. To verify this thought, he made an empirical research on the basis of country-level cross-section data and got the same result [2]. Ralph C. Bryant (2007) studied the demographic structural differences between developing and developed countries, and concluded that the differences in demographic factors may affect the investment and exchange rates in developed and developing countries; the results indicate that the main reason for capital flows in developed and developing countries is the difference in their aging process, and with the deepening of a country's population aging degree, the

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country may reduce domestic investment and increase direct investment to foreign countries [3]. William Poole (2007) conducted relevant research by taking the actual economic conditions and demographics into comprehensive consideration; as a result, it is found that the process of population aging has effect on many behaviors such as work and investment, so that various resources are transferred from the country having high population aging ratio to a country having low population aging ratio, resulting in trade balance surpluses and deficits in countries [4].

With respect to the issue of population aging and regional economic growth, Chinese scholars have also made a lot of relevant researches. Wherein, Ding Zhihong and Jiang Xiangqun believe that deepening the population aging is positive to promote regional economic growth; due to the deepening of population aging, the consumption of the elderly population is also increasing; this may lead to enlarged burden to the society to certain extent, while it also provides huge potential for the development of industry for aged people and has far-reaching significance for future economic development [5]. Wu Cangping (1999) believed that population aging might affect a country's economy in aspects of consumption, labor productivity, and savings, but it was difficult to conclude whether the impact is positive or negative mainly for reason that there was lack of persuasive empirical research [6]. By research, Tian Xueyuan (2006) maintained that due to the deepening of China's aging extent, China would gradually enter "demographic deficit" period from "demographic dividend" period. He respectively analyzed the influence of population aging on economy from many perspectives such as income distribution, savings, consumption, industrial structure and labor employment [7].

Population aging has great impact on political culture, regional economy and social environment, and the impact on the development of regional economy is the most fundamental. In general, population aging's impact on a series of economic fields such as the supply and demand of labors, national income distribution, regional economic growth, savings, consumption and investment determines the political environment and social development in a region. Therefore, making research on population aging is of great application value for the sustainable development of modern regional economy.

II. Status Quo of Population Aging in Yunnan Province

As can be seen from "Fig.1", the population aging rate in Yunnan Province had been increasing year by year, and reached 8.76% up to 2015. From 2000 to 2015, the average aging rate was 7.29%, the annual average growth rate was 0.276%, and the growth rate in recent decade was 2.76%. This shows that aging is deepening year by year. Compared with the standards specified by the United Nations, the population age structure of Yunnan Province had changed from the adult type in 2000 to the aged type in 2010. However compared with the national average, Yunnan's aging extent is a little weak. Source: Statistical Yearbook of China

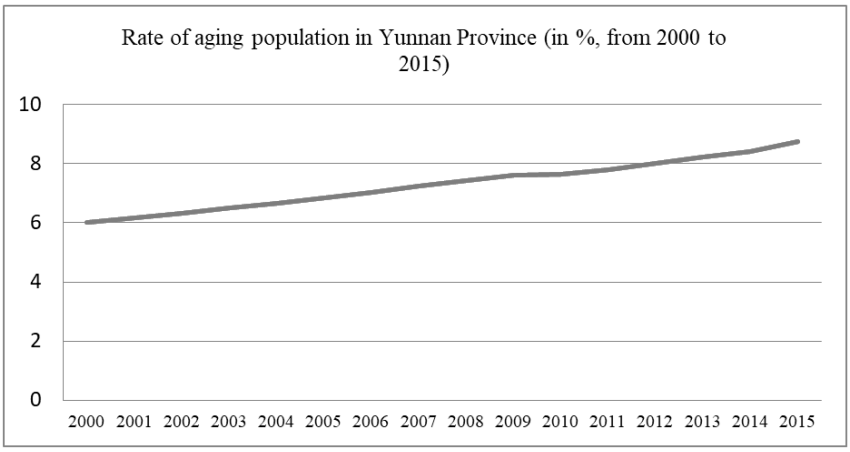

Fig. 1. The aging rate in Yunnan Province from 2000 to 2015.

III. Analysis and Empirical Study on the Correlation Between Population Aging and Regional Economic Growth Elements in Yunnan Province

A. Gray Correlation Analysis

The grey system theory proposed the concept of making gray correlation analysis on each subsystem for the first time, aiming to find out the numerical relationship between subsystems (or factors) in the system by taking certain methods. In short, the gray correlation analysis means that in the development process of the system if two factors change in the same way, namely the degree of synchronous change is high, it can be maintained that the correlation extent between the two factors is relatively large; otherwise, the correlation extent is relatively small [8].

The gray correlation is established as follows:

Step 1: it is assumed that a matrix is formed by *n* number of data:

$$(X'1(i)) = \{X'1(1)、X'1(2)、\ldots\ldots、X'1(n)\}$$
$$(X'2(i)) = \{X'2(1)、X'2(2)、\ldots\ldots、X'2(n)\}$$
$$(X'3(i)) = \{X'3(1)、X'3(2)、\ldots\ldots、X'3(n)\}$$
$$\ldots\ldots\ldots\ldots\ldots\ldots$$
$$(X'm(i)) = \{X'\ m(1)、X'm(2)\ldots\ldots、X'\ m(n)\}$$

The total number of factors in the system is $n, X1、X2、X3、\ldots\ldots Xn$ and is taken as a comparative sequence; then a comparison is made between m number of sub-sequences and the reference sequence to find out the correlation between them.

Step 2: the reference data sequence is an ideal comparison criterion and can be formed by the optimal value or the worst value of an index, or be other reference value selected in accordance with the evaluation purpose. It is recorded as:

$$(X'0) = \{X'0(1)、X'0(2)、\ldots\ldots、X'0(m)\}$$

Step 3: nondimensionalize the index data; then form the nondimensionalized data sequences into the following matrix:

$$\{X0、X1、X2、\ldots\ldots、Xn\}$$

The commonly used dimensionless methods include the average value and initial value methods and so on. In this paper, the following formula is used:

$$Xi(k) = \frac{X'\ i(k)}{X'\ i(1)} \quad \begin{matrix} i = 0、1、2、\ldots\ldots n \\ k = 1、2、3、\ldots\ldots m \end{matrix}$$

Step 4: calculate the index sequence of each evaluated object one by one, namely:

$$\left|X0(k) - Xi(k)\right| (k = 1、2、\ldots m,\ i=1、2、\ldots n)$$

Step 5: determine the minimum difference $\square minmin\left|X0(k) - Xi(K)\right|$ and the maximum difference $\square maxmax\left|X0(k) - Xi(k)\right|$ in the matrix.

Step 6: calculate the correlation coefficient:

$$\ell = \frac{\min\min\left|X0(k) - Xi(k)\right| + \rho \max\max\left|X0(k) - Xi(k)\right|}{\left|X0(k) - Xi(k)\right| + \rho \max\max\left|X0(K) - Xi(k)\right|}$$

Wherein, ρ takes value within $(0,1)$, and generally is 0.5. Gray correlation coefficient is the degree of correlation between each comparative sequence and each point of the reference sequence, and dynamically describes the degree of correlation between the comparative sequence and the reference sequence; the larger the coefficient is, the larger the correlation is, and vice versa.

Step 6: calculate the correlation degree:

$$r(i) = \frac{1}{m}\sum_{k=1}^{m} \ell i(k)$$

B. *The Impact of Population Aging on Consumption*

Consumption generally consists of household consumption and government consumption. Household consumption includes rural household consumption and urban household consumption. As can be seen from "Table I" from 2010 to 2016, household consumption was higher than government consumption; and the expenditures of them are both in rising trend.

TABLE I. THE EXPENDITURE AND PROPORTION OF RURAL AND URBAN HOUSEHOLD CONSUMPTIONS IN YUNNAN PROVINCE

Year	Final consumption	Household consumption expenditure (100 million yuan)	Proportion of household consumption (%)	Government consumption expenditure (100 million yuan)	Proportion of government consumption (%)
2010	4332.64	3123.69	72.1	1208.95	27.9
2011	5273.62	3821.44	72.5	1452.18	27.5
2012	6306.75	4543.53	72.0	1763.22	28.0
2013	7364.18	5244.58	71.2	2119.60	28.8
2014	8207.52	5750.89	70.1	2456.63	29.9
2015	8855.33	6354.25	71.8	2501.08	28.2
2016	9605.69	6912.78	72.0	2692.91	28.0

[a.] Source: 2017 Statistical Yearbook of Yunnan Province

1) Gray correlation analysis on population aging and household consumption: Household consumption (X0) is used as reference sequence; per capita GDP (X1) population aging proportion (X2), labor population proportion (X3) and urban resident's per capita disposable income (X4) are used as comparative sequences; price index is used as comparative sequence (X5) (the retail price of goods in 2010-2016 is the benchmark), as shown in "Table II". All the data are sourced from the "Statistical Yearbook of Yunnan Province" and "Statistical Yearbook of China".

TABLE II. STANDARDIZATION RESULTS OF DATA SUCH AS HOUSEHOLD CONSUMPTION AND POPULATION AGING PROPORTIONS DURING 2010-2016

Year	X0	X1	X2	X3	X4	X5
2010	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2011	2.0470	2.1575	1.1518	0.8760	1.8446	1.0386
2012	2.4338	2.4857	1.1898	0.8528	2.0928	1.0099
2013	2.8093	2.8359	1.2278	0.8314	2.2304	1.0036
2014	3.0805	3.0534	1.2784	0.8115	2.4130	1.0000
2015	3.4037	3.2262	1.3291	0.7901	2.6190	0.9911
2016	3.7029	3.4661	1.3671	0.7702	2.8412	0.9970

TABLE III. DIFFERENCES BETWEEN THE ABSOLUTE VALUES OF REFERENCE SEQUENCE (X0) AND EACH COMPARATIVE SEQUENCE DURING 2010-2016

Year	X1	X2	X3	X4	X5
2010	0.0000	0.0000	0.0000	0.0000	0.0000
2011	0.1105	0.8952	1.1710	0.2024	1.0084
2012	0.0519	1.2440	1.5810	0.341	1.4239
2013	0.0266	1.5815	1.9779	0.5789	1.8057
2014	0.0271	1.8021	2.2690	0.6675	2.0805
2015	0.1775	2.0746	2.6136	0.7847	2.4126
2016	0.2368	2.3358	2.9327	0.8617	2.7059

As can be seen from "Table III", Δmax = 2.9327, Δmin = 0.0000, so the gray correlation coefficient can be calculated on the basis of the matrix of gray correlation coefficients between each comparative sequence and reference sequence shown in "Table III" and with reference to the calculation formula of the coefficient.

TABLE IV. GRAY CORRELATION COEFFICIENTS BETWEEN HOUSEHOLD CONSUMPTION AND PER CAPITA GDP, AND POPULATION AGING AND OTHER INDEXES IN YUNNAN PROVINCE

Year	（X0,X1）	(X0,X2)	(X0,X3)	(X0,X4)	(X0,X5)
2010	0.0000	0.0000	0.0000	0.0000	0.0000
2011	0.9299	0.6209	0.5559	0.8787	0.5925
2012	0.9658	0.5410	0.4812	0.8113	0.5073
2013	0.9822	0.4811	0.4257	0.7169	0.4481
2014	0.9818	0.4486	0.3925	0.6872	0.4134
2015	0.8921	0.4141	0.3594	0.6514	0.3780
2016	0.8609	0.3856	0.3333	0.6299	0.3514

TABLE V. THE DEGREES OF CORRELATION BETWEEN HOUSEHOLD CONSUMPTION AND PER CAPITA GDP, LABOR POPULATION PROPORTION AND OTHER FACTORS DURING 2010-2016

Per capita GDP	Population aging proportion	Labor population proportion	Per capita disposable income of urban household	Price index
0.9354	0.4818	0.4247	0.7292	0.4485

From the above "Table IV" and "Table V", it can be seen that the order of degrees of correlation between them is as follows: per capita GDP > per capita disposable income of urban household > proportion of population aging > price index > proportion of labor population. Among them, per capita GDP has the largest gray correlation with household consumption and is the main factor affecting household consumption. Generally speaking, the consumption demand of aged population is less than that of labor population, so the impact of labor population's consumption demand on household consumption is greater than that of aged population's. The degree of correlation between per capita disposable income of urban household and household consumption is just next to that between per capita GDP and household consumption. This indicates that the impact of price index on household consumption is greater than that of labor population proportion on household consumption.

2) Gray correlation analysis on population aging and government consumption: In a similar way, household consumption (X0) is used as reference sequence; per capita GDP (X1) population aging proportion (X2), labor population proportion (X3) and urban resident's per capita disposable income (X4) are used as comparative sequences; price index is used as comparative sequence (X5).

TABLE VI. THE DEGREES OF CORRELATION BETWEEN GOVERNMENT CONSUMPTION AND PER CAPITA GDP, LABOR POPULATION PROPORTION AND OTHER FACTORS DURING 2010-2016

Per capita GDP	Population aging proportion	Labor population proportion	Per capita disposable income of urban household	Price index
0.5358	0.6398	0.5832	0.6952	0.6379

As can be seen from "Table VI", the order of degrees of correlation between them is as follows: per capita disposable income of urban household> proportion of population aging> price index> proportion of labor population> per capita GDP. The per capita disposable income of urban household has the largest impact on government consumption, and the impact of the proportion of population aging ranks second. This indicates that population aging also has large impact on government consumption.

C. The Impact of Population Aging on Investment

Generally, total investment includes fixed capital investment and inventory increase, but fixed capital investment accounts for a large proportion. In recent years, the total capital investment of Yunnan Province has

increased rapidly. As shown "Fig. 2", the fixed capital investment in 2016 was 1382188 million Yuan, 6.8 times of that in 2006; after 2010, the annual average growth rate was up to more than 200%; and total fixed capital and gross capital formation increased at similar rates. Source: Statistical Yearbook of Yunnan Province

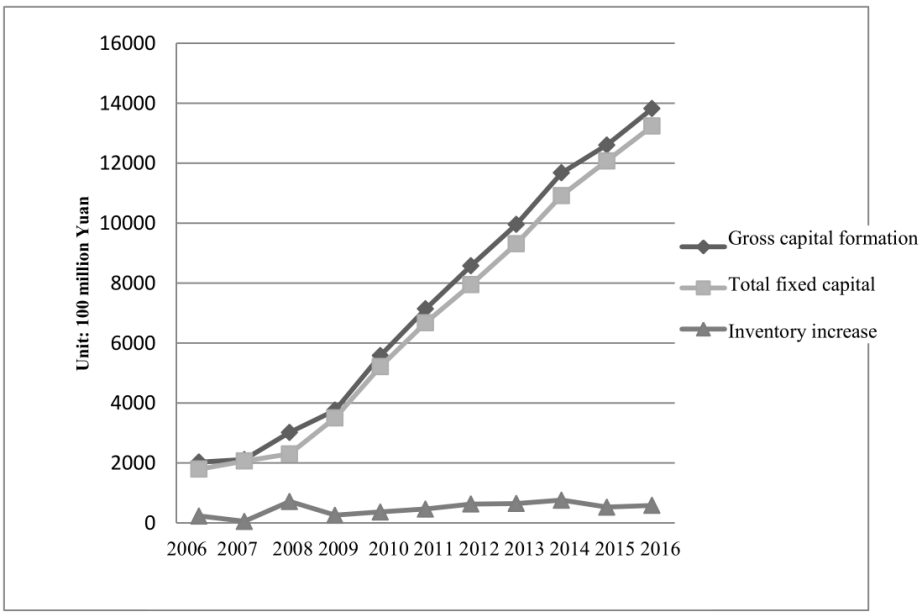

Fig. 2. Gross capital formation, total fixed capital and inventory increase during 2006-2016.

Gray correlation analysis on population aging and investment: This paper uses the total capital investment to measure the investment standard of Yunnan Province; the total capital investment is used as the reference sequence (X0), per capita GDP as comparative sequence (X1), household consumption price index as comparative sequence (X2), population aging proportion as comparative sequence (X3), and actual foreign investment as comparative sequence (X4); as deposit interest rate is an important factor affecting investment, China's one-year fixed deposit rate (RMB) is used as comparative sequence (X5); all the data are sourced from the "Statistical Yearbook of Yunnan Province" and "Statistical Yearbook of China".

TABLE VII. GRAY CORRELATION DEGREE BETWEEN TOTAL INVESTMENT AND PER CAPITA GDP AND OTHER FACTORS IN YUNNAN PROVINCE

Per capita GDP	Household consumption price index	Population aging proportion	Actual foreign investment	Interest rate on deposits
0.5604	0.4185	0.4324	0.4772	0.4299

As can be seen from "Table VII", per capita GDP and actual foreign investment have greater impact on total investment, and per capita GDP is in positive correlation with total investment. The correlation degree of population aging proportion ranks third. Relevant research shows that low degree of population aging has a great role in attracting foreign investment, because low degree of population aging means that there are sufficient labor capitals. In general, population aging proportion and actual foreign investment have different but not so large different degrees of gray correlation with Yunnan's total investment. This shows that the factors affect the total investment in different ways, and thus have somewhat different impact on total investment. In terms of population aging, its change has a greater impact on the total investment of Yunnan Province [9].

D. The Impact of Population Aging on Net Export

Gray correlation analysis on population aging and net export: as can be seen from "Fig. 3", during 2005-2015, Yunnan Province experienced a surplus in import and export trade; especially in 2013, the import and export trade balance was negative, indicating the sharp increase of export trade in 2013; up to 2014, import trade increased and export trade reduced; the gap between import and export trade increased from 2013 to 2015, indicating a sharp increase in import trade in 2013-2015.

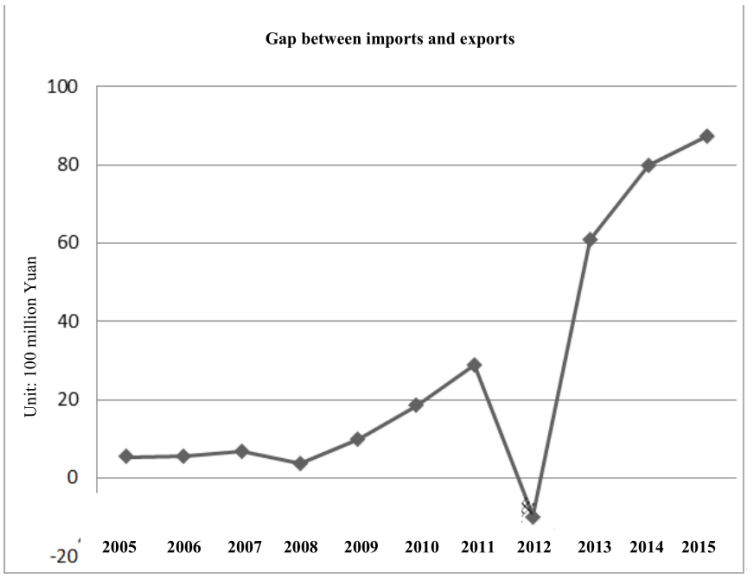

Fig. 3. Trade gap between imports and exports in Yunnan Province from 2000 to 2015.

E. Variables and Data Sources

In this paper, the following formula is used to measure net export: net export = total export trade - total import trade; net export is used as reference sequence (XO), population aging proportion as comparative sequence (X1), exchange rate as comparative sequence (X2), the average exchange rate within one year as the benchmark of exchange rate, per capita GDP as comparative sequence (X3), foreign direct investment as comparative sequence (X4), and market openness (equivalent to import amount/GDP) as comparative sequence (X5). All the data are sourced from "Statistical Yearbook of Yunnan Province Each Year"

F. Empirical Analysis on Gray Correlation Degree and the Result

TABLE VIII. GRAY CORRELATION DEGREES BETWEEN TOTAL INVESTMENT AND PER CAPITA GDP AND OTHER FACTORS IN YUNNAN PROVINCE

Population aging proportion	Exchange rate	Per capita GDP	Foreign direct investment	Market openness
0.5219	0.5141	0.5599	0.6636	0.5112

According to the correlation degree of the said factors as shown in "Table VIII", order of each factor's degree of correlation with net export is as follows: foreign direct investment> per capita GDP> proportion of population aging> market openness> exchange rate. Foreign direct investment has the highest correlation with net export and thus has the largest impact on net export. Through analysis, it can be known that from 2000 to 2011 net export was in rising trend; the sharp decrease in net export during 2011-2013 indicates that the fluctuation of exchange rate in 2011 poses large impact on trade balance; in a long run, the rising of RMB exchange rate may reduce the export of goods in Yunnan Province, while increasing import may affect the stability of Yunnan's trade in the future. Market openness also has large impact on Yunnan's net export; generally, market openness is positively correlated to foreign trade growth.

IV. CONCLUSION AND COUNTERMEASURES

A. Conclusion

As a whole, Yunnan's population aging is speeding up, but is weak compared with that in other provinces in China and is out of the step of economic growth. The results of empirical study on gray correlation degree are as follows: in Yunnan Province, population aging is closely related to consumption, investment and net export; the order of degrees of correlation between population aging and the three factors is "net export> investment> consumption". This indicates that Yunnan's population aging at this stage has the greatest impact on its net export, and has the least impact on consumption. In general, Yunnan's population aging mainly affects its consumption, investment and net export and further causes influence on the regional economy growth [10].

B. Countermeasures

1) Adjusting the industrial structure and guiding the development of industry for aged people: Because the consumption demand, consumption hobbies and consumption structure of aged population are very different from those of young people, their consumption is biased towards health care and service. With the gradual deepening of population aging extent, the consumption demand of aged population will also increase. However, at the present stage, Yunnan's industrial structure for aged people is not perfect and can hard meet various demands of the increasingly aging population; thereby, aged people oriented industrial economy should be added in the development of regional economy. For example, industries such as health care and insurance, leisure and service oriented to aged people can be added to promote aged population's consumption [11]. It is also

feasible to formulate some preferential tax policies, and adjust relevant fiscal expenditures, to provide a relaxed and pleasant environment for the development of aged people oriented industries.

2) Improving the social insurance system and stimulating the consumption of aged population: From the process of China's old-age security, it can be known that different pension insurance systems are used in China's urban and rural areas. This structure will lead to the decentralization of pension insurance. Therefore in order to perfect the basic pension system, it is needed to incorporate rural labor force into the pension insurance system, build up an urban-rural area integrated overall pension system, gradually adjust the ratio of pension insurance contributions for employees and cadres in urban area, integrate the diversified resources within urban area, and then develop and perfect a new social insurance system, such as nursing insurance and house-for-pension mode. Market mechanism can be introduced in Yunnan by drawing on internationally successful experiences; social organizations, enterprises and private agencies can be encouraged to invest in pension insurance; it is also feasible to perfect the medical insurance system, eliminate urban and rural “dual structure” through urban and rural overall planning for basic medical insurance and eventually build up a uniform urban and rural medical insurance to practically guarantee the benefits rural aged population.

3) Improving export trade and promoting the growth of net export: According to the above empirical analysis, it is known that the population aging in Yunnan has the most significant impact on net export. As the aged population increases, China's income from foreign trade will decrease. This is because the increase in the aged population leads to increase in domestic consumption of goods such as medical, service and consumer goods, so that the total amount of import is reduced. In response to the decline in net export, Yunnan Province should adjust the growth mode of foreign trade, transform the product structure into high-tech and high value-added orientation, and further create a brand new situation of foreign trade. Diversification strategy should be implemented on product export; the government should encourage enterprises to export, stimulate the export scope of some enterprises' products by means of tax breaks and exemptions and providing innovative funds, guide to maintain the development goal of enterprise export trade consistent with the regional economic growth target of Yunnan Province, and optimize structural trade, while updating the industrial structure [12].

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