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Population Aging and Labor Income Share: Theoretical Mechanisms and Cross-Country Evidence

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Abstract

Against the backdrop of intensifying global population aging and its increasingly prominent multi-faceted impacts on economic and social development, this paper comprehensively employs theoretical analysis and empirical research methods to conduct an in-depth investigation into the concept of labor income share and its influencing factors. Focusing on variables such as technological progress, labor market supply-demand dynamics, and human capital, it explores the relationship between population aging and labor income share. The research finds that population aging affects labor income share by altering labor market supply-demand relationships. Simultaneously, through technological progress and human capital accumulation, aging also exerts indirect influences on labor income share. Furthermore, due to differences in economic structures across countries and regions, the impact of population aging on labor income share demonstrates significant heterogeneity. These research outcomes provide important theoretical and practical references for addressing labor income distribution issues in the context of population aging.

Keywords

Population aging; Labor income share; Theoretical mechanism; Empirical research; Policy recommendations

1. Introduction

Global population aging is accelerating. Since the 1970s, due to improved health and declining birth rates, the proportion of elderly people has been on the rise in many countries. For example, Japan's population aged 65 and over reached 29.1% in 2023, while Germany and Italy had 22.8% and 23.2%, respectively. China has also entered a deeply aging society with a 14.9% share of its population. This trend profoundly impacts the social economy, particularly affecting the labor income share in national income distribution.

The labor income share in national income distribution, as a key factor directly tied

to the interests of the working population, is the first to bear the brunt of significant impacts from population aging. The labor income share refers to the proportion of labor compensation in national income. It is not only closely linked to the immediate interests of workers, influencing the income and consumption levels of urban and rural residents, but also plays a crucial role in the stable operation and long-term sustainable development of the economy. A moderate labor income share can effectively stimulate consumption, boost domestic demand, and promote healthy economic growth. Conversely, if the labor income share deviates from a reasonable range, it may exacerbate income disparities among workers in different sectors, leading to a series of socioeconomic conflicts.

Labor income share directly affects workers' interests and is increasingly influenced by aging in the context of global population decline. As a proportion of national income, this share not only impacts household consumption but also concerns economic stability and sustainable development: an appropriate share can boost consumption and promote healthy economic growth; conversely, it may exacerbate income disparities across industries and trigger social conflicts. Therefore, exploring the intrinsic relationship between these two aspects is crucial for grasping economic trends, optimizing distribution structures, and formulating policies. It also provides decision-making references for governments, businesses, and workers to address aging.

Since the beginning of the 21st century, the relationship between population aging and labor income share has attracted considerable academic attention, with numerous scholars conducting multidimensional research. Since the 1980s, labor income shares in Western countries have shown a declining trend, breaking the "Kaldor fact" of stable labor income shares. Subsequently, extensive studies have explored the causes of changes in labor income shares, focusing on structural factors, biased technological progress, imperfect competition, and the globalization of goods and capital (Liu Yalin, Shen Guangjun,and Yao Yang, 2022).However, research examining the trends in labor income shares from the perspective of population aging remains relatively scarce.Against the backdrop of China's increasingly prominent aging trend, while related studies have emerged, most focus on areas such as technological innovation (Wang Wei and Jiang Zhenmao, 2016; Kang Meiling et al., 2024), savings rates (Du Yang and Feng Yonggang, 2023), human capital formation (Pan Junyu et al., 2023),and labor productivity(Cheng Qian and Lu Jiehua, 2024),with limited literature addressing the impact of population aging on labor income share from an income distribution perspective. Wu Xiong and Gong Zhimin (2022),Wu Xiao,Bo Lihong,and Li Haiming (2021),and Wei Xiahai et al.(2014) have analyzed the effects of population aging on labor income distribution through mechanisms such as capital deepening and biased technological progress,mostly based on empirical studies using China's provincial panel data.This paper aims to explore the impact of population aging on labor income share from an international

perspective and empirically test related theories using cross-country data.

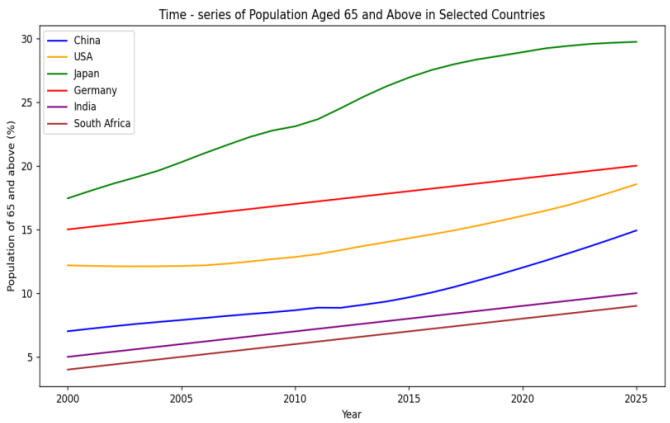

Figure 1: Population aging trends in selected countries (population aged 65 and above)

2. Theoretical Analysis

2.1 Theoretical Model

This paper uses the proportion of the elderly population to the total population to depict the degree of population aging., Assuming the fertility rate among the younger population is n, The number of young population in Year t is L_t, Then the number of elderly population in the t period is πL_{t-1}..Where π represents life expectancy, and the number of children in the population is nL_t.Issue No. t: Degree of Population Aging $\pi L_{t-1}/(\pi L_{t-1}+L_t+nL_t)=\pi/(\pi+n+n^2)$, The extension of life expectancy is an important factor contributing to population aging, and its prolongation can reflect the deepening of aging. When both life expectancy increases and fertility rates decline, the degree of population aging intensifies. Therefore, this section constructs an overlapping generations dynamic general equilibrium model incorporating fertility rates and life expectancy to study the impact of aging on labor income share. Although the model is structurally relatively simple, it possesses strong extensibility, providing a benchmark framework for examining the effects of aging-related policies and expanding theoretical mechanisms. The model framework is as follows:

(1) Representative Individual Behavioral Decision-Making

Assume a representative individual lives for two periods, experiencing youth and old age respectively. During youth, the individual earns wage income through labor and allocates it between consumption and savings. In old age, the retired individual consumes using savings income. This paper specifies the utility function of the representative individual as follows:

$$U=\ln\left(C_t^y\right)+\pi_t\beta\ln\left(C_{t+1}^o\right) \quad (1)$$

Among them, β represents the time discount factor, , C_t^y and C_{t+1}^o represent consumption during youth and old age respectively. The budget constraints faced by individuals are as follows:

$$C_t^y + S_t = (1 - vn) W_t \tag{2}$$

$$C_{t+1}^o = (1 + r_{t+1}) S_t \tag{3}$$

Among them, v represents the time cost of raising each child and n represents the number of children. W_t represents the wage rate of young people in period t, r_{t+1} represents the interest rate of capital in period $t+1$, and S_t represents savings. The optimal saving function can be obtained by solving the maximization of representative individual utility:

$$S_t = \frac{\beta\pi}{1 + \beta\pi}(1 - vn) W_t \tag{4}$$

According to the life cycle consumption theory, with the extension of life expectancy, rational individuals increase their savings to cope with the increased consumption in old age due to the extension of life expectancy, so as to smooth their lifetime consumption.

(2) Enterprise decision-making

Assuming that the firm is in perfect market competition, the final product sector uses capital and labor to produce the final product, and its production function is in the form of fixed alternative elasticity (Constant Elasticity of Substitution, CES):

$$Y_t = A_t \left[(1 - \omega)^{\frac{1}{\varepsilon}} K_t^{\frac{(\varepsilon - 1)}{\varepsilon}} + \omega^{\frac{1}{\varepsilon}} [(1 - \mathrm{vn}) L_t]^{\frac{(\varepsilon - 1)}{\varepsilon}} \right]^{\frac{\varepsilon}{(\varepsilon - 1)}} \tag{5}$$

Among them, parameters A_t, ω, ε and represent the level of technology, the importance of labor in production, and the substitutability elasticity of capital and labor factors, respectively. Y_t, K_t and $(1 - vn) L_t$ represent total output, total capital, and total labor force in period t, respectively. Drawing on Li and Lin's (2015) approach, assuming a depreciation rate of 1 for capital, we define labor-capital ratio as $k_t = K_t / (1 - vn) L_t$. By solving the problem of maximizing corporate profits, we can obtain:

$$W_t = \left[(1 - \omega)^{\frac{1}{\varepsilon}} k_t^{\frac{(\varepsilon - 1)}{\varepsilon}} + \omega^{\frac{1}{\varepsilon}} \right]^{\frac{1}{(\varepsilon - 1)}} \omega^{\frac{1}{\varepsilon}} \tag{6}$$

$$1 + r_t = \left[(1 - \omega)^{\frac{1}{\varepsilon}} k_t^{\frac{(\varepsilon - 1)}{\varepsilon}} + \omega^{\frac{1}{\varepsilon}} \right]^{\frac{1}{(\varepsilon - 1)}} (1 - \omega)^{\frac{1}{\varepsilon}} k_t^{\frac{-1}{\varepsilon}} \tag{7}$$

(3) Theoretical analysis

(1) Define equilibrium

Given the initial capital of the economy K_0, Macro equilibrium means that there are individual choice variables $\{C_t^y, C_{t+1}^o, S_t\}$, Total capital and labor $\{K_t, (1 - vn) L_t\}$ and factor price $\{W_t, R_t\}$ meet the following conditions:

a.On factor prices $\{W_t, R_t\}$ and life expectancy and birth rates $\{\pi_t, n\}$ given the premise, the individual chooses $\{C_t^y, C_{t+1}^o, S_t\}$ maximize your utility;

b.Given the factor price $\{W_t, R_t\}$, enterprises choose $\{K_t,(1-vn)L_t\}$ to maximize profits;
c.Labor market equilibrium, individual labor supply equal to the total demand of enterprises for labor;
d.The capital market is balanced, household savings equal to investment, and the dynamic accumulation equation of capital satisfies:

$$K_{t+1} = L_t S_t \tag{8}$$

(2) Solve the equilibrium
When the economy converges to a steady state, it satisfies $k_{t+1} = k_t = k^*$。Equations (4), (6) and (8) are used to find the equilibrium labor k^* per capital.At the same time, according to equations (5) and (6), the labor income share LS_t is solved. The expressions are as follows:

$$k^* = \frac{1}{n}\frac{\beta\pi}{1+\beta\pi}\left[(1-\omega)^{1/\varepsilon}\left(k^{*(\varepsilon-1)/\varepsilon}\right)+\omega^{1/\varepsilon}\right]^{1/(\varepsilon-1)}\omega^{1/\varepsilon} \tag{9}$$

$$LS = \omega^{1/\varepsilon}\Big/\left((1-\omega)^{1/\varepsilon}\left(k^*\right)^{(\varepsilon-1)/\varepsilon}+\omega^{1/\varepsilon}\right) \tag{10}$$

(3) Analyze equilibrium
The impact of population aging on capital deepening and labor income share is examined from the two aspects of fertility rate and life expectancy. The following propositions are put forward:
Proposition 1: When the per capita capital exceeds a certain threshold, the decline in fertility rate promotes capital deepening.
Proposition 2: When per capita capital exceeds a certain threshold, life expectancy extension promotes capital deepening.
Proposition 3: The effect of capital deepening on the share of labor income depends on the elasticity of labor substitution ε .When $\varepsilon>1$ capital deepening reduces the share of labor income；When $\varepsilon<1$， capital deepening increases the share of labor income, and at that time, capital deepening has nothing to do with the change of labor income share.

2.2 Theoretical mechanism

2.2.1 Labor supply perspective

The decline in the working-age population and the shortage of labor supply in the labor market due to aging, according to the principle of supply and demand, result in reduced labor supply. This leads companies to increase wages to attract workers, enhancing their bargaining power and increasing their share of labor income. The shortage of labor resources further drives companies to improve labor productivity. Labor-intensive technological innovations further boost corporate labor income, thereby increasing the share of labor income even more.

2.2.2 Capital factor perspective

Aging population leads to a decline in the savings rate and a reduction in capital supply. When capital demand remains unchanged or increases, capital becomes relatively scarce, causing an increase in capital prices and higher costs for businesses to use capital. To reduce costs, companies adjust their input structure, reducing capital usage and increasing labor input, thereby raising the share of labor income. However, from another perspective, aging population also increases the burden of elderly care, leading to higher expenditures by governments and businesses on pension security. This may crowd out productive investments by businesses, affecting economic growth and labor productivity, and negatively impacting the share of labor income.

2.2.3 Technological progress perspective

In the face of labor shortages, companies, to save on labor-intensive inputs, tend to rely more on capital for technological innovation, favoring capital-intensive technological progress. Favoring capital-intensive technological progress will increase the marginal output of capital while reducing the marginal output of labor, which may weaken the share of labor compensation in national income distribution in the short term.In the long run, technological progress will drive economic growth, leading to the emergence of new industries and jobs. If these new industries and jobs require more labor-intensive factors, the share of labor compensation in national income distribution may rise.

2.2.4 The human capital perspective

Human capital is the capital embodied in workers, including their knowledge, skills and health. In the context of population aging, human capital has an increasingly critical impact on the share of labor income.

As the population ages, the number of workers decreases, but the quality of the workforce (i.e., the level of human capital) has a more pronounced impact on the share of labor income. On one hand, although older workers may experience declines in physical strength and other aspects, they often accumulate rich experience and specialized knowledge, which are valuable forms of human capital. If these experiences and knowledge can be effectively utilized, such as through knowledge transfer and mentorship programs, it not only enhances corporate productivity but also increases the share of labor income. On the other hand, for younger workers, population aging intensifies competition among companies for highly skilled and qualified talent. This drives workers to focus more on investing in their own human capital, such as pursuing higher education and participating in various vocational training programs to improve their skill levels. As the human capital of younger workers improves, their labor productivity also rises, leading to higher wages in the labor market and an increase in the share of labor income. Generally, education level is used to measure the size of human capital.

3. Empirical analysis

3.1 Indicator description

Labor income ratio (LS) is the percentage of workers' remuneration in the total national income, which represents the results of labor factors in the distribution of production activities. It is also the primary index to evaluate the reasonable degree of income distribution and the level of economic development. The calculation method is as follows:

$$\text{Labor income share} = \frac{Labor\ remuneration}{National\ income} \quad (11)$$

Among them, the remuneration of workers covers monetary forms such as wages, bonuses and allowances as well as non-monetary forms such as material benefits.

3.2 Data selection and model construction

3.2.1 Model specification；specification of model

The impact of demographic changes on the labor income share is a widely concerned issue in economic growth. In order to explore the mechanism of the impact of demographic changes on the labor income share, this paper selects the sample from 2004 to 2023 from the long-term cross-country or regional sequence data, and divides the sample into the following indicators.

(Explained variable) Labor income share: as a core indicator to measure the proportion of labor factor returns in the economy, it reflects the status of workers in the distribution of economic output.

(Explanatory variable) Population aging index: two commonly used population aging indexes, the proportion of the population over 65 years old and the proportion of the population over 65 years old, are selected. The proportion of the population over 65 years old reflects the level of population aging and depicts the changing characteristics of population structure.

Other control variables: To reflect economic realities, various factors can impact the labor income share, hence a series of control variables are included. Among them, the indicator for technological progress is total factor productivity, which comprehensively reflects the contribution of technological innovation and management improvements to output; the labor market supply and demand indicator uses the unemployment rate, intuitively reflecting the balance of supply and demand in the labor market; generally, the education level of workers is used to measure human capital.

Based on the above data, the following regression model is constructed:Based on the above data, the following regression model is constructed:

$$LS = \alpha + \beta_1 \times AG_{it} + \beta_2 \times TF_{it} + \beta_3 \times IS_{it} + \beta_4 JK_{it} + \varepsilon \quad (12)$$

Among them: LS is the share of labor income;AG_{it} is the impact brought by the aging of the population index;

TF_{it} is the impact of technological progress indicators;IS_{it}it is the impact of labor market supply and demand;

JK_{it} it is the impact of human capital; α is the constant term, β is the coefficient, and ε is the error term.

3.2.2 data statistics

A detailed statistical analysis was conducted on the sample data collected from various countries between 2004 and 2023. First, descriptive statistics were performed for each variable, calculating statistical measures such as mean, median, standard deviation, minimum, and maximum values. Taking the labor income share as an example, research from the International Labour Organization indicates that the share of labor income in global income showed a notable decline from 2004 to 2019, dropping from 52.9% to 52.3% between 2019 and 2022 and remaining at this level through 2022. In 2023, the proportion of labor compensation in China's manufacturing value-added was 41.2%, while the labor compensation share in the United States was 56.1%.

Additionally, time-series graphs were plotted for each variable. From the time-series graph of the population aging indicator, it is evident that over time, the old-age dependency ratio and the proportion of the population aged 65 and above in numerous countries or regions have exhibited a continuous upward trend, indicating an increasingly severe global trend of population aging.

3.3 Analysis of empirical results

Through linear regression, the relationship between population aging and labor income share was plotted using software:

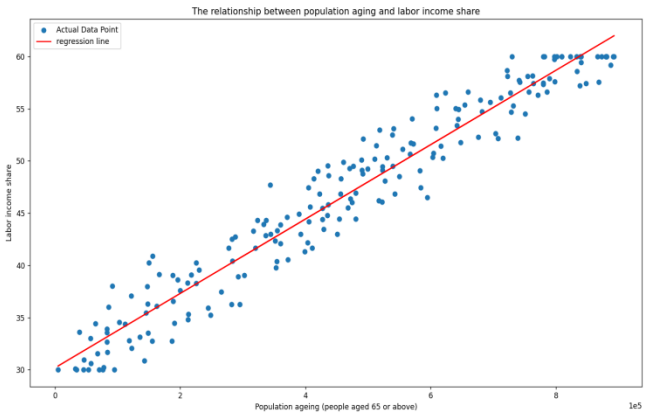

Figure 2: The relationship between population aging and labor income share

The blue scatter points in the figure represent actual values, while the red line denotes the regression line. The overall trend exhibits a relatively gentle upward trajectory. Although the actual values appear somewhat dispersed, they generally cluster around the regression line, indicating a significant positive linear correlation

between population aging (measured by the number of people aged 65 and above) and labor income share. In other words, as the population aged 65 and above increases, the labor income share tends to rise.

The rationality of the relationship between population aging and labor income share can be explained from both economic theory and practical development perspectives. In the initial stages of population aging, the growth rate of the elderly population proportion is too small to significantly reduce labor supply. Additionally, technological progress often tends to be capital-biased, meaning new technologies frequently substitute for labor, thereby enhancing the productive role of capital and leading to a decline in labor income share. However, as population aging deepens, the persistent shortage of labor significantly alters the supply-demand dynamics in the labor market. Workers' bargaining power for wages strengthens noticeably, and firms respond by increasing wages to attract and retain labor, resulting in an increase in labor income share. Consequently, over time, as population aging becomes more pronounced, a positive correlation gradually emerges between population aging and labor income share.

The actual data points do not adhere perfectly to the regression line but exhibit minor dispersion, suggesting that factors other than population aging may also influence labor income share. These include changes in macroeconomic conditions, industrial restructuring, shifts in policies and regulations (such as tax policies and labor protection policies), and technological progress. These factors may act individually or collectively to alter labor income share, leading to different outcomes under varying circumstances. For instance, during an economic recession, firms facing operational pressures may reduce wages or cut jobs, thereby affecting labor income share. Similarly, changes in tax policies, such as adjustments to corporate or personal income tax rates, directly impact firms' costs or workers' actual income levels, subsequently influencing labor income share.

3.4 Model testing

(1) Statistical test

We conduct statistical tests to test the model, and use the goodness of fit test R 2 to measure the degree of fit of the model to the data, where the formula is:

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \acute{y}_i)^2}{(y_i - \overline{y})} \quad (13)$$

Among them, y_i is the actual share of labor income, $\acute{y}_i$is the share of labor income predicted by the model, and $\overline{y}$ is the mean of the share of labor income，the value of R^2 ranges from 0 to 1, and the closer it is to 1, the better its fit.

After calculation, we obtained a value of $R^2$of 0.952, approaching 1. This indicates that the model has good fit and can effectively explain changes in labor income share.

This suggests that the variables selected and their configurations in the model can, to some extent, accurately depict the relationship between population aging and labor income share, as well as the impact of other control variables on labor income share. This provides a reliable basis for further economic analysis and policy formulation.

(2) Multiple collinearity test

Multiple collinearity refers to the phenomenon of high linear correlation between explanatory variables in a regression model. This can lead to inaccurate parameter estimates and invalid tests. In this paper, the Variance Inflation Factor (VIF) method is used for testing multicollinearity in the model. The calculation method for the Variance Inflation Factor is as follows:

$$VIF_j = \frac{1}{1 - R^2} \quad (14)$$

VIF_jj is the variance inflation factor of the explanatory variable, and R^2 is the coefficient of determination obtained by regressing the dependent variable on other explanatory variables. Generally,VIF_j>10 indicates severe multicollinearity,5 <VIF_j<10 indicates strong multicollinearity, and when VIF_j<5, multicollinearity is weak.

Through calculation, the variance collision factor of explanatory variables is obtained as follows:

Table 1. Calculation results

explanatory variable	explained variable
ageing of population；aged tendency of population	2.5
technical progress	3.2
Labor market supply and demand indicators	2.7
educational level；level of education	1.4

From the calculation results, it can be observed that for all explanatory variables—whether population aging, technological progress, education level, or labor market supply-demand indicators—the variance inflation factors among them are all less than 5.This indicates that the degree of multicollinearity among the explanatory variables in the model is relatively weak, the model is relatively robust, and the parameter estimation results are fairly reliable.

4. Research results and prospects

4.1 Research conclusion

Through constructing regression models and conducting empirical analysis, we have discovered a significant linear positive correlation between population aging and labor income share. In the early stages of population aging, labor income share may decline due to insignificant reductions in labor supply and capital-biased technological progress. However, as population aging intensifies, labor shortages become more pronounced, workers' bargaining power strengthens, and labor income share demonstrates an upward trend.

The control variables for labor income share include technological progress, human capital, and labor market supply-demand dynamics. In the short term, technological progress may be capital-biased, leading to a decline in labor income share; however, in the long run, it may ultimately improve labor income share through diffusion and enhancement of workers' skills. Labor market supply-demand conditions serve as an intuitive reflection of labor market competition, directly affecting workers' bargaining power and further influencing labor income share. Human capital is also a crucial variable, as the level of education can impact the magnitude of aging's effect on labor income share.

Model testing results indicate that the model exhibits good fitting performance (R^2 =0.952), passes economic significance tests and multicollinearity tests, suggesting that the selected variables and model specification can, to a certain extent, accurately capture the relationship between population aging and labor income share, as well as the influence of other control variables.

4.2 Outlook and recommendations

(1) From the perspective of government policy, the government should promote cooperation between universities, scientific research institutions and enterprises to develop technological achievements suitable for the current situation of labor shortage. At the same time, a unified national labor market information platform should be set up to update data such as job supply and demand and salary level in real time to reduce information asymmetry

(2) From the perspective of enterprises, attention should be paid to the changes in the labor market brought about by population aging, and contingency plans should be made as early as possible. In the event of labor shortages, investment in technological innovation and intensive factor management should be increased to enhance labor productivity, while appropriately adjusting the structure of factor inputs to adapt to cost changes resulting from population aging.

(3) From the perspective of workers, it is essential to continuously enhance their quality and skill levels. With the gradual advancement of technology and changes in industrial structure, there are increasingly higher demands on workers' skills. By improving their education levels and participating in vocational skill training, workers can elevate their overall competence, strengthen their market competitiveness, and secure higher labor income, thereby increasing the share of labor income.

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