Dynamics of Dependency Ratio and Its Impact at Provincial Level in China: A Labor Productivity Perspective

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1. Research background and topic

Growth in the number of older persons is a global phenomenon: According to the *World Population Prospects 2022* published by United Nations, in 2021, there were 132 countries and regions that have entered an aging society, among which 73 are considered deeply aged societies and 26 are super-aged societies. It is expected that between 2017 and 2050, virtually every country in the world will experience a substantial increase in the size of the population aged 60 years or over.

This demographic change has profound social and economic consequences, including imbalances in society, changes in family structures, and impacts on healthcare, politics, and the economy around the world. How to actively respond to population aging has become an emerging global governance issue.

China has one of the fastest growing ageing populations in the world, and is expected to become the “super-aged” society around 2035. This fact has implications for the economy and policy areas in terms of providing services and state pensions. The status called" Rapid ageing and slower growth" will inevitably pose a serious challenge to the economic growth model that has traditionally relied on the "demographic dividend" for a long time. How to effectively respond to the impact of population aging on the economy and society has become an urgent issue that needs to be resolved in the process of promoting high-quality development in China at present. Scholars in the past generally used the Age Dependency Ratio (ADR), which is the ratio of the total number of children (0~14 years old) and the elderly population (65 years old and above) to the working-age population (15-64 years old), to measure the social dependency burden. ADR captures the interrelationship between the working-age population and the dependent population, effectively measuring the burden over the long term, and is crucial for analyzing and examining the socio-economic impacts of aging at both the macro and micro levels.

Accurate estimation of the dependency ratio is a prerequisite for assessing the potential economic consequences and future policy making and modification brought about by aging. Based on the fact that not all working individuals are equally productive, our study innovatively takes into account the differences in labor productivity caused by varying population age structures. **Our study presents the productivity-weighted labor productivity dependency ratio (PWLFDR), a new measure of dependency burden based on the labor productivity of the working age population.** This approach allows for a clearer assessment of the dynamic

changes in total output and support burden caused by various population age structures at provincial level. Our study provided an alternative method to measure the dependency burden and helped to give scientific insights for future evidence-backed, forward-looking policy design to address the negative impacts of aging.

2. Theoretical focus

When discussing the contribution of aging to economy and the dependency burden, most of the studies used the total number of the working-age population. This is useful for understanding the trend of population dynamics over a long period of time. However, the economic impact of aging as well as the dependency burden may be affected by differences in the age distribution of the working-age population. Neglect of the age differences may lead to biased conclusions in the analysis of short-term economic burden. It is therefore necessary to further explore the differences in age structure the study of mid- to long-term consequences of population aging. Usually we used the conventional age dependency ratio (ADR) to calculate the burden. The conventional ADR considers everybody aged 15–64 as equally productive and all people above age 65 as unproductive. However, labor productivity has been changing significantly in recent years, and in the future, young people are likely to be significantly more educated than middle-aged and older people, and older people are likely to be significantly more productive because of their higher level of education. Therefore, it is necessary to account for labor productivity differences and its evolution in the study of the aging burden. In this paper, we proposed an innovative dependency indicator, PWLFDR（Productivity Weighted Labor Force Dependency Ratio）to more accurately analyze the economic effect/burden posed on each province. This indicator can help approximate differences in productivity through various age groups.

$$\mathrm{PWLFDR}_t^c = {D_t^c}\Big/{(\beta_1 * \mathrm{youth}_t^c + \beta_2 * \mathrm{adult}_t^c + \beta_3 * \mathrm{old}_t^c)}$$

Here, t represents for time, c represents for different province, D_t^crepresents the number of dependents within a provincial region, youth_t^c, adult_t^c, and old_t^c denote the quantities of young working age population (15-29), middle-aged (30-44 years old), and middle-aged to elderly (45-64 years old) populations within the labor force in the region, respectively. β_1, β_2, and β_3 are the labor productivity coefficients for the young, middle-aged, and middle-aged to elderly populations, respectively. $\beta_1 * \mathrm{youth}_t^c + \beta_2 * \mathrm{adult}_t^c + \beta_3 * \mathrm{old}_t^c$ represents the labor force weighted by labor productivity within the administrative region.

For PWLFDR_t^c, labor force is weighted by labor productivity. This presents the most significant difference from traditional dependency ratio. Moreover, the larger the value of $\beta_1 * \mathrm{youth}_t^c + \beta_2 * \mathrm{adult}_t^c + \beta_3 * \mathrm{old}_t^c$, the higher the quantity of labor force weighted by labor productivity, indicating a higher total social output and a relatively lower social burden. Of all the indicators above, the most important step is the weights estimation, which will be shown in the next part.

3. Methods

The crucial part is the estimation of the differences in productivity caused by age variety. In theory, Population growth will affect the supply of labor, the higher the population growth rate, the greater the supply of labor; at the same time, there are differences in savings and consumption

behaviors among different age groups of the population, which affect the capital formation. Therefore, we assume that output satisfies the Cobb-Douglas production function embedded with the age structure of the labor force,

$$Y = AK^{\alpha}(\sum \delta_i L_i)^{\frac{\beta}{\rho}} H^{\gamma}$$

Y represents total output, A represents the contribution of technological progress to output, A represents capital, H represents human capital, L_i represents the labor force in different age groups (i=1,2,3), α, β, and γ represent the output elasticities of capital, labor, and human capital, respectively, and ρ is the elasticity parameter, indicating the substitutability between different age groups. We take the logarithm of the production function, then we obtain the non-linear relationship between total output and population age structure as well as other variables

$$lnY = lnA + \alpha * lnK + \beta/\rho * \ln(\sum \delta_i L_i) + \gamma * lnH$$

4. Data

Out study utilizes panel data from 31 provinces, municipalities, and autonomous regions in China for the 2000, 2005, 2010, 2015, and 2020. The core variable of total output in this study is measured by regional GDP, and capital is represented by the total fixed investment. For the human capital variable, we refer to classical studies and measure it using the average years of education.

The on population age structure data mainly comes from the "The 5th Census Data in 2020," "1% National Population Sample Survey Data in 2005," "The 6th Census Data in 2010," "1% National Population Sample Survey Data in 2015," and "The 7th Census Data in 2020." Total output, total fixed investment, and education levels come from the "China Statistical Yearbook" from 2000 to 2021.

5. Expected Findings

(1) **Significant differences exist in terms of labor productivity across young, middle-aged, and elderly working age population.** We conducted a regression analysis on the labor productivity of different age groups and found the labor productivity of the middle-aged working age population (30~44) is the highest, followed by the young working age population (15~29). In contrast, labor productivity of the elderly working age population (45~64) is relatively lower, and exhibits a characteristic of a cliff-like decline.

(2) **The impact of differences in labor productivity under various age structures on provincial social dependency burdens is significant.** A larger proportion of young (15~29) and middle-aged working age population (30~44) with higher labor productivity can effectively alleviate the dependency burden. In contrast, we found a cliff-like decline in labor productivity of elderly working age population (45~64). The larger the share of this group in the labor force, the heavier social burden it caused. For economically developed provinces represented by Guangdong and Shanghai, they enjoy a comprehensive social service system and competitive industries. These relative advantages will help attract a large portion of working age population inflow (aged 15 to 29 and 30 to 44), then boosting the overall labor productivity and thus alleviating the social support pressure on the province.

(3) **PWLFDR can more accurately reflect the impact of population age structures and provide an alternative way to measure the social dependency burden.** For developed provinces and municipalities such as Beijing and Guangdong, the labor productivity-weighted

dependency ratio is lower than the traditional dependency ratio. However, for provinces with relatively disadvantaged economic development in the northeastern and southwestern China, such as Liaoning and Sichuan province, the labor productivity-weighted dependency ratio is actually higher than that of the traditional age dependency ratio. This is highly consistent with existing studies on dependency ratio in Europe, where aging is more pronounced. Being different from the ADR, this alternative method to measure the dependency burden will help to give scientific insights for future evidence-backed, forward-looking policy design to address the negative impacts of aging.