

A Study on the Impact of China's Demographic Structure on Human Capital Accumulation—Based on a Panel Data Model

YANG Lu, CHEN Wenxuan

Jiangxi University of Finance and Economics, Nanchang, China

With the development of the times, the role of human capital in economic growth has been highlighted. However, in the current academic world, the research on the topic of demographic structure and human capital accumulation is not closely integrated. China is now in a period of economic transformation and upgrading, and it is urgent to change the traditional economic growth model, increase human capital investment, and cultivate new growth momentum. Therefore, this paper examines the impact of China's population structure on human capital accumulation by constructing a mathematical model based on relevant panel data of 31 provinces (municipalities and autonomous regions) from 2001 to 2020. The empirical results show that human capital accumulation in China has a certain lagging effect, while population age and urban-rural structure enhance human capital accumulation in both quantitative and qualitative terms, respectively. In addition, industrial transformation, economic growth level, and per capita income all have significant positive effects. The effect of education, on the other hand, is not significant, while the interaction between urbanization and industrial structure may hurt it. Based on this, this paper proposes targeted countermeasures and suggestions in terms of fully developing the population quality dividend, fully tapping the talent knowledge dividend, continuously improving the health dividend, and continually tapping the aging dividend.

Keywords: demographic structure, human capital accumulation, empirical analysis, regression model

Introduction

As time progresses, the role of physical capital in economic development is gradually weakening, while the role of human capital is becoming increasingly prominent. Since the 21st century, the trend of population aging, less childbearing, and urbanization has become more obvious, and the demographic structure will have a more significant impact on human capital accumulation. In what way is the accumulation of human capital achieved in this process? The article intends to study the current situation of China's population structure, construct a mathematical model, apply empirical analysis to systematically elaborate and answer this question, and propose relevant countermeasures and suggestions. Therefore, it is of great practical significance to analyze the impact of demographic structure on human capital accumulation by studying the population data of each province in the past twenty years, to make corresponding suggestions.

YANG Lu, Ph.D., lecturer, department of international economics, Jiangxi University of Finance and Economics, Nanchang, China.

CHEN Wenxuan, bachelor student, department of international economics, Jiangxi University of Finance and Economics, Nanchang, China.

Correspondence concerning this article should be addressed to CHEN Wenxuan, Jiangxi University of Finance and Economics, No. 169, Shuanggang East Street, Changbei National Economic and Technological Development Zone, Nanchang, China.

Literature Review

Current Status of Demographic Research

At present, China's aging problem is getting more and more serious, and it is urgent to find the transformation of economic growth momentum. Domestic scholars' research on demographic structure mainly focuses on exploring two major perspectives of its impact on economic development and industrial upgrading and putting forward relevant development suggestions based on research studies. Tie (2019) also investigates the issue of processing trade upgrading in this context, i.e., the extent to which the level of labor supply in China's manufacturing industry affects the domestic value added of China's processing trade products. By establishing a multisectoral general equilibrium model, Guo, Yan, and Li (2021) explored the role of aging on the development of the service industry from the perspective of the population age structure, and made a systematic analysis of the phenomenon of "aging before wealth", and proposed countermeasures to promote the development of the service industry and face the aging problem.

Current Status of Human Capital Research

Domestic scholars' research on human capital focuses on its endogenous relationship with firm performance and economic development and explores the external effects of human capital. By establishing a theoretical model related to human capital participation, internal control, and firm performance, Xu, Zhu, Liu, and Peng (2021) found a positive relationship between human capital participation in surplus distribution and firms' internal control level. Liu (2021) explored the mechanism of the role of green intellectual capital in high-tech enterprises and encouraged that technology enterprises should strengthen the development and management of green intellectual capital and improve their dynamic capabilities.

In the context of the new normal of economic development, accelerating human capital accumulation is the key to enabling economic transformation and upgrading, so the importance of human capital is self-evident. The combination of demographics and macroeconomics has gradually resulted in a large number of representative research results. Regarding the relationship between human capital and economic growth, scholars at home and abroad have conducted a lot of discussions on it and also achieved many academic results. However, the impact of population structure on human capital accumulation has rarely been studied. The current studies focus on the correlation between population aging and productivity and economic growth but lack a combined analysis of the two. Meanwhile, empirical studies of human capital in China lack strong convincing power due to the lack of research on the mechanism of demographic change in China. Therefore, this paper tries to start from the current situation of demographic change in China, introduce demographic structure into human capital accumulation, and at the same time use panel data based on theoretical analysis to conduct empirical research, establish a mathematical model, and explore the intrinsic correlation between the two, to enrich research results in related fields and provide more theoretical structures and practical suggestions for the influence of demographic structure on human capital accumulation.

Theory and Mechanism

The Current Situation of China's Population Structure

Population structure mainly refers to a series of characteristics of the population in terms of fertility behavior, age structure, the urbanization process, family structure, etc. The following is a brief analysis of the new trends in China's current population structure.

Population aging trend. According to the official indicators, a country has entered an aging society when the percentage of people over 60 years old exceeds 10% or when the percentage of people over 65 years old exceeds 7%. Statistics show that the proportion of people over 65 years old in China reached 10.1% in 2014, a figure that can indicate that China has “fully entered the elderly society”. With the release of the results of the 7th census in 2020, China’s population structure has once again drawn the attention of the society, with 18.7% of the population over 60 years old and 13.5% of the population over 65 years old.

The Current Situation of Human Capital Accumulation in China

Despite the significant aging trend in China, the working-age population in China is still relatively young, and the huge labor force is still able to support the rapid development of the economy. At the same time, with the popularization of education, the improvement of people’s mindset, and the increasing investment in their education and training, the quality of China’s population is also improving, and this performance is sufficient to compensate for the negative impact of the declining population size dividend. China’s demographic dividend is gradually changing to a talent dividend, which provides stronger intellectual and labor support for the development of the economy and can further promote the implementation of the strategy of developing the country with science and technology and strengthening the country with talents. Such a reciprocal, virtuous cycle will significantly drive the transformation and upgrading of China’s industrial structure and increase total factor productivity, thus promoting the sustainable and healthy development of the economy and society.

Research Analysis of the Impact of China’s Population Structure on Human Capital Accumulation

The current changes in the population age structure are mainly reflected in the following: the birth rate of the population has significantly decreased and the trend of fewer children has taken shape, while the proportion of the working-age population has increased, leading to the growth of the working population and the expansion of the stock of human capital; in the process of urbanization, the rural labor force continues to gather in developed cities and the urban-rural population structure has changed, a trend that helps promote the coordination of human capital supply and demand, which leads to the appreciation of human capital. The former focuses on the quantitative accumulation of human capital, while the latter focuses more on the quality and sustainability of human capital.

There is a well-known assertion in the demographic transition model—the so-called three-stage model, with the first stage of high mortality and high growth rates, followed by birth and growth rates that begin to decrease, and the third stage of even lower birth and growth rates. Around 1950, the country’s demographic structure took the shape of a pyramid, i.e., the number of the three groups—young children, youth, and elderly—declined in steps. Currently, China is in the second to a third transition period, with economic development and improved medical technology, people’s average life expectancy has further increased, but at the same time, the aging problem has also come to the fore, and the population age structure tends to be rectangular. With the deepening of the demographic structure, China has now entered a period of high working age, and the labor productivity of different age groups shows an overall trend of “inverted U”, so the labor productivity of China will increase, while the dependency ratio will decrease, the freedom of the working population will increase, so the total amount of human capital will also increase.

Empirical Analysis

The current status of China's population structure has been briefly analyzed in the previous section, and this chapter empirically investigates the correlation between China's population structure and human capital accumulation using panel data for each province from 2001 to 2020 and provides an in-depth discussion based on the empirical results.

Construction of the Indicator System

Selection and description of indicators. Based on the results of previous studies, and taking into account the specific situation of Chinese provinces and the availability of panel information in China, this paper selects seven evaluation indicators.

1. Human capital level (human capital)

In this paper, the educational attainment of the school-age labor force is chosen to measure the level of human capital. The quoted formula: the average number of years of education in the labor force = the share of the employed population who are illiterate and semi-literate $\times 1.5$ + the share of the employed population who received primary education $\times 7.5$ + the share of the employed population who received junior high school education $\times 10.5$ + the share of the employed population who received senior high school education $\times 13.5$ + the share of the employed population who received college and above $\times 17$ for calculation. Among them, the data related to the educational attainment of laborers in each region are obtained from *China Population and Employment Statistical Yearbook* and *China Statistical Yearbook of 2001-2020*.

2. Age demographics (age)

The contribution rate between each age group cannot be precisely defined and calculated, so the ratio of the school-age labor force to the total population, which contributes most to human capital, is chosen as an indicator in this chapter. The relevant information is mainly obtained from the *China Statistical Yearbook* and *China Population and Employment Statistical Yearbook from 2001 to 2020*.

3. Urban and rural population structure (city)

This paper collects and compiles the urban population and total year-end resident population of each province and city from 2005-2019, and calculates the urban and rural population structure of each province and city using the formula: urban and rural population structure = urban population/total population. Due to the incomplete urbanization data of some provinces, the missing data were derived by incremental estimation method, and the data were obtained from *China Statistical Yearbook*, *China Population and Employment Statistical Yearbook*, etc. from 2005-2019.

4. Level of economic growth (GDP)

The comprehensive indicators generally used to measure China's economic development are per capita income, GDP, and GDP per capita. Given that this thesis is a study of the role of demographics on human capital accumulation, GDP per capita is chosen to measure the level of economic development. Its data are obtained from the *China Statistical Yearbook from 2001 to 2020*.

5. Income level (income)

This chapter uses the indicator of per capita disposable income of the residents to measure the income level. Starting in 2013, the National Bureau of Statistics conducted a comprehensive survey on the income and living conditions of rural residents. The scope, methodology, etc. of this survey differs to the pre-2013 survey of

households by urban and rural areas. Therefore, the data from 2005 to 2012 can be calculated by the formula: disposable income of residents = disposable income of urban residents \times urban population/total number of people + net income per capita of rural residents \times rural population/total number of people. All data are from the *China Statistical Yearbook 2005-2020*.

6. Government investment in education (edu)

The level of human capital is closely related to the level of education, so government investment in education is a necessary explanatory variable. In this paper, the share of financial education expenditure in GDP is used to measure education investment, and the data are obtained from the *China Statistical Yearbook from 2001 to 2020*, where the expenditure data for the education sector in 2019 and 2020 are calculated based on the growth ratios in 2017 and 2018.

7. Industrial transformation (industry)

The industrial transformation studied in this paper is the dynamic adjustment between the primary, secondary, and tertiary industries. The formula: industrial transformation = (value added of secondary industry + value added of tertiary industry)/regional GDP, is quoted to measure the level of industrial transformation in China. The relevant data are obtained from the *China Statistical Yearbook from 2001 to 2020*.

8. Interaction items (city-industry)

The interaction term is derived by multiplying two explanatory variables, the urban-rural demographic structure term, and the industrial transformation term. Since the change in China's urban and rural population structure is related to the quantity and quality of labor resources, this interaction term is chosen to test the role of industrial transformation in China's urbanization process on the country's human capital accumulation.

The detailed descriptive statistics of the variables are as follows in Table 1.

Table 1

Descriptive Statistics of the Variables

Variable	Mean	Std. dev.	Min	Max	Observations
lncapital	2.3576	0.1403	1.6096	2.7376	584
age	0.7283	0.0362	0.6346	0.8384	527
city	0.5315	0.1467	0.2071	0.9415	465
lnGDP	10.1805	0.8172	8.0063	12.013	619
lnincome	9.6145	0.6199	8.1781	11.1876	496
edu	0.0420	0.0221	0.0183	0.1814	527
industry	0.8825	0.0630	0.6533	0.9973	620
city-industry	0.4792	0.1577	0.1688	0.9290	465

Notes. Incapital is a logarithmization of the capital, lnGDP is a logarithmization of the GDP variable, Incapital is a logarithmization of the capital.

Construction of the Model

Model selection.

1. Static panel estimation

First, this paper uses two models for estimation: fixed effects and random effects. p -value less than 0.05 in Hausman's test uses fixed effects, and the results show that the fixed effects model is better than the random effects model.

Table 2

Static Panel Estimation Results

	Random effects lncapital	Fixed effects lncapital
age	0.2520 (1.63)	0.2300 (1.43)
city	0.9360** (2.10)	0.3888 (0.88)
lnGDP	-0.0014 (-0.05)	0.0260 (0.92)
lnincome	0.1169*** (3.77)	-0.0562 (-1.31)
edu	-1.3342*** (-7.45)	-1.8488*** (-9.57)
industry	0.0176 (0.07)	-0.3058 (-1.17)
city-industry	-0.5991 (-1.33)	0.2589 (0.56)
cons	0.9201*** (4.23)	2.4925*** (7.55)
R^2	0.7285	0.751
N	371	371

Notes. The t -values of the tests are shown in parentheses under the regression coefficients in the table.

** and *** denote 5% and 1% significance levels, respectively.

From the results in the above table, it is clear that the effect of demographic change on human capital accumulation has significant utility, but the static panel model does not fully reflect the growth lag of human capital and the endogenous properties of the model. The accumulation of human capital in the demographic process is correlated with both present and past changes in the population ratio, and human capital accumulation is time-dependent, and human capital accumulation has a corresponding effect on the demographic structure, for which we will use a dynamic panel model of GMM to conduct a more reasonable regression analysis.

2. GMM dynamic panel estimation

For both endogenous and time-lagged reasons, we introduce primary lags of human capital into the regression model to test its time-lagged properties, while excluding the primary autocorrelation of the remaining variables.

3. Unit root test

In the panel data, it is necessary to conduct a unit root test for each variable, so this paper uses Fisher's test to prevent the phenomenon of "pseudo-regression", and the results are shown in Table 3, which shows that the variables are relatively smooth.

Table 3

Fisher Unit Root Test

Variable	Z	p -value
lncapital	-13.1666	0.0000
age	-8.8239	0.0000

Table 3 to be Continued

city	-13.9183	0.0000
lnGDP	-21.9387	0.0000
lnincome	-16.6718	0.0000
edu	-15.2397	0.0000
industry	-19.7893	0.0000
city-industry	-16.6718	0.0000

4. Co-integration test

The results of the cointegration test are shown in Table 4, which shows that there is a long-run cointegration relationship among the variables.

Table 4

Co-Integration Test

Statistic	Value	Z-value	p-value
Gt	-3.433	-3.419	0.000
Ga	-13.196	0.275	0.608
Pt	-11.685	-3.621	0.000
Pa	-12.894	-1.142	0.127

Analysis of empirical results. In the GMM model, human capital accumulation itself has a certain lag, and the correlation between age demographic structure, urban-rural demographic structure, industrial structure transformation, economic growth level, and per capita income has a positive effect on human capital accumulation, while the interaction term has a negative effect on human capital accumulation, and the correlation between education investment and human capital accumulation is not significant.

1. Lag of human capital accumulation

The results show that the first-order lagged effects of human capital levels are significant and positive in the process of gradually adding the influencing factors, indicating that human capital accumulation has dynamic persistence and lagged effects.

2. Impact of demographic structure on human capital accumulation

From the results of the empirical study, both types of demographic changes have a significant positive cumulative effect on human capital accumulation in China, but the age structure transition contributes to a greater extent.

With the transformation of China's demographic structure, the proportion of the young labor force in China is increasing, the scale of the labor market is expanding, and the total amount of human capital is growing. The urban-rural demographic structure, on the other hand, has brought about the transfer of the rural labor force. In order to adapt to the transformation of economic structure, people keep learning and self-improvement, which improves the quality of human capital, which has caused a hugely positive effect on human capital accumulation. However, due to many problems in the urbanization process, the quantitative improvement of the labor force brought by the change in age demographic structure may play a more significant role in promoting human capital accumulation than the qualitative improvement of the labor force brought by the change in urban-rural demographic structure.

3. Impact of the level of economic growth on human capital accumulation

From the empirical results, the level of economic growth will have a significant positive effect on human

capital accumulation. The sustained and healthy economic development can create a favorable macro environment for human capital accumulation in China.

4. The effect of per capita income level on human capital accumulation

Growth in disposable income per capita has had a positive effect on the growth of human capital. The increased level of economic development gives people more physical capital to invest in human capital and to improve their overall quality and capabilities and those of their offspring through additional learning and training, thus improving their income, the quality of their lives, and their own well-being.

5. Impact of government investment in education on human capital accumulation

The insignificant impact of education investment on human capital accumulation is mainly due to the low proportion of education investment, the imbalance of education expenditure structure, and the insufficient allocation of social resources in China. To effectively improve the role of education on human capital accumulation, it is necessary to solve these series of difficulties as soon as possible.

6. The impact of industrial transformation on human capital accumulation

The empirical results show that industrial transformation has a positive effect on human capital accumulation in China. Changes in industrial structure will affect the demand for human resources, which in turn will affect the level and accumulation of human capital. The transformation and upgrading of industrial structure will generate new economic growth points, which in turn will lead to changes and upgrades in the structure of human capital in China, which in turn will lead to the improvement of labor productivity and inject vitality into the sustained economic growth. In today's society, the continuous development of new industries has put forward higher requirements for the comprehensive quality of talents, which is conducive to promoting the accumulation of human capital in social development and increasing the stock of human capital.

7. Impact of the interaction term of urbanization and industrial transformation on human capital accumulation

From the results of the empirical study, both urbanization and industrial transformation will promote the growth of human capital in China, but the interaction between the two will instead hinder the growth of human capital, which means that with the increasing proportion of secondary and tertiary industries, their role in the growth of human capital has not been fully exploited.

Table 5

Dynamic Panel Estimation Results

	(1)	(2)	(3)
	lncapital	lncapital	lncapital
L. lncapital	0.0338 (1.25)	0.0298*** (4.08)	0.0295*** (3.82)
age	-0.2262 (-1.56)	0.1802* (1.66)	0.2379** (2.47)
city	1.2915*** (8.13)	0.8698*** (6.15)	0.3516 (0.80)
city-industry	-0.5709*** (-3.85)	-0.2421*** (-3.19)	0.3093 (0.74)
lnGDP	0.0228 (0.83)	0.0215 (1.01)	0.0262 (1.26)

Table 5 to be Continud

lnincome	0.0165 (0.40)	-0.0558 (-1.14)	-0.0608 (-1.27)
edu		-1.7868*** (-4.84)	-1.8519*** (-5.46)
industry			-0.3278 (-1.52)
_cons	1.6551*** (7.01)	2.2100*** (8.25)	2.4749*** (8.50)
<i>N</i>	404	346	346

Notes. L. Incapital is the lagged one period of Incapital.

The *t*-value of the test is shown in parentheses under the regression coefficients in the table.

*, **, and *** denote the significance levels of 10%, 5%, and 1%, respectively.

Conclusions

Using relevant panel data for 31 provinces and autonomous regions from 2001 to 2020, this paper examines the role of China's overall demographic structure on human capital accumulation and, through empirical analysis, draws the following conclusions.

First, human capital accumulation in China has a certain lag effect, both in the present and in the lag phase, which has a significant driving effect on itself. Secondly, the demographic structure of China has an obvious positive effect on human capital accumulation, as the change in the age structure of the population expands the quantity of age-appropriate labor force, while the change in the urban and rural structure of the population enhances the quality of the labor force. However, at the same time, we should be aware that the problem of population aging in China is becoming more and more serious, and we should be alert to the shift from demographic dividend to demographic debt to prevent it before it happens. Third, industrial transformation, economic growth level, and per capita income have obvious positive effects on human capital accumulation. The transformation and upgrading of industries will generate higher requirements for human resources and thus will inevitably lead to human capital accumulation. Fourth, the interaction between urbanization and industrial structure will hurt human capital accumulation. This may be due to the different degrees of industrial transformation in different regions and the lack of coordination between industrial structure and population structure, and the coupling problem between the two will hinder the accumulation of human capital. Fifth, the insufficient investment in education and its low share of GDP, as well as the unreasonable structure of expenditure leading to the unbalanced distribution of educational resources among regions, make education not produce the expected effect on human capital accumulation. We should develop the population quality dividend comprehensively and continuously increase the investment in education. The relevant departments need to pay more attention to education, strive to increase the proportion of education expenditure in the financial expenditure, pay attention to improving the disparity in education expenditure between regions, and build more public schools, while also working to break the institutional barriers and play the supplementary role of private schools.

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