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A Literature Review on China's Population Aging, Human Capital and R&D Capital Stock

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Abstract

This paper mainly studies the impact of population aging on human capital, and combs the relevant literature. This paper compares the different status quo of population aging in China and abroad, and the different effects of population aging in different countries. We also want to know whether the aging of population affects the stock of R&D capital and whether this impact is brought about by the change of human capital. Through the existing literature, we find that population aging will directly lead to the reduction of R&D human capital stock, which is generally accepted by all countries. At the same time, the change of human capital brought by population aging brings about the change of education capital and health capital. But scholars have not yet reached a clear conclusion. Through the study of this conduction effect, we can further explore the mechanism of population aging.

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1. Background

The acceleration of population aging has become a very serious social problem, affecting China's social, economic and other aspects of development. The causes of China's aging population are complex and there are many factors. According to the China Statistical Yearbook 2017, the average life expectancy in China has increased from 67.77 years in 1981 to 76.34 year in 2015. The increase in life expectancy will affect people's behavior, including investment in health and education, which will further affect population aging.

The dependency ratio of the elderly in China is on a rising trend. On the one hand, the birth rate of the population is declining; on the other hand, the life expectancy of the elderly is getting longer and longer, and the proportion of the population over 65 is getting larger and larger. Faced with this trend, we have to think about some problems. First, how will population aging affect people's behavior? Secondly, how does the behavior of the aging population affect human capital, especially healthy human capital and educational human capital? Finally, what impact will this change in human capital ultimately reflect on the stock of R&D capital? Based on this, if we want to draw a conclusion, it is necessary to explore the following issues. (1) Whether human capital is related to population aging and how it is related to human capital, it is necessary to measure and calculate human capital, and then explore the relationship from an empirical point of view; (2) What is the relationship between aging and R&D capital stock, and whether aging will bring about the increase or decrease of R&D capital stock, which naturally leads to the measurement of R&D capital stock in China; (3) Whether the impact of aging on R&D capital stock is transmitted through the change of human capital, it needs to establish a conduction model to explore this conduction relationship.

2. The Significance and Measurement of Human Capital

It is generally believed that human capital refers to the sum of knowledge, skills and physical strength (health status) with economic value existing in workers, and is the embodiment of workers comprehensive quality (Becker, 1964; Schultz, 1961). In the current world economic development, human capital has become the driving force and source of technological innovation, economic growth and sustainable development (Lucas, 1988; Romer, 1990). With the acceleration of China's aging, human capital research cannot be ignored. Domestic scholars have explored Chinese human capital from various perspectives, which to a certain extent has promoted the country's attention to human capital.

Most of the existing studies on human capital focus on the role of health and education. As an important part of human capital (Grossman, 1972) health status and changes have an increasing impact on national economic growth. Foreign scholars have also proved through data that health has a significant role in promoting economic growth, and a considerable part of the contribution of long-term economic growth can be explained by health (Arora, 2001; Mayer, 2001). Whether China's economic growth has the same relationship with health capital or not, some scholars have examined the relationship between health and wage income from a micro perspective to prove that there is a positive relationship between health capital and economic growth. Some domestic scholars directly verify from the empirical point of view that there is a significant positive correlation between healthy human capital and economic growth, and conclude that the elasticity of health index to economic growth is about 0.08, which suggests that China should pay more attention to health care (Luokai, 2006). In the extended Ramsey model, the effect of food consumption and nutrition on healthy human capital is considered. The relationship between healthy human capital, material capital and consumption is discussed, and the effect of health on long-term economic growth is also studied. The results show that in the presence of exogenous technological progress, Fogel-type healthy human capital can increase the economic growth rate (Wang, 2012).

Over the years, China's education level has been constantly improving, and the education level of the labor force has also been continuously improving. The educational hierarchy of human capital has undergone great changes. Some scholars have studied the role of human capital at different levels of education in the economy. They believe that human capital at the secondary level of education has a strong positive impact on total output in the short term, while high-level human capital is an important driving force for medium and long-term economic growth (Yu, 2013).

Most theoretical studies on human capital usually emphasize the effects of education or health alone. So more and more scholars have applied education and health indicators to measure human capital, but have not yet studied the specific form of human capital. In common theoretical models, scholars regard education and health as two kinds of capital. Human capital is generated by the combination of these two kinds of capital according to Cobb-Douglas production technology. This model proves that the investment structure of human capital has a restrictive effect on economic growth. In this model, the growth and stock of human capital will affect economic growth and contribute to economic growth.

Scholars in china and abroad are increasingly mature in the study of human capital, and the role of human capital in China's economic growth and regional economic development is becoming more and more obvious. However, due to technical limitations and difficulties in data acquisition, the problem of comprehensive measurement of human capital remains to be solved. Domestic scholars have continuously explored and studied human capital in China, thus promoting people's understanding of the development status and role of human capital in China. However, in the research, many scholars will measure human capital by the degree of education, which ignores the important factors such as training, work experience, life cycle and so on, so it can not cover all the contents of human capital. In view of the importance of human capital measurement, Stiglitz Committee puts human capital in a more important position than GDP in measuring the sustainable development of national economy.

At present, there are three main methods for the comprehensive measurement system of human capital in China: one is the cost method (Kendrick, 1976) that is, the initial stock of human capital plus total investment minus depreciation; the other is the income method, that is, the net present value of individual income in the life cycle, the representative model is J-F lifetime income method (Jorgenson & Fraumeni, 1989; Jorgensons & Fraumeni, 1992a); the third is the characteristic method. Laroche and Merette (2000) construct the human capital index with some characteristics such as education level, work experience, etc. Fourthly, the balance method (World Bank, 2006) is mainly used by the World Bank.

3. Population Ageing and Human Capital

China's birth rate is in a downward trend, and the life expectancy of the population continues to increase, which has caused great changes in China's population structure and also has a certain impact on China's economic growth. The aging population and the decline of birth rate have brought about the shortage of labor supply, which is not conducive to the sustained economic growth. The impact of human capital brought by this aging phenomenon has become an urgent issue for scholars to study. Because most of the developed countries in the global economy are facing the phenomenon of population aging, scholars from all over the world have explored the impact of human capital brought about by population aging. Because of the different research

backgrounds, there are many viewpoints such as disadvantageous theory, advantageous theory and mixed theory. Scholars who hold the view of "advantageous theory" believe that mature labor experience will continue to accumulate, and the decline in fertility gives young people the opportunity to receive higher education, so human capital will be accumulated. Choi and Shin (2015) introduced human capital and material capital accumulation in the OLG model, which proved that aging has a significant long-term impact on the economy and that aging will give the next generation more opportunities to invest in human capital; moreover, he took advantage of the Korean population, and found that the aging of the Korean population has reduced the growth rate of labor supply, but brought about wage increases, thus promoting the investment of human capital Endowment. Zhong and Yu (2017) considered the advantages and disadvantages of population aging from the perspective of "dividend". He believed that "education dividend" had an alternative role to "population dividend". The improvement of education level could alleviate or even offset the negative effect of the disappearance of population dividend. The disadvantage view holds that human capital investment will decline with age. Beckers and Chiswick (1966) believes that when human capital gradually accumulates, the increase in age will bring about a decrease in marginal return on investment. From the perspective of opportunity cost, aging will lead to a decrease in human capital investment. Some scholars have established OLG model to directly analyze the impact of population aging on human capital accumulation and analyzed the intermediary effect of population aging on healthy human capital and educational human capital in the process of influencing economic growth from an empirical point of view. The results show that aging will lead to an increase in healthy human capital, and will occupy educational expenditure to restrain the increase of educational human capital (Zhang & Zhao, 2018a). From a group perspective, the rising proportion of the elderly population will inevitably bring more political pressure, which will inevitably lead to an increase in social welfare and medical expenditure. Social expenditure is more inclined to the elderly population, which occupies public expenditure in other areas and presents intergenerational imbalance (Rubinfeld, 1977). Miller (1996) studied education expenditure in 48 states and Texas counties to study the impact of the proportion of people over 65 on per capita education expenditure. The results show that aging reduces education expenditure. Poterba (1997) argues that the increase in life expectancy due to population ageing means longer retirement time. In order to protect elderly consumption, the elderly will reduce their investment in their children's human capital. Some scholars directly believe that the aging population will lead to the deterioration of the quality of human capital because the knowledge of the elderly is outdated and the ability to innovate decreases. Even though the quality of human capital of the elderly population is improving, it is still lower than that of young people, so human aging has a negative impact on human capital (Cepar & Troha, 2015). Scholars who hold the view of "mixed theory" believe that the relationship between aging and human capital is complex and non-monotonous. Zhangs, Zhang, and Lee (2003) found that there is a "hump" relationship between the decline of adult mortality and public education expenditure. When people's life expectancy is relatively low, the median age voters tend to raise tax rates to increase public human capital investment. When aging reaches a certain level, the median age voters support reducing tax rates to reduce public human capital investment. Ultimately, the speed of human capital accumulation is rising first and then declining. Summing up the above three viewpoints, we find that most scholars discuss the impact of aging on government human capital investment from a macro perspective, and mostly from the perspective of social relations to build models of intergenerational conflicts. Especially foreign scholars seldom study from the micro-perspective, in fact, there is a certain social background, because the western developed countries have entered the aging earlier, and have established a relatively perfect social security and education system. Old-age pension and education for minors are provided by the overall social planning (Chetty & Finkelstein, 2012) so micro-family decision-making has less impact. At the same time, the western countries do not emphasize the support of their children to their parents, so the burden of providing for the aged will not have a micro-impact on human capital investment. Unlike the developed countries in the West, China has entered an aging society before it is rich. The social security mechanism cannot meet the needs of the elderly. Families not only take care of the elderly but also take care of family education. Therefore, it is necessary to balance the old-age and education. In China, there is feedback between generations of families, and the burden of providing for the aged will be fed back to the investment of family human capital. Therefore, some Chinese scholars examine the impact of aging on human capital investment from a micro perspective. If we look at the intergenerational competition of family resources, some scholars believe that the aging population objectively increases the cost of care needs of the elderly, and the family resources for the care of the elderly will become scarce. Simply investing in the human capital of children by parents, and investing in their children's education, parents enjoy part of the right of return in output (Yu, 2013) which promotes inter-generational cooperation within families. China strengthens intergenerational cooperation in human capital investment through the propaganda of filial piety, which solves the pension problem to a certain extent. At present, the intergenerational relationship between parents and children of the elderly in China is characterized by a more prominent exchange of equivalents. Parents bear the investment of human capital, care and family services for their children, while children bear the responsibility of providing old-age care for their parents. There is a causal relationship between the two. Although the function of family pension in China has weakened to some extent, the filial piety culture for thousands of years means that the mechanism of intergenerational mutual benefit within the

family still plays a huge role (Lin & Yi, 2013). In the transition between tradition and modernity, the Chinese family structure is affected by both traditional customs and modern trends. It develops into a small form and maintains a lineal family (Wangs, 2014) (Wang, 2014). At present, long-term family care is still the main mode of elderly care in China (Jiang & Liu, 2014). Children's time companionship and financial support for elderly parents are very common (Jie, 2014). Li (2016) studied how aging affects micro-human capital investment under the weakening trend of Chinese family's pension function from a micro perspective. The results show that aging significantly reduces the level of Chinese family's human capital investment, and has a significant negative effect on the probability and scale of the family's human capital investment. From both macro and micro perspectives, the existing research results show that population aging has an impact on human capital. However, due to different social backgrounds, resource endowments and research perspectives, there is no definite relationship between population aging and human capital. In this regard, we can consider exploring the relationship between population aging and human capital under the OLG model, dividing human capital into healthy human capital and educational human capital, then quantifying human capital and making empirical analysis. Firstly, the relationship between population aging and human capital is analyzed from a macro perspective, and then the impact of human aging on household human capital investment is explored with the family as a unit to further verify the macro research results. Through theoretical models and micro-macro empirical analysis, a basic conclusion is drawn on the relationship between population aging and human capital in China.

4. Estimation of R&D Capital Stock

For a long time, the important role of R&D activities in technological progress and economic growth has become the consensus of scholars. The endogenous growth theory emphasizes the importance of R&D activities and considers that technological progress is the source of long-term economic growth (Lucas, 1988; Romer-Paul, 1986). In an empirical analysis, technology is difficult to quantify. Scholars usually use R&D input data as an indicator of economic growth. However, R&D capital stock can be used as an excellent index to measure R&D investment, so it is necessary to reasonably estimate R&D capital stock. The measurement of R&D capital stock has gone through two stages. Before 2009, it was the first stage. Scholars used the perpetual inventory method to calculate R&D capital stock. They also discussed R&D investment, R&D price index and initial capital stock of R&D deeply, which has certain reference significance (Coe & Helpman, 1995; Goto & Suzuki, 1989; Griliches, 1980; Hall & Mairesse, 1995; Kim & Park, 2003). After 2009, the government began to capitalize on R&D expenditure. In 2008, SNA revised the accounting method of R&D expenditure, no longer taking R&D expenditure as intermediate consumption but as fixed capital formation. Since then, many countries have begun to implement new standards and measured R&D investment and R&D capital stock under the new standards. Throughout China, although many scholars have measured R&D capital stock in many ways, the official has not carried out the capitalization of R&D expenditure accounting. At present, domestic scholars have used the sustainable inventory method of foreign scholars for reference in the accounting of R&D capital stock in China, and have made some improvements on this basis. But in general, the calculation method is insufficient, and the research is still in the early stage. Therefore, it is necessary to make a new measurement of China's R&D capital stock according to the latest accounting methods. At the same time, in order to support the problems to be studied in this paper and facilitate the needs of empirical research, the re-calculation of R&D capital is also to better understand the relationship between population aging, human capital, and R&D capital stock, so as to put forward meaningful suggestions for policy.

5. Population Aging and R&D Capital Stock

From the theme of this paper, we can see that the focus of this study is population ageing. If population ageing is related to R&D capital stock, the final foothold is people. Therefore, the aging of population affects the quality and quantity of labor force, and then it can be transmitted to the R&D capital stock. This also shows that we are concerned about the human capital factor in the R&D capital stock, while the material capital factor does not focus on research.

Table-1. Total fertility rate, life expectancy and population growth for G-7 countries

Country	Life expectancy at birth		Total fertility rate		Old-age dependency ratio		Population growth rate	
	1960-1965	2005-2010	1960-1965	2005-2010	1960-1965	2005-2010	1960-1965	2005-2010
Canada	71.27	80.54	3.68	1.63	13.1	20.4	1.895	1.129
France	70.67	80.89	2.83	1.97	18.8	25.9	1.343	0.573
Germany	69.98	79.76	2.47	1.36	17.0	31.6	0.885	-0.196
Italy	69.62	81.48	2.47	1.39	14.5	30.9	0.766	0.617
Japan	68.97	82.67	1.99	1.34	8.9	36.0	1.020	0.059
United Kingdom	71.01	79.65	2.81	1.88	18.1	25.2	0.670	0.580
United States	70.08	78.13	3.40	2.06	15.2	19.5	1.381	0.923

Source: (United Nations, 2013).

Table-2. Change in level of education in advanced countries

	Percentage of adult population with:		
	Average years of schooling	**Complete secondary education**	**Complete higher education**
1975	8.0	34.9	8.0
2010	11.0	63.9	16.6

Source: Weil (2012), Data for population 25+.

From the above two charts, we can see that the life expectancy of G7 countries has increased obviously in the past 30 years, but the overall fertility rate is in a downward trend, and the dependency ratio for the elderly has also increased significantly (United Nations, 2013).

From the perspective of education, the education level of the population in developed countries is getting higher and higher. The proportion of entrepreneurs receiving higher education increased from 8% in 1975 to 16.6% in 2010 (Weil, 2012). With the advent of aging, life expectancy is gradually prolonged, and people's life expectancy is also growing, which will lead to a series of behaviors, which have an impact on fertility and educational decisions is worth exploring.

Because changes in fertility and educational behaviour can be transmitted to changes in R&D, which is also the ultimate issue to be studied in this paper. Many scholars (Boucekkine, Croix, & Licandro, 2003; Boucekkine, De la Croix, & Licandro, 2002; De la Croix & Licandro, 1999; Junsen & Zhang, 2005; Kalemli-Ozcan, 2002) have studied the changes in life expectancy, education and savings brought about by ageing, and then how to influence the long-term economic growth rate, but neglected the R&D study, which plays an important role in economic growth.

Ken-ichi and Tabata (2016) believes that when life expectancy is high, it has a negative effect on economic growth and when life expectancy is low, it has a positive effect on economic growth. He also finds that children's education subsidy will continue to promote economic growth, while child support subsidy has a negative effect on economic growth, which is formally generated by the restriction between the quality and quantity of R&D personnel.

6. Conclusion

This paper mainly discusses the following issues. First, how population aging affects human capital, especially educational human capital and healthy human capital. This issue will be explored from macro and micro-family perspectives. Secondly, how population aging affects the factors of R&D personnel in R&D capital stock, and then how does it affect R&D capital stock?

What are the mechanisms through which this effect is ultimately transmitted? In order to study these problems, this paper will study them from both theoretical and empirical perspectives. The theoretical model will mainly establish OLG model, explore the balance point of family optimal decision-making, and bring human capital into the equation of R&D capital stock as an intermediate variable to study how human capital affects R&D capital stock.

Finally, according to the series of direct effects and transmission effects of population aging, the impact of population aging is determined, and then a series of opinions and policy recommendations are put forward to solve the problem of population aging.

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