Original scientific paper
UDC: 614:314.118:330.35](510)
https://doi.org/10.18045/zbefri.2019.1.29

The effect of healthy human capital improvement on savings and growth: An empirical study based on China's inter-provincial panel data*[1]

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Abstract

The traditional life cycle hypothesis believes that the aging of population will not only drag down the level of social savings, but also adversely affect economic growth. However, the human capital factor may change the influence mechanism of population structure change. This study attempts to focus on a specific factor of improving healthy human capital (HHC), through endogenous treatment of fertility rate and survival rate, considering the aging expectation of rational man, to explore its effect de facto on savings rate and economic growth while using the inter-provincial panel data of China from 1996 to 2012 to verify the inherent logical relationship between the rapid improvement of HHC and the "high savings-high growth" model. The findings of this research are as follows: The improvement of HHC is an important factor to improve China's savings rate and economic growth in corresponding period. It means that the improvement of HHC

* Received: 21-02-2018; accepted: 26-02-2019

[1] This work has been fully supported by the National Social Science Fund of China (18BGJ018), the Ministry of Education Humanities and Social Sciences General Project: Leverage Ratio Paradox and Monetary Policy Choice in the Background of Overcapacity (17XJC790015) and National Bureau of Statistics National Statistical Science Research Project: Overcapacity Monitoring and Early Warning System Study in China's Industrial Sector (2016LY07).

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is enough to alter the mechanism of macro-impact of demographic changes, and therefore constitutes a crucial long-term regulation and control means outside the adjustment of birth policy. Among them, promoting public environmental governance, improving the social security system, strengthening individual expectations for health and driving the expected behavior of aging while achieving linkages with investment in educational human capital are worthy of attention.

Key words: *healthy human capital, aging expectation, savings rate, economic growth*

JEL classification: *I15, J11, J24*

1. Introduction

According to the life cycle hypothesis of Modigliani and Brumberg (1954), demographic changes will alter the behavior of household savings. As the proportion of the working-age population increases, the total social savings rate will grow; Since the working-age population are "producers" while the children and the elderly are "consumers" to be supported (Zhong Shuiying & Li Kui, 2009), the aging of population will not only drag down the level of social savings rate, but also exert an adverse impact on economic growth. The above theoretical transmission mechanism is supported by a large number of empirical studies (Leff, 1969; Hayashi, 1989; Wang Dewen et al., 2004; Koga, 2006; He Juhuang, 2006; Jiang Yunqi, 2009; Zhang Zhiyuan et al., 2016; Zou Wei, 2017).

However, the influence mechanism of demographic changes to savings rate fluctuations and economic growth has uncertainty: variables such as fertility rate and survival rate that are capable of changing population structure will be become endogenous due to other factors; residents savings and consumer behavior will be interfered by the expected factors of homo economicus, which will also affect choice of economic growth mode. The concept of human capital essentially impacts the logical relationship between demographic changes and macroeconomic variables such as savings or growth.

According to Schultz's (1961), human capital theory, investment in education, health and immigration will promote capital formation, thereby changing the mechanism and actual impact of demographic changes on savings and growth. Although Muskin (1962) included education and health in the concept of human capital, the existing economic growth theory focuses on educational human capital, and use it as a proxy variable for human capital (Schultz, 1971; Lucas, 1988). However, the discussion of healthy human capital is limited by statistical and measurement difficulties, as well as differences in macro and micro effects. There are widespread controversies in both theory and empirical evidence (Fogel, 1994, 1997, 2002; Arora, 2001; Bhargava, Jamison, Lau, Murry, 2001; Von Zon and Muysken, 2001, 2003; Ashraf, Lester and Weil, 2008).

Logically, improved healthy human capital cannot only reduce infant mortality, but also change the reproductive behavior of the population, which in turn affects demographic changes (Pokins et al., 2005). It also changes its saving behaviors through the expected aging of rational man possibly, and ultimately influence economic growth (Mason and Lee, 2004; Li, 2007). Therefore, it is of great theoretical value to explore the practical impact of HHC on social savings rate and economic growth. On the other hand, the reduction of the labor force and rapid aging are exerting significant constraint over China's "high savings-high growth" model and sustainable economic development.Even considering the implementation of comprehensive two-child policy and further fertility release, the problem of demographic deterioration is still difficult to change in a short term. It is also of great practical significance to find short-term alternative arrangements beyond the adjustment of family planning policy from the perspective of HHC.

The purpose of this study is to incorporate the consideration of human capital factors and set out from ground of HHC, to internalize the indicators of population structure changes such as fertility rate and survival rate, and to consider the expected aging behaviors of rational man, exploring comprehensively the actual impact of HHC improvement on savings rate changes and economic growth with the help of inter-provincial panel data of China from 1996 to 2012, focusing on the following two hypotheses:

Hypothesis 1: HHC Improvement will affect infant survival rate, adult fertility rate, aging expectations, etc., and exert significant influence on social savings rates and economic growth.

Hypothesis 2: The improvement of HHC is conducive to reducing infant mortality while improving the expectation of aging. Its positive effect on savings rate and economic growth is significantly higher than its negative effect, and HHC ultimately promotes savings rate and economic growth.

The follow-up structure of this thesis is as follows: part II is the literature review on the impact of HHC on savings and growth; part III is the building of theoretical model; part IV is empirical test based on China's inter-provincial panel data from 1996 to 2012; part V is the discussion and analysis of the empirical results; the last part is the conclusion and recommendations for future research.

2. Literature review

There is a long-standing debate concerning the impact of improved HHC on savings rate. At micro level, some believe that individual investment on HHC may crowd out the accumulation of physical capital, imposing a negative impact on savings rate (Wang Dihai, 2008; Feng Yan et al., 2016). However, others suggest

that investment on HHC is only a by-product of income improvement. Health improvement can actually improve individual productivity and individual income, and may not have a negative impact on savings rate (Strauss & Thomas, 1997; Von Zon and Muysken, 2001, 2003). Furthermore, the extension of life expectancy essentially reduces people's time preference and increases risk aversion, increasing savings rate together with productivity improvement (Arora, 2001).

In terms of theoretical development, according to the life cycle hypothesis of Modigliani and Brumberg (1954), the improvement of HHC will increase the survival rate of the population and life expectancy at the macro level, thereby accelerating the process of population aging and ultimately reducing savings rate. But many studies have challenged this hypothesis and believe that it only considers the consumption burden brought by more "pure consumers" under the aging conditions, not the aging expected behaviors by rational man due to the increase in life expectancy, thus the possibility of re-arranging consumption and savings in the life cycle. Such behavior will increase national savings rate in a different way(Jones, 2001; Kalemli, 2002; Lagerlof, 2003; Zhang et al., 2003; Issa, 2003; Morand, 2004; Tabata, 2005; Tamura, 2006; Aisa andPueyo, 2004). Mason and Lee (2004) refer to the effect of aging to reduce savings rate as "component effect", and the effect of aging expectation to promote the increase of savings rate as "behavioral effect", and believe that the final impact depends on the comprehensive comparison of these two effects. Empirical evidences from Hurd (1987), Deaton (1994), Yuan Zhigang (2000), Bloom et al. (2003), Li (2007), and Wang Wei (2008) all indicate the existence of "behavioral effect" of aging on social savings rate.

There are more extensive discussions on the relationship between HHC improvement and economic growth. At micro level, most studies believe that the improvement of HHC will enhance individual productivity and time of labor supply, and health maintenance is not only a labor skill investment, but also a service-oriented consumption, improving individual utility level and positively driving economic growth (Barro, 1996; Liu Guoen et al., 2004; Gao Mengyu, 2005, Lin Xiangsen et al., 2016). However, there are also views that health, as an investment product, will directly or indirectly promote economic growth, but as a consumer product, there will be trade-off relation with physical capital accumulation (Zon and Muysken, 2001, 2003). The improvement of HHC has a capital shallow effect, which may reduce per capita income (Ashraf, Lester and Weil, 2008), even creating a poverty trap by crowding out the accumulation of material capital (Wang Dihai et al., 2008).

In response to the above differences, Feng Yan and Chai Zhihong (2016) classified HHC investment as "private health investment" and "public health expenditure", and believe that the impacts of the two investments on output efficiency and economic growth are not the same. Luo Yongmin (2011) also pointed out that HHC investment and HHC stock are two different concepts, the former is about "input" while the latter focus on "output". Their evaluation mechanism for economic impact are completely

different. From the perspective of changes in terms of stocks and outputs, most studies have confirmed that HHC improvements are positively driving economic growth. Fogel's (1994, 1997, 2002) study found that HHC improvements can roughly explain 50% of UK economic growth since 1800. Bhargava, Jamison, Lau, and Murry (2001) found that improvements of HHC and adult survival rate (15-60 years) have a significant impact on economic growth in low-income countries. Arora (2001) found that the improvement of HHC can explain 30-40% of economic growth in 10 industrialized countries since 1870, and from the causal test, HHC improvement is not a by-product of economic growth.

The choice of proxy variables for HHC is the key to technical analysis. Based on the existing measurement results, as long as the proxy variables are positioned in the perspective of public expenditure, or using the indicators of public capital stocks such as adult survival rate, life expectancy, number of hospital beds per person, or number of doctors per person, there will be a conclusion of HHC improvements making positive contributions to economic growth.

Table 1: Quantitative analysis results of HHC's contribution on economic growth

Source of Literature	Proxy Variables of Economic growth	Proxy Variables HHC	Data Sources	Regression Coefficient
Bhargava et al. (2001)	Per capital GDP rate	Adult survival rate (ASR)	92 countries 1965-1990	0.181*
Heshmati (2001)	The logarithm of the difference of labor per capital GDP between 1990 and 1970	The logarithm of the average public health expenditure per capital	OECD countries 1970-1992	0.175*
Webber (2002)	Per capital (labor force) GDP growth rate	Average calorie intake per person	46 countries 1960-1990	0.08-0.22*
McDonald and Roberts (2003)	Per capital (labor force) GDP growth rate	Log (80-expected life)	77 countries 1960-1989	0.12*
Rivera and Currais (2003)	The logarithm of the difference of labor per capital GDP between 2000 and 1960	Log (Public Health Expenditure/GDP)	OECD countries 1960-2000	0.18-0.26*
Rivera and Currais (2004)	Per capital (labor force) GDP growth rate	Public Health Expenditure	17 regions in Spain 1973-1993	0.13*
Bloom et al. (2004)	Per capital GDP growth rate	Life expectancy logarithm	104 countries 1960-1990	0.04*
Jamison et al. (2005)	Per capital GDP growth rate	Adult survival rate logarithm	53 countries 1978-2005	0.50*
Narayan et al. (2010)	Per capital GDP	Proportion of Public Health Expenditure in GDP	Five Asian countries 1974-2007	0.168-0.218*

Note: The superscript * means significant at least at 98% signifinance level.

Source: summarized by the author

In summary, in terms of the impact of HHC improvement on savings rate and economic growth, there are actually three research dimensions: firstly, HHC investment can be divided into two different modes, individual behavior and public behavior, having different economic impacts; secondly, HHC investment and stock fall into two different economic concepts, and between them, there is a relationship similar to input and output; thirdly, the improvement of HHC also has the distinction between microscopic effects and macroscopic effects, and the impact mechanisms of those are also different.

This article is not intended to explore comprehensively the economic effects of HHC improvement in the interweaving concepts, but to try to put it at the level of macroeconomic impact of HHC stock changes by selecting appropriate proxy variables, and explore its actual impact on social savings rate and economic growth based on specific studies in China.

At the operational level, China is undoubtedly the best sample to test the impact of HHC improvement on macro economy. After the 1990s, despite the huge demographic changes brought about by the implementation of the "family planning" policy, China's HHC level was also significantly improved. The number of doctors per 1,000 people in China and the number of hospital beds per 1,000 people in hospitals and health centers increased from 1.17 and 2.02 in the initial period of reform and opening up to 4.94 and 4.24 in 2012 respectively, an increase of 322% and 110%. Infant mortality rate has also dropped from 35‰ in the early stage of reform and opening to 13.1‰ in 2010, and the life expectancy of the population has increased from 67.9 years in 1980 to 74.8 years in 2010, corresponding to the typical economy model in the same period: high savings-high investment-high growth. Under the constraints of the exogenous birth control policy, the effect of the HHC improvement on social savings rate and economic growth will undoubtedly be more fully and effectively demonstrated.

This research will not only help improve the existing discussion on HHC and even the mechanism and impact of human capital formation, but also help re-examine the macroeconomic impact of demographic changes from a more endogeneous perspective. In practice, it also helps find out other supporting policy measures in addition to the adjustment of exogenous population policies which can effectively hedge the demographic structure changes and its negative economic impacts. As a result, it is a valuable both to theoretical research and practice.

3. A theoretical model

Based on the model of Li et al. (2007), our starting point is to make fertility and survival rates endogenous. Then we discuss whether healthy human capital could impact savings rate and economic growth through the mediator of population

structure. In order to achieve this, we construct an overlapping generation model to analyze people's savings behavior in a perfect annuity market.

There are three periods that an agent lives in: the childhood; the middle age and the old age. The number of children refers to N_{0t}. In addition to consumption, they make no choices and the consumption comes from their altruistic parents. The middle-aged agents refer to the total labor force with population of N_{1t}. The income they earned refers to W_t, which is divided between consumption C_t for themselves and their kids, and savings S_t for the old-age consumption. The elderly has a population of N_{2t}, and they consume those savings and interest R_t drew from it.

There are two mechanisms through which the age structure is affected by healthy human capital. One is to reduce the fertility rate F_t. The improvement of healthy human capital brings China's infant mortality rate down from 35‰ at the initial the reform and opening to 4‰[5] in 2010. While ideal children can survive, there is no need to have excessive kids. Therefore, the decline in infant mortality may directly lead to lower fertility rate (Perkins, et al. 2005). Although the main reason for declining fertility rate is the long-standing family planning policy, HHC improvement is also an effective way. Barro (1996) built a model about health and fertility to confirm the theory . The other effect is to increase the survival rate (or life expectancy) V_t of adults. The statistics show that life expectancy in China extends from 68 years old at the initial reform and opening to 73 years old in 2010, increased by 7.4%.

A lower fertility rate leads to a downward children dependency ratio which has positive "composition effect" of children on savings. A higher survival rate (life expectancy) increases the elderly dependency ratio which brings about a negative "composition effect" of aging and a positive "behavioral effect" of aging on savings[6].

Therefore, we assume that the fertility and survival rates decrease and increase exponentially to healthy human capital, namely $F_t = B_1 a^{-X_t}$. B_1 refers to all the other influential factors except for healthy human capital, such as the family planning policy, changes in the concept on birth brought about by the improvement of education, and the increased participation of female in the labor market. The relationship between healthy human capital and survival rate is $V_t = B_2(1 - b^{-X_t})$, where B_2 is all the other factors, such as improved life standards and the education level, $a,b > 1$ and X_t refers to healthy human capital in period t. Then the population of childhood, the elderly and the total are:

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[5] Data source: census data for the corresponding year

[6] For simplicity, aging and growth effects brought by changes of child and aging dependency rate are regarded as the "composition effect" of child and aging respectively; and that brought by life expectancy is namely as the "behavioral effect" of aging.

$$N_{0t} = N_{1t}B_1a^{-X_t};$$

$$N_{2t} = N_{1t-1}B_2(1 - b^{-X_{t-1}});$$

$$P_t = N_{1t}(1 + B_1a^{-X_t}) + N_{1t-1}B_2(1 - b^{-X_{t-1}}).$$

This model is in a perfect annuity market so that workers can put their savings in the capital market of their firms. When getting old, they can get interest of the savings for consumption. The annuity income is $R_tN_{1t-1}s_{t-1} / N_{1t-1}B_2(1 - b^{-X_{t-1}})$ and s refers to personal savings.

Hence, the life-cycle utility function of a middle-aged agent is:

$$U_t = \log c_t + B_2(1 - b^{-X_t})\beta\log c_{2t+1} \tag{1}$$

In equation (1), c_t refers to the consumption of an agent and his or her families; β is the time discount factor; c_{2t+1} is consumption in his or her senior. Thus, the lifetime budget constraint of an agent is

$$c_t = w_t - s_t \tag{2}$$

$$c_{2t+1} = R_{t+1}N_{1t}s_t / N_{1t}B_2(1 - b^{-X_t}) \tag{3}$$

With equation (1), (2) and (3), the optimal consumption, savings and its optimal proportion are:

$$c_t = \Gamma_{ct}w_t \qquad \Gamma_{ct} = \frac{1}{1 + B_2(1 - b^{-X_t})\beta} \tag{4}$$

$$s_t = \Gamma_{st}w_t \qquad \Gamma_{st} = \frac{B_2(1 - b^{-X_t})\beta}{1 + B_2(1 - b^{-X_t})\beta} \tag{5}$$

$$c_{2t+1} = \beta R_{t+1}c_t \tag{6}$$

Γ_{ct} and Γ_{st} represent the proportion of the agent's consumption and savings in labor income. In equation (4) and (5), improving healthy human capital decreases the proportion of consumption and increases the proportion of savings.

Following the work of Li et al. (2007) and Romer (1986) , the production function is:

$$Y_t = AK_t^{\alpha}(\overline{k}_t^{\theta}N_{1t})^{1-\alpha} \tag{7}$$

where Y is output; K capital; $A > 0$; $0 < \alpha < 1$; $0 \leq \theta \leq 1$. When $\theta = 0$, the function is a neoclassic model, whereas when $\theta = 1$, it is an AK model. In the equilibrium $k_t = \overline{k}_t$, the labor and capital income are:

$$W_t = (1-\alpha)Ak_t^{\alpha+\theta(1-\alpha)},\ R_t = \alpha Ak_t^{(\alpha-1)(1-\theta)} \tag{8}$$

Then, the aggregate output is $Y_t = W_t N_{1t} + K_t R_t$. As the old-age survivors get the capital income, their consumption is expressed as:

$$K_t R_t = N_{1t-1} B_2 (1 - b^{-X_t-1}) \tag{9}$$

In a closed economy, the social aggregate savings in period t (S_t) is the aggregate demand of capital in period t+1 (K_{t+1}). The equation is:

$$K_{t+1} = S_t = Y_t - N_{1t} c_t - N_{1t-1} B_2 (1 - b^{-X_t-1}) c_{2t} \tag{10}$$

With equation (2), (9) and (10), we have:

$$K_{t+1} = S_t = N_{1t} s_t \tag{11}$$

We assume capital per worker is k_t, and $k_t = K_t / N_{1t}$. Combining (4), (8) and (11), we have:

$$k_{t+1} = A(1-\alpha)\Gamma_{st} k_t^{\alpha+\theta(1-\alpha)} \frac{1}{B_1 a^{-X_t}} \tag{12}$$

Which proves that the improvement of healthy human capital increases the social capital per worker.

Then assuming the social aggregate savings rate is $\overline{\Gamma}_{st}$, and $\overline{\Gamma}_{st} = S_t / Y_t$, the aggregate savings rate becomes:

$$\begin{aligned} \overline{\Gamma}_{st} &= [N_{1t} y_t - N_{1t} c_t - N_{1t-1} B_2 (1 - b^{-X_{t-1}}) c_{2t}] / N_{1t} y_t \\ &= 1 - (1-\alpha)\Gamma_{ct} - [N_{1t-1} B_2 (1 - b^{-X_{t-1}}) / N_{1t}](c_{2t} / y_t) \end{aligned} \tag{13}$$

Where $y_t = Y_t / N_{1t}$ is output per worker. Putting (2), (3), (8), (12) into (13), we can get:

$$\overline{\Gamma}_{st} = \alpha + \frac{(1+\alpha) B_2 (1 - b^{-X_t}) \beta}{1 + B_2 (1 - b^{-X_t}) \beta} - \alpha \frac{B_1 a^{-X_{t-1}}}{B_2 (1 - b^{-X_{t-1}})} \left[\frac{N_{1t-1} B_2 (1 - b^{-X_{t-1}})}{N_{1t}} \right] \tag{14}$$

There are some conclusions we can draw from equation (14):

(a) $B_2(1 - b^{-X_t})\ \beta / 1 + B_2(1 - b^{-X_t})\beta = \Gamma_{ct}$ represents the proportion of individual saving rate, which is positive to the social aggregate saving rate. Improvement of healthy human capital increases the survival rate of adults ($B_2(1 - b^{-X_t})$). Then the agent's savings rate rises, following the social aggregate savings rate.

(b) $B_1 a^{-X_{t-1}}$ is the fertility rate in period t–1, which is negative to the social aggregate savings rate. This indicates that the aggregate savings rate rises through lowering the fertility rate.

(c) $B_2(1 - b^{-X_{t-1}})$ is the adult survival rate which is positive to the social aggregate savings rate. It indicates that the improvement of healthy human capital increases the rate of adult survival and further increase the savings rate.

(d) $N_{1t-1}B_2(1 - b^{-X_{t-1}})/N_{1t}$ is the old-age dependency rate which is negative to the ratio of aggregate savings. Thus, the improvement of healthy human capital increases the savings rate by increasing the dependency ratio.

Then we can regard (a) and (c) as the positive "behavioral effect" of aging on savings, which mainly depends on the agent's behavior when expecting aging and the healthy human capital is improving. (b) is the positive child "composition effect" of children on savings. And (d) is the negative aging "composition effect" of aging. So:

$$g_t = \frac{\eta_t - \eta_{t-1}}{\eta_{t-1}} = \frac{\eta_t}{\eta_{t-1}} - 1 = \frac{Y_t / P_t}{Y_{t-1} / P_{t-1}} - 1 = \frac{Y_t}{Y_{t-1}} \frac{P_{t-1}}{P_t} - 1 = \frac{Y_t}{Y_{t-1}} \frac{1}{n_t + 1} - 1$$
$$= (\frac{k_t}{k_{t-1}})^{\alpha+\theta(1-\alpha)} (N_{1t} / N_{1t-1})[1/(1+n_t)] - 1 \tag{15}$$
$$= [A(1-\alpha)\Gamma_{st-1}(N_{1t-1} / N_{1t})]^{\alpha+\theta(1-\alpha)} k_{t-1}^{-(1-\alpha)(1-\theta)[\alpha+\theta(1-\alpha)]} (N_{1t} / N_{1t-1})[1/(1+n_t)] - 1$$

Where η_t is per capita output in period t; n_t is the population growth rate and g_t refers to economic growth.

The logarithmic version of equation (15) is:

$$\ln g_t = [\alpha + \theta(1-\alpha)] \ln[A(1-\alpha)\Gamma_{st-1}(N_{1t-1} / N_{1t})]$$
$$-(1-\alpha)(1-\theta)[\alpha + \theta(1-\alpha)] \ln k_{t-1} + \ln(N_{1t-1} / N_{1t}) + \ln(\frac{1}{n_t + 1}) \tag{16}$$
$$= \gamma_0 + \gamma_1 \ln \Gamma_{st-1} - \gamma_2 \ln(1+n_t) + \gamma_3 \ln(1 - SP_t) - \gamma_4 \ln \eta_{t-1}$$

In equation (16), γ_0 is the constant term and coefficient γ_1; γ_2; γ_3; γ_4 is positive. Moreover, $\Gamma_{st-1} = B_2(1 - b^{-X_{t-1}})\beta \,/\, B_2(1 - b^{-X_{t-1}})\beta + 1$ represents the proportion of the agent's savings in period t-1, which determines the capital demand in period t. When healthy human capital improves, the individual savings ratio increases through rising individual savings rate. Then economy grows. This is the positive "behavioral effect" that healthy human capital has on economic growth by increasing ratio of adults' survival.

$SP_t = 1 - N_{1t} / [N_{1t}(1 + B_1 a^{-X_t}) + N_{1t-1}B_2(1 - b^{-X_{t-1}})]$ is the total population dependency rate, the sum of child dependency rate and aging dependency rate, which is negative to economic growth. The improvement of healthy human capital promotes economy by decreasing children dependency rate, which is the positive children "composition effect". However, improved healthy human capital restrains economic growth by increasing aging dependency rate, which is the negative aging 'composition effect' of aging.

To sum up, on the one hand, healthy human capital is positive to savings and economic growth by decreasing child dependency rate. On the other hand, it is negative to savings and economy growth by increasing elderly dependency ratio. Also, it has positive effect when expecting aging. Thus, the ultimate effect of healthy human capital on savings and economic growth depends on the combined effect of the above-mentioned three effects.

4. Empirical data and analysis

Based on the theoretical model above, the ultimate impact of healthy human capital on savings and growth depends on a comprehensive comparison of two different effects, and whether healthy human capital improvement can ultimately reverse the negative impact of population aging on savings and growth needs to be supported by empirical data analysis. Considering that China' economy maintained its unique "high savings-high growth" model under the deterioration of its population structure since the 1990s and it is accompanied by significant improvements in human capital indicators, especially healthy human capital indicators. Therefore, we selected China's inter-provincial panel data from 1996 to 2012 as a research sample to verify the logical connection between rapid improvement of healthy human capital and the "high savings-high growth" model by constructing an econometric model.

4.1. Model construction and index selection

Based on equation (14), the empirical model about relationship between healthy human capital and savings is specified as:

$$\ln Sav_{it} = \zeta_0 + \zeta_1 \ln Md_{it} + \zeta_2 \ln \Omega_{it} + \eta_i + \gamma_t + u_{it} \tag{17}$$

Where i and t represent location and time respectively. And all the variables in the model are the logarithmic version. lnSav is the logged social aggregate savings rate; and lnMd, the logged healthy human capital. According to Li and Huang (2009) and Wang et al (2008), the level of healthy human capital is measured as the number of sickbeds per capita and doctors per capita, which are referred as Md1 and

Md2. Besides, lnΩ refers to those logged control variables. Based on the existing literature, control variables are as follows: the first one is the economic growth rate, Δln(gdp) (see Leff, 1969; Mason, 1988). A favorable economic environment is an important guarantee to increased savings and we assume that the economic growth is positively related to aggregate savings rate. The second one is the size of government Gov (Wang Wei, 2010). The greater the government expenditure, the higher degree of the government intervention in the economy, which is negative to aggregate savings rate. The third one is the real interest rate Ir (Rossi, 1989; Loayza et al., 2000). When the substitution effect of the real interest rate is greater than its income effect, it is beneficial to the improvement of savings rate. The fourth one is inflation rate If (Kraay, 2000); when the inflation rate continuous increases, it will increase one's inflation expectation and boost consumption and restrain savings. The fifth is individual income growth rate Ig (Loayza et al., 2000; Zhong Shuiying, 2009). According to the life cycle hypothesis, the improvement of savings rate depends on individual income growth. The final one is the urban-rural income gap Rur (Yuan Zhigang et al., 1999) . The larger the income gap between urban and rural, the greater "duality" of economic structure, which is bad for economic growth. Then γ_t, η_j and u_{it} refer to Time fixed effects, regional fixed effects and random disturbances term.

Based on equation (16), the economic growth is specified as:

$$D\ln Pgdp_{it} = \varphi_0 + \varphi_1 \ln Pgdp_{it-1} + \varphi_2 \ln Sav_{it} + \varphi_3 \ln Sav_{it} * \ln Md_{it} + \\ + \varphi_4 \Omega_{it} + \gamma_t + \eta_t + u_{it} \quad (18)$$

Pgdp refers to GDP per capita and DlnPgdp is the logarithmic differential form which can be regarded as the growth rate of per capita GDP. Sav represents the aggregate savings rate. The increased aggregate savings rate promotes aggregate investment rate and further boosts economic growth. lnSav*lnMd represents the interaction-term of social aggregate savings rate and healthy human capital. This term is used to evaluate the marginal effect of healthy human capital on economic growth through aggregate savings rate. If its coefficient is positive, the improved healthy human capital enhances the marginal effect; otherwise it undermines the marginal effect. γ_t, η_j and u_{it} also refer to Time fixed effects, regional fixed effects and random disturbances term.

In equation (18), the control terms are as follows: The first one is the per capita GDP (Pgdp) of the period lagged, which is negative to economic growth, meaning its convergence to economic growth. The second one is population growth rate (n). Rising population growth rate restrains the economic growth according to neoclassic economic growth theory. The third one is the educational human capital (Hu), which provides high-quality labor-force and creative manpower. The fourth one is the size of government (Gov), which is negative to the economic

growth because it decreases the economic freedom. The others are the size of foreign capital (FDI) and the degree of openness (Open), which reflect the foreign trade situation of a country or region, and they should be positive to economic growth. Explanation and descriptive statistics of all variables are provided in table 2.

Table 2: Explanation and descriptive statistics of all variables

Variables	Mark	Explanation	Minimum	Maximum	Mean	Standard deviation
Savings ratio (%)	Sav	(GDP-consumption)/ GDP	8.84	62.54	44.54	9.44
Sickbeds per capita	Md1	sickbeds/population	0.00145	0.00541	0.00270	0.00084
Doctors per capita	Md2	doctors/population	0.00094	0.00441	0.00176	0.00062
GDP growth rate (%)	Δln(gdp)		4.7	23.8	11.4	2.5
Government size (%)	Gov	Fiscal expenditure/ GDP	5.10	35.69	14.22	5.76
Real interest rate (%)	Ir	One-year real interest rate	-3.08	7.63	2.24	3.07
Inflation	If	CPI	1.00	1.54	1.15	0.09
Individual income growth rate (%)	Ig	Growth rate of the sum of urban disposable income and rural net income	0.41	125.90	10.26	7.36
Urban-rural income gap	Rur	urban disposable income/rural net income	1.60	4.76	2.84	0.65
Per capita GDP (Yuan)	Pgdp		2048	59700	11898	8779
Population growth rate (‰)	N	Population natural growth rate	-1.90	14.85	6.32	3.56
Educational human capital (Year)	Hu	Average years of schooling	4.17	10.88	7.29	1.14
Foreign capital size (%)	FDI	FDI/GDP	0.00	2.03	0.37	0.38
Openness (%)	Open	Total foreign trade/ GDP	3.16	179.91	32.46	42.56

Note: The data used here originates from Statistical Yearbook of China; China Labor Statistical Yearbook; Compilation of Statistical Data for the 50 Years of New China; China Economic Information Network and statistical yearbooks in each province from 1996 to 2012, which cover 29 provinces, autonomous regions and municipalities. Chongqing and Tibet is excluded.

Source: Author's Calculations

According to Bond, Hoeffer and Temple (2001), the logarithm of population growth rate plus 0.05 represents the sum of an exogenous rate of technical advance and a depreciation rate. Moreover, the negative real interest rate plus 0.1 is used to take its log. All the variables measured in currencies are converted according to the corresponding price index (taking 1996 as base period) or exchange rate.

4.2. Model estimation and empirical results

4.2.1. Estiations on savings rate and healthy human capital

The relationship between savings and healthy human capital is reported in table 3. We first use fixed effect model and random effect model. In columns (1) and (3), healthy human capital is measured by the number of sickbeds per capita, and in columns (2) and (4), the number of doctors per capita is applied. The F-test of fixed-effect estimations and the BP-test of the random-effect estimations show that it is more proper to adopt panel model regression instead of pooled regression. Moreover, in the panel model, the P-value of Hausman-test in table 3 is 0, indicating that it is the fixed-effect model that should be chosen. Before performing the fixed-effect model regression, it is necessary to test the cross-sectional correlation, the sequence correlation, and the heteroscedasticity of the panel. And the results in table 4 are those by using the Pesaran test, the Wooldridge sequence test, and the modified Wald test respectively. The results show that there exists the problem of cross-sectional correlation and sequence correlation by using either the number of the sickbeds per capita or the number of doctors per capita to perform the regression. Therefore, we adopt the GLS to control the above-mentioned problems. The regression results are showed in estimates (5) to (8), in which estimates (7) and (8) are added dummy variables like time and region based on estimates (5) and (6).

The regression results of estimates (5) and (6) show that when taking the number of sickbeds and doctors per capita as proxy variables of healthy human capital, its coefficient is significantly positive. The coefficient remains to be positive even adding time and regional dummy variables in estimates (7) and (8). Thus, the impact of China's healthy human capital on population structure brings overall positive effect to social aggregate savings rate regardless the influence of time and region. As there are many additional healthy human capital measurement methods in previous literature, we also perform a robustness test by taking public health expenditure per capita as the proxy variable of human capital (Heshmati, 2001; Rivera and Currais, 2004; Narayan et al., 2010; Jiang Pin and Tian Chengshi, 2009; Chen Hao, 2010) to exclude errors in variable selection. The result showed in estimate (9) indicates that the healthy human capital is still significantly positive to savings.

Table 3: Estimate results of savings model

Dependent Variables	Fixed-effect		Random-effect		GLS				
	Estimate (1)	Estimate (2)	Estimate (3)	Estimate (4)	Estimate (5)	Estimate (6)	Estimate (7)	Estimate (8)	Estimate (9)
$\ln(Md_1)$	0.39*** (0.08)		0.40*** (0.07)		0.39*** (0.02)		0.25*** (0.04)		
$\ln(Md_2)$		-0.05 (0.08)		0.07 (0.07)		0.21*** (0.01)		0.15*** (0.04)	
ln(MI)									0.34*** (0.04)
Δln(gdp)	2.55*** (0.96)	2.7*** (0.99)	2.17*** (0.99)	2.41* (1.03)	0.77** (0.33)	0. 65 (0.49)	1.21*** (0.41)	0.74*** (0.20)	1.07*** (0.21)
ln(Gov)	-0.00 (0.06)	0.02 (0.06)	-0.11* (0.05)	-0.05 (0.06)	-0.27*** (0.02)	-0.21*** (0.02)	-0.26*** (0.02)	-0.26*** (0.04)	-0.18*** (0.02)
ln(Ir+0.1)	0.17*** (0.04)	0.23*** (0.04)	0.25*** (0.04)	0.31*** (0.04)	0.22*** (0.03)	0.29*** (0.03)	0.16*** (0.05)	0.23*** (0.05)	0.32*** (0.05)
ln(If)	-0.05 (0.14)	-0.08 (0.15)	-0.14 (0.14)	-0.15 (0.15)	0.00 (0.05)	-0.06 (0.04)	-0.07 (0.05)	-0.06 (0.06)	-0.05 (0.05)
ln(Ig)	0.18 (0.19)	0.03 (0.02)	0.01 (0.02)	0.02 (0.02)	0.00 (0.00)	0.01** (0.00)	0.00 (0.00)	0.00 (0.00)	0.12 (0.09)
ln(Rur)	0.13 (0.09)	0.00 (0.09)	0.05 (0.09)	-0.11 (0.09)	-0.12*** (0.03)	0.25*** (0.03)	-0.19*** (0.04)	-0.17*** (0.06)	-0.23*** (0.08)
F-test	0.00	0.00							
BP-test			0.00	0.00					
Time Dummy Variable	No	No	No	No	No	No	Yes	Yes	Yes
Region Dummy Variable	-	-	No	No	No	No	Yes	Yes	Yes
Sample Number	493	493	493	493	493	493	493	493	493

Note: ***; ** and * represent the significance level of 1%; 5% and 10% respectively. And the estimate software is *stata10.0.*

Source: Author's calculations

Therefore, the improvement of healthy human capital can boost aggregate savings rate due to the positive effect. That is, the 'behavioral effect' of aging and 'composition effect' of children can completely offset the negative effect of the "composition effect" of aging.

Table 4: The general test results of panel-data model

Correlation test	Taking the number of sickbeds per capita as dependent variable		Taking the number ofdoctors per capita as dependent variable	
	F-Value; Chi-square Value	P-Value	F-Value Chi-square Value	P-Value
*Hausman*test	30.4	0.00	33.5	0.00
Pesaran test	12.0	0.00	17.7	0.00
Wooldridge sequence test	51.2	0.00	48.6	0.00
Modified Wald test	29.1	0.46	29.9	0.42

Source: Author's calculations

Regarding the control variables, our results show that the economic growth rate and real interest rate are positive to social aggregate savings rate. This indicates that a favorable economic environment increases the savings rate, and the income effect of real interest rate on China's social aggregate savings rate is greater than its substitution effect. The size of government and the urban-rural income gap is significantly negative to savings, i.e. the government's intervention in market and the urban-rural 'dual' economic structure are bad for the increase of social aggregate savings rate.

4.2.2. Estimations on savings, human capital and growth

In this section, we adopt GMM estimation to avoid endogeneity in OLS. There are two forms of GMM estimation, the differential GMM estimation (Dif-GMM) proposed by Arellano and Bond (1991) and systematic GMM estimation (Sys-GMM) put forward by Arellano & Bover (1995) and Blundell & Bond (1998). The Sys-GMM is based on the Dif-GMM and combines the difference equation and level equation. It performs estimation by choosing the one-period lagged dependent variables and first-order difference endogenous variables as instrumental variables of the endogenous variables in the level equation. Therefore, we adopt Sys-GMM, which take the healthy human capital as endogenous variable because the economic growth and healthy human capital are interrelated. So Ln(Mdt-1) and its lagged terms of more than one period are performed as instrumental variables in the difference equation. Meanwhile the differential terms of Ln(Mdt)'s lagged term are performed as tool variables in level equation. Furthermore, we adopt proxy OLS and fixed-effect model in equation (18) to test the robustness of the GMM

estimation. If the coefficient of lagged dependent variables in GMM is between the coefficient in proxy OLS model and fixed effect model, the estimate result of GMM is robust. The estimate results are reported in table 5.

Table 5: Estimated results of growth model

	Proxy OLS		Fixed-effect		Sys-GMM estimation		
	Estimation (1)	Estimation (2)	Estimation (3)	Estimation (4)	Estimation (5)	Estimation (6)	Estimation (7)
$\ln(Pgdp_{t-1})$	-0.46*** (0.11)	-0.50*** (0.10)	-1.82*** (0.22)	-2.10*** (0.36)	-0.67*** (0.07)	-0.77*** (0.08)	-0.87*** (0.06)
ln(Sav)	0.29*** (0.07)	0.33*** (0.05)	0.53*** (0.12)	0.47*** (0.10)	0.40*** (0.06)	0.34*** (0.04)	0.37*** (0.06)
ln(Sav)*ln(Md)	0.07*** (0.02)	0.08*** (0.01)	0.12*** (0.04)	0.07*** (0.01)	0.12*** (0.02)	0.08*** (0.02)	0.16*** (0.04)
ln(n+0.05)	-1.14*** (0.27)	-0.89*** (0.11)	-1.71*** (0.30)	-1.22*** (0.14)	-0.96*** (0.12)	-1.01*** (0.19)	-1.00*** (0.23)
ln(Hu)	0.51*** (0.18)	0.28*** (0.09)	0.40*** (0.10)	0.28*** (0.10)	0.27*** (0.07)	0.36*** (0.12)	0.41*** (0.14)
ln(Gov)	-0.26 (0.21)	-0.27*** (0.07)	-0.18 (0.19)	-0.36*** (0.07)	-0.21*** (0.05)	-0.31*** (0.10)	-0.39*** (0.06)
ln(FDI)	0.05*** (0.01)	0.11 (0.09)	0.07*** (0.01)	0.06*** (0.01)	0.05*** (0.02)	0.04*** (0.00)	0.12 (0.09)
ln(Open)	0.29*** (0.05)	0.31** (0.04)	0.24*** (0.06)	0.22** (0.05)	0.37*** (0.04)	0.26** (0.06)	0.30*** (0.07)
Time Dummy Variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region Dummy Variable	Yes	Yes	-	-	Yes	Yes	Yes
Arellano-Bond AR(1)					0.00	0.00	0.00
Arellano-Bond AR(2)					0.16	0.24	0.19
Sargan excessive identification test					0.46	0.59	0.66
Diff-Sargan test					1.00	1.00	1.00
Valid sample	464	464	464	464	464	464	464

Note: ***; ** and * represent the significance level of 1%; 5% and 10% respectively. Tool variable in difference equation are ln(Pgdpt-2); Ln(Mdt-1); lagged terms of more than one period and time dummy variable. Tool variables in level equation are ln(Pgdpt-1); Ln(Md); the differential terms of its lagged terms and the time dummy variable. The estimate software is *stata10.0*.

Source: Author's calculations

In columns (1), (3) and (5) in table 5, healthy human capital is measured by the number of sickbeds per capita; and in columns (2), (4) and (6) human capital is measured by the number of doctors per capita. As the results showed, coefficient of ln(Pgdpt-1) is -0.46 and -0.50 in proxy OLS regression; -1.82 and -2.10 in fixed-effect mode and -0.67 and -0.77 in sys-GMM. So, adopting sys-GMM estimation is robust.

In regression of estimates (5) and (6), the P-Value of Arellano-Bond AR (1) is 0.00 and the P-Value of Arellano-Bond AR (2) is larger than 0.1, which means there is no second-order sequence correlation. Moreover, the Sargan over-identification test is around 0.5 and the P-Value of Diff-Sargan test is 1, which means the selected instrumental variable is effective. And the coefficient of cross term, ln (Sav)*ln (Md), is significantly positive, which indicates that the improvement of healthy human capital raises the marginal effect that social aggregate savings rate brings on economic growth. The regression yields similar result when using public health expenditure per capita (MI) to measure healthy human capital in regression of estimate (7). Thus, the "behavioral effect" of aging and the "composition effect" of children of the improved healthy human capital on economic growth can offset its "composition effect" of aging and boost economy.

Of all the control variables, the per capita GDP is significantly negative to show its convergence of inter-provincial economic growth; the coefficient of ln(n+0.05) and ln(Gov) are significantly negative, which means the population growth and government's intervention in economy has restrained the growth; the coefficient of ln(Hu);ln(FDI) and ln(Open) are positive, indicating that the high educational human capital; large size of foreign capital and high degree of openness are beneficial for China's economic growth.

5. Results and discussion

Based on an overlapping generation model which can reflect individual's savings behavior in the full annuity market, the article performs an empirical test on the relationship between China's healthy human capital and savings rate and economic growth based on the provincial panel data during 1996-2012. The regressions are estimated by adopting GLS and Sys-GMM specifically.

The result shows that, in the empirical verification on the aggregate savings rate as explained variable, the improvement of healthy human capital has a very striking positive pulling effects on the aggregate savings rate, without influenced by time or regional effect, which is indicated by various measurements of healthy human capital such as number of sickbeds per capita and doctors per capita , and public health expenditure per capita, indicating both a relatively strong soundness and that the 'positive effects' on savings by healthy human capital (elderly 'behavioral

effects' and infant 'composition effects') can completely offset the 'negative effects' on savings (elderly 'composition effects'), and boost China's aggregate saving rate.

The results confirm that, in the empirical verification on economic growth rate as explained variable, the improvement of healthy human capital has similarly a very striking positive pulling effects on economic growth, which may not only be verified in the verification of various instrumental variables and proxy variables, but indicate that the improvement of healthy human capital is also conducive to improving the marginal effect of the aggregate saving rate on economic growth by using the interaction-term of social aggregate savings rate and healthy human capital as explanatory variable. This further indicates that the positive role of healthy human capital to China's economic growth is higher than the negative drag of aging, hence boosting economic growth.

The above-mentioned results of empirical analysis verify our original hypotheses: the decline of infant mortality rate may lead to the decline of infant dependency rate, hence reducing the supporting burden of working population.; the improvement of medical care conditions may lead to improve the expected longevity, hence improving aging expectation, and the improvement of healthy human capital was an important positive factor in pushing the rise of China's savings rate and economic growth, the effect of which is much higher than the negative effect of the rise of elderly dependency rate and the supporting burden of working population on savings and growth.

On the other hand, such empirical results have proven that the variable of demographic structure is endogenous: the demographic change is not an exogenous variable to savings and growth. They are not only influenced by exogenous population policy like one-child policy, but affected by the changes in healthy human capital, such as lowering or boosting fertility and survival rate, and influencing the aging expected behavior, hence affecting the mechanism for the variable of demographic structure to influence savings and growth.

Practically, this article helps clarify some misunderstanding about the effect that demographic changes have on China's economy. Firstly, the demographic change is not an exogenous variable to savings and growth and the positive effect should not be counted on the family planning policy only. Secondly, the improvement of healthy human capital can help boost savings rate and economic growth obviously. Thus, we should be optimistic to the long-term outlook of China's economy.

6. Conclusios

Based on the impact mechanism of healthy human capital on savings and growth, this paper constructed an overlapping generation model which can reflect both

demographic changes and aging behaviors, and performs an econometric test based on samples from 1996 to 2012 in China. The results reveal that the rapid improvement of healthy human capital served as an important support for the continuation of "high savings-high growth" model in China, and substantially reversed the negative impact of demographic deterioration. This proves the initial hypothesis of this paper: the improvement of healthy human capital can significantly promote the social savings rate and economic growth by affecting the population structure and aging expectations.

From the results above, we cannot be pessimistic about China' economic growth just because of the demographic structure deterioration. The mechanism of demographic structure changes for savings and growth will be constrained by factors such as the improvement of healthy human capital. In the current policy practice in China, in addition to relaxing the "family planning" policy and restoring the long-term policy measures of the total population fertility rate, some supporting policy arrangements can be made to gain time and space for restoring economic growth from demographic dividend through public health investments.

From another perspective, there are two different effects on the improvement of healthy human capital to savings and growth: it can extend life expectancy and promote savings and growth, and may push up the total care ratio to curb savings and growth, therefore, attention should be paid to the trade-off of the two effects. In the past two decades, China's family planning policy and public HHC investment have jointly promoted the decline of the total care (support) ratio, which in turn promoted the formation of the "high savings - high investment" model and the rapid economic growth. In the future, however, with the decline of child dependency ratio gradually reaching bottom, the elderly dependency ratio will be accelerating, resulting in the change of total dependency (support) ratio from decreasing to increasing. This is likely to drag down the positive mechanism of the "component effect" of HHC, which will impact the rate of social savings and economic growth. In response to such change, China's HHC investment should focus more on the stimulus of aging expectation and its "behavioral effects", including gradual improvement of medical and social security systems and more comprehensive and systematic environmental governance to effectively improve the individuals' expectations for health.

In addition to healthy human capital, based on the model estimates of this paper, it is also necessary to pay attention to other traditional economic growth promotion mechanisms, such as increasing investment in educational human capital characterized by the average years of education. Considering the interaction between educational human capital and healthy human capital, we should seek a systematic solution based on the overall framework of human capital to improve savings and promote growth. This will undoubtedly have more important practical significance for offsetting the negative impact of demographic structure deterioration.

References

Aisa, R., Pueyo, F. (2004) "Endogenous Longevity, Health and Economic Growth: a Solow Growth for a Longer Life", *Economics Bulletin*, Vol. 9, No. 3, pp. 1–10.

Arellano M., Bover O. (1995) "Another Look at the Instrumental Variable Estimation of Error-Compon ents Models", *Journal of Econometric*, Vol. 68, pp. 29–52, doi: 101016/0304-40 76 (94)01642-d.

Arellano, M., Bond S.R.(1991) "Some Tests of Specificion for Panel Data: Monte Carlo Evidence and An Application to Employment Equations", *Review of Economic Studies*, Vol. 58, pp. 127–297, doi: 10.2 307/2297968.

Arora, S. (2001) "Health, Human Productivity, and Long-Term Economic Growth", *The Journal of Economic History*[Internet], Vol. 61, No. 3, pp. 699–749. Available at: < http://www.jstor.org/stable/2698133>. [Accessed: December 9, 2017]

Barro, R.J. (1996) "Health and Economic Growth", Paper Presented at the "Senior Policy Seminar on Health, Human Capital and Econnomic Growth: Theory, Evidence and Polcies" Pan American Health Organization and Inter- American Development Bank, Washington D.C.

Bhargava, A. et al. (2001) "Modeling the effects of health on economic growth", *Journal of Health Economics*, Vol. 20, No. 3, pp. 423–440, doi: 10.1016/s0167-6296(01)00073-x.

Bloom D.E., Canning, D., Graham, B. (2003) "Longevity and Life-cycle Savings", *Scand. J. of Economics,* Vol. 105, No. 3, pp. 319–338, doi: 10.1111/1467-9442.t01-1-00001.

Blundell, R. And Bond, S. (1998) "GMM Estimation with Persistent Panel Data: An Application to Production Functions", *Journal of Econometrics,* Vol. 87, pp. 115–143, doi: 10.1016/S0304-4076(98)00009-8.

Bond, Hoeffer and Temple (2001) "GMM Estimation of Empirical Growth Models", *Cepr Discussion Paper*, Vol. 159, No. 1, pp. 99–115, doi: 10.1002/9781118716410.ch13.

Deaton, A., Parson, C. (1994) "Saving, growth, and aging in Taiwan". In David A. Wise ed., *Studies in the Eeonomics of Aging*, Chieago, University of Chieago Press. doi: 10.3386/w4330.

Dewen Wang, Fang Cai, Xuehui Zhang (2004) "Saving and Growth Effects of Demographic Transition: the Population Factor in the Sustainability of Chinas' Economic Growth", *Population Research*, No. 9, pp. 2–11, doi: 10.3969/j.issn.1000-6087.2004.05.001.

Dihai Wang, Liutang Gong, Hongyi Li (2008) "Health Human Capital, Healthy Investment and Economic Growth". *Management World*, No. 3, pp. 27–39, doi: 10.1201/9781420009521.ch3.

Duncan T., Strauss J. (1997) "Health and wages: Evidence on men and women in urban Brazil", *Journal of Econometrics,* Elsevier, Vol. 77, No. 1, pp. 159–185, doi: 10.1016/s0304-4076(96)01811-8.

Dwight H. Perkins, et al. (2005) *Economics of Development*, China Renmin University Press, pp. 211–214, doi: 10.2307/1971635.

Fogel, R. (1994) "Economic Growth, Population Theory, and Physiology: The Bearing of Long-Term Processes on the Making of Economic Policy", *The American Economic Review,* Vol. 84, No. 3, pp. 369–395, doi: 10.3386/w463.

Fogel, R. (1997) "The Global Struggle to Escape from Chronic Malnutrition since 1700", CPE working papers, University of Chicago – Centre for Population Economics.

Fogel, R. (2007) "Capitalism and Democracy in 2040: Forecasts and Speculations", NBER Working Papers 13184, National Bureau of Economic Research, Inc, doi: 10.3386/w13184.

Guoen Liu et al. (2004) "Health Capital and Income Growth in China". *China Economic Quarterly,* Vol. 4, No. 1, pp. 18, doi: https://10.13821/j.cnki.ceq.2004.04.003.

Hao Chen. (2010) "A Structural Analysis on the contribution of Hygienic Investment to China's Health Development and Economic Growth". *Chinese Journal of Population Science,* No. 2, pp. 92–100, doi: http://kns.cnki.net/kns/detail/detail.aspx?FileName=ZKRK201002010&DbName=CJFQ2010.

Hayashi, F. (1989) "Japan's Saving Rate: New Data and Refleetions", *NBER Working Paper*, No. W3205, doi: 10.3386/w3205.

Heshmati, A. (2001) "On the Causality between GDP and Health Care Expenditure in Augmented Solow Growth Model", *Stockholm School of Economics Working Paper in Economics and Finance,* No. 423.

Hurd, M.(1987) "Saving of the elderly and desired bequests", *The Ameriean Eeonomic Review,* Vol. 77, No. 3, pp. 298–312, doi: 10.2307/1804096.

Issa, H. (2003) "Human Capital, Demographic Transition and Economic Growth", *CGBCR Discussion Paper Series*[Internet], University of Manchester, Manchester. Available at: <http://www.ses.man.ac.uk/CGBCR/ Discuss.htm>.

Jianfang Yang, Liutang Gong, Qinghua Zhang (2006) "Human Capital Formation land its Effects on Economic Growth". *Management World,* No. 5, pp. 10–18, doi: http://kns.cnki.net/kns/detail/detail.aspx?FileName=GLSJ200605002&DbName=CJFQ2006.

Jin Zou (2017) "Heterogeneity Influence of Demographic Trends on House Price". *Economic Survey*, No. 1, pp. 94–99, doi: 10.15931/j.cnki.1006-1096.2017.01.016.

Jones, C. (2001) "Was an Industrial Revolution Inevitable? Economic Growth Over the Very Long-run", *Advances in Macroeconomics*, Vol. 2, pp. 1–45. doi: h10.2202/1534-6013.1028.

Juhuang He (2006) "Is the Population Bonus Large?". *The Journal of Quantitative & Technical Economics,* No. 7, pp. 24–35, doi: 10.13653/j.cnki.jqte.2006.07.003.

Kalemli O.S. (2002) "Does Mortality Decline Promote Economic Growth?", *Journal of Economic Growth,* Vol. 7, pp. 411–439, doi: 10.2139/ssrn.315839.

Koga. M. (2006) "The Decline of Japan's Saving Rate and Demographic Effeets", *Japanese Eeonomic Review*, Vol. 57, No. 2, pp. 312–321, doi: 10.1111/j.1468-5876.2006.00369.x.

Kraay, A. (2000) "Household Saving in China", *The World Bank Economic Review,* Vol. 14, No. 3, pp. 545–570.

Lagerlof N.P. (2003) "From Malthus to Modern Growth: Can Epidemics Explain the Three Regimes", *International Economic Review*, Vol. 44, No. 2, pp. 361–800, doi: 10.1111/1468-2354.t01-1-00088.

Leff, Nathanisl H. (1969) "Dependency Rate and Saving Rate", *American Economic Review,* Vol. 59, No. 1, pp. 886–896, doi: 10.2307/3438951.

Li H., Zhang J., Zhang J. (2007) "Effects of longevity and dependency rates on saving and growth: Evidence from a panel of cross countries", *Journal of Development Economics,* Vol. 84, No. 1, pp. 138–154, doi: 10.1016/j.jdeveco.2006.10.002.

Li, H., Huang, L. (2009) "Health, Education, and Economic Growth in China: Empirical Findings and Implications", *China Economic Review*, Vol. 20, No. 3, pp. 374–387, doi: 10.1016/j.chieco.2008.05.001.

Loayza, N., Schmidt H.K., Servn, L. (2000) "What Drives Saving across the World", *Review of Economics and Statistics,* Vol. 82, No. 3, pp. 165–181, doi: 10.1162/003465300558678.

Lucas, Robert Jr. (1988) "On the mechanics of economic development", *Journal of Monetary Economics*, Elsevier, Vol. 22, No. 1, pp. 3–42, doi: 10.1016/0304-3932(88)90168-7.

Mason A., Lee R. (2004) "Reform and Support Systems for the Elderly in Developing Countries: Capturing the Second Demographic Dividend", *GENUS*, Vol. 62, No. 2, pp. 11–35, doi: 10.2307/29789308.

Mason, A., 1988, "Saving, Economic Growth, and Demographic Change", *Population and Development Review,* Vol. 14, No. 1, pp. 113–44, doi: 10.2307/1972502.

Mengtao Gao, Yang Yao. (2005) "Health Shocks and Farmers' Income Capabilities". *Economic Research Journal,* No. 12, pp. 15–25, doi: http://kns.cnki.net/kns/detail/detail.aspx?FileName=JJYJ200512002&DbName=CJFQ2005.

Modigliani F., Brumburg, R. (1954) "Utility Analyses and the Consumption Function", In K.K. Kurihara ed., *Post Keynesian Economics*, New Brunswick, NJ: Rutgers University Press, pp. 388–436.

Morand O.F. (2004) "Economic Growth, Longevity and the Epidemiological Transition", *The European Journal of Health Economics,* Vol. 5, No. 2, pp. 166–174, doi: 10.1007/s10198-003-0219-9.

Mushkin, S. (1962) "Health as an Investment", *Journal of Political Economy*, Vol. 70, No. 5, pp. 129–157, doi: 10.1086/258730.

Narayan, S., Narayan P.K., Mishra, S. (2010) "Investigating the Relationship Between Health and Economic Growth : Empirical Evidence from a Panel of 5 Asian Countries", *Journal of Asian Economics,* Vol. 21, No. 4, pp. 404–411, doi: 10.1016/j.asieco.2010.03.006.

Ping Jiang, Chengshi Tian (2009) "Analysis of the Contribution of Government Investment in Regional Health Industry to Economic Growth". *Research on Financial and Economic Issues,* No. 2, pp. 82–88, doi: http://10.19654/j.cnki.cjwtyj.2009.02.014.

Quamrul H., Ashraf., Lester, A., Weil, D.N., (2009) "When Does Improving Health Raise GDP?" NBER Chapters, in: *NBER Macroeconomics Annual 2008*, Vol. 23, pp. 157–204, doi: 10.1086/593084.

Rivera, B., Currais, L. (2004) "Public Health Capital and Productivity in the Spanish Regions: A Dynamic Panel Data Model", *World Development,* Vol. 32, No. 5, pp. 871–885, doi: 10.1016/j.worlddev. 2003.11.006.

Romer P.M. (1986) "Increasing returns and long-run growth", *Journal of Political Economy*, Vol. 94, pp. 1002–1037, doi: 10.1086/261420.

Rossi, N. (1989) "Dependency Rates and Private Savings Behavior in Developing Countries", *Staff Papers International Monetary Fund*, Vol. 36, No. 1, pp. 166–181, doi: 10.2307/3867173.

Schultz, T.W. (1961) "Investment in Human Capital", *American Economic Review,* Vol. 51, No. 1, pp. 1–17, doi: 10.2307/2230051.

Schultz, Theodore W. (1971) " Investment in Human Capital: The Role of Education and of Research", *American Journal of Agricultura Economics,* Vol. 53, No. 1, pp. 692–693, doi: 10.2307/1237858.

Shuiying Zhong, Kui Li. (2009) "The Impact of Dependence Ratio on Household Savings Rate". *Chinese Journal of Population Science*, No. 1, pp. 42–51, doi: 10.3969/j.issn.1000-6087.2004.05.001.

Tabata, K. (2005) "Population Aging, the Cost of Health Care for Elderly and Growth", *Journal of Macroeconomics Volume*, Vol. 27, No. 3, pp. 472–493, doi: 10.1016/j.jmacro.2004.02.008.

Tamura, R. (2006) "Human Capital and Economic Development", *Journal of Development Economics*, Vol. 79, No. 1, pp. 26–72, doi: 10.1016/j.jdeveco.2004.12.003.

Wei Wang (2008) "Determinants of Chinese Household Saving Rate: An Analysis Based on Dynamic Panel Data at Provincial Level of the Period 1995-2005".

Journal of Finance and Economics, No. 2, pp. 53–64, doi: http://10.16538/j.cnki.jfe.2008.02.008.

Wei Wang (2010) "Saving and Growth Effects of the One-Child Policy: Theory and China's Empirical Study". *Economic Research Journal,* Vol. 45, No. 10, pp. 63–77, doi: http://kns.cnki.net/kns/detail/detail.aspx?FileName=JJYJ201010006&DbName=CJFQ2010.

Xiangsen Lin, Qiang Xie (2016) "An Analysis of the Factors Affecting China's Old Age Retirement: Based on the Data from CHARLS". *Contemporary Finance & Economics,* No. 9, pp. 3–13, doi: http://10.13676/j.cnki.cn36-1030/f.2016.09.001.

Yan Feng, Zhihong Chai (2016) "Impacts of Health Human Capital on Economic Growth". *Research on Economics and Management,* No. 2, pp. 21–27, doi: http://10.13502/j.cnki.issn1000-7636.2016.02.003.

Yongmin Luo (2011) "Public Health Expenditure, Health Human Capital and Economic Growth". *South China Journal of Economics*, No. 4, pp. 3–15, doi: http://kns.cnki.net/kns/detail/detail.aspx?FileName=NFJJ201104006&DbName=CJFQ2011.

Yunyun Jiang (2009) "Intergenerational Analysis of the Influence of China's Population Structure Change on National Savings". *Economic Science*, No. 1, pp. 30–38, doi: 10.19523/j.jjkx.2009.01.004.

Zhang, J., Zhang, J., Lee, R. (2003) "Rising Longevity, Education, Savings and Growth", *Journal of Development Economics,* Vol. 70, pp. 83–101. doi: 10.1016/s0304-3878(02)00088-3.

Zhigang Yuan, Zheng Song (2000) "The Age Composition of Population,the Endowment Insurance System and Optimal Savings Ratio in China". *Economic Research*, No. 11, pp. 24–32, doi: http://kns.cnki.net/kns/detail/detail.aspx?FileName=JJYJ200011002&DbName=CJFQ2000.

Zhiyuan Zhang, Minghong Zhang (2016) "Will the Increase in the Elderly Labor Force Affect the Employment Rate of the Young Labor Force?: An Angle of Investigation on the Impact of Delayed Retirement on the Labor Market". *Economic Science*, No. 3, pp. 49–60, doi: 10.19523/j.jjkx.2016.03.004.

Zon A.H., Muysken J. (2003) "Health as a Principal Determinant of Economic Growth", Working paper, MERIT-Infonomics Research Memorandum.

Zon A.H., Muysken, J. (2001) "Health and Endogenous Growth", *Journal of Health Economics,* Vol. 20, pp. 169–185, doi: 10.1016/S0167-6296(00)00072-2.

Utjecaj poboljšanja zdravlja ljudskog kapitala na štednju i rast: empirijska studija utemeljena na panel podacima među-pokrajina Kine[1]

Ren Wang[2], Rui Wang[3], Hongqi Ma[4]

Sažetak

Tradicionalna hipoteza životnog ciklusa vjeruje da starenje stanovništva ne samo da smanjuje razinu društvene štednje, već negativno utječe i na gospodarski rast. Međutim, čimbenik ljudskih kapitala može promijeniti mehanizam utjecaja na promjene strukture stanovništva. Ova studija pokušava se usredotočiti na specifičan čimbenik poboljšanja zdravih ljudskih kapitala (HHC), endogenim tretmanom stope plodnosti i stope preživljavanja, s obzirom na očekivanu starosnu dob racionalnog pojedinca, kako bi se, de facto, istražio njegov utjecaj na stopu štednje i gospodarski rast uz primjenu panel podataka među-provincija Kine od 1996. do 2012. godine u cilju provjere inherente logičke veze između brzog poboljšanja HHC-a i modela "visokog rasta s visokim uštedama". Rezultati ovog istraživanja su sljedeći: poboljšanje HHC-a važan je čimbenik koji utječe na povećanje stope štednje i gospodarski rast Kine u odgovarajućem razdoblju. To znači da je poboljšanje HHC-a dovoljno da promijeni mehanizam makro-učinaka demografskih promjena, te stoga pruža ključna sredstva za dugoročnu regulaciju i kontrolu koja su izvan okvira natalitetne politike. Među njima značajnu pozornost zaslužuju promicanje javnog upravljanja zaštitom okoliša, poboljšanje sustava socijalne sigurnosti, jačanje individualnih očekivanja u svezi zdravlja i poticanje očekivanog obrasca starenja stanovništva uz postizanje povezanosti s ulaganjima u obrazovni ljudski kapital.

Ključne riječi: *zdravi ljudski kapital, očekivana starosna dob, stopa štednje, gospodarski rast*

JEL klasifikacija: *I15, J11, J24*

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[1] Ovaj rad je u potpunosti financiran od strane Nacionalnog fonda za društvene znanosti Kine (18BGJ018), Općeg projekta Ministarstva obrazovanja humanističkih i društvenih znanosti: Leverage Ratio Paradox and Monetary Policy Choice in the Background of Overcapacity (17XJC790015) i Nacionalnog znanstvenog istraživačkog projekta Nacionalnog zavoda za statistiku: Overcapacity Monitoring and Early Warning System Study in China's Industrial Sector (2016LY07).

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