

# Research on the Impact of Issuing Central Bank Digital Account on Improving Domestic Demand Under the Background of Population Aging

Lu Wenxi<sup>1</sup>, Jiang Huanshu<sup>2</sup>

<sup>1</sup>Jiangsu University, No.301, Xuefu Road, Jingkou District, Zhenjiang, Jiangsu, 212013, China

<sup>2</sup>Jiangsu University, No.301, Xuefu Road, Jingkou District, Zhenjiang, Jiangsu, 212013, China

**Abstract**— By establishing an Over Lapping Generation model (OLG model) and introducing Central Bank Digital Account (CBDA), this paper discusses the impact of population aging and CBDA on economic growth. The study found that after the introduction of CBDA, population aging can promote the accumulation of human capital, but hinder the accumulation of physical capital at the same time. When the increasing effect of population aging on the accumulation of human capital is greater than its inhibiting effect on the accumulation of physical capital, the government should reduce the tax rate and increase the proportion of public education expenditure. When the effect of ageing on human capital accumulation is not sufficient to offset the effect of ageing on physical capital accumulation, the government should raise taxes and spend less on public education and more on health care.

**Keywords**— Aging of Population, CBAD, Economic Growth.

## I. INTRODUCTION

Over the past four decades of reform and opening up, China has been able to play an important role in global value chains thanks to low-cost labor and other advantages. Its economy has achieved sustained and rapid growth, and its people's living standards and health care capacity have been greatly improved. But at the same time, the average life expectancy of China's population is increasing year by year, and the high cost of child-rearing leads to the continuous low birth rate in recent years, under the combined action of the two, the aging degree of China is deepening. According to the criteria of population aging defined by the United Nations Population Aging and Its Socio-economic Consequences, a country or region is considered to be aging when the number of elderly people aged 65 and above accounts for more than 7% of the total population. By the end of 2014, the number of elderly people aged 65 and above in China had reached 1.38. 100 million, more than the elderly population of Europe combined; In 2019, the elderly population over 60 years old in China is 250 million, accounting for 18% of the total population. It is expected that by 2050, the elderly population will reach 487 million, accounting for 1/3 of the total population. The super aging society will be accompanied by the retirement life of the post-80s and post-90s. The Ministry of Civil Affairs announced on October 23, 2020 that during the 14th Five-Year Plan period, the elderly population in China will exceed 300 million and enter the moderately aging population.

Population aging affects economic growth from capital accumulation, savings rate and monetary policy. First of all, Romer (1986) and Lucas et al.(1988) proposed the endogenous economic growth theory, believing that technological progress comes from the accumulation of physical capital and human capital in "Learning by Doing", while population aging has a two-way impact on the accumulation of the two kinds of capital. In terms of physical capital accumulation, when the elasticity of capital output is small, the extension of average life

expectancy will increase the physical capital accumulation. When the elasticity of capital output is large, the relationship between physical capital accumulation and the degree of population aging presents an inverted "U" shape(Geng Zhixiang, 2016). In terms of human capital accumulation, the deepening of population aging will increase the burden of family pension and thus reduce the education expenditure for teenagers, which has a crowding out effect on human capital accumulation(Wang Wei, 2016). However, some scholars have found through empirical studies that the decline of mortality (namely, the extension of life expectancy) has a positive effect on human capital investment and economic growth rate(Sala et al., 2004). Secondly, there are two different views on the impact of population aging on savings. One view is that people in the old age are in a negative saving state, and the aging of population will increase the burden of social pension, reduce the national saving rate, and thus not conducive to economic growth. Another point of view is that rational actors will actively increase savings when they observe demographic structure changes, thus inducing the "second demographic dividend" and promoting economic growth(Li et al., 2007). Meanwhile, population aging may lead to deterioration of macroeconomic environment, narrowing of operation space and weakening of monetary transmission effect, making the natural interest rate gradually approach the lower limit of zero interest rate(Fang Xiancang et al., 2019). Since the 1990s, The Japanese economy has gradually fallen into the "deflation trap" and "liquidity trap", and the overall economic downturn is known as the "lost two decades". At the same time, in recent years, the economy of the European Union countries has also gradually weakened, and the inflation rate has been under 2% for a long time. All countries are struggling to find a way out.

Digital currency is a new form of currency gradually evolved with the rise of science and technology and the continuous improvement of social civilization. Central bank digital currency plays a positive role in saving costs, exerting

policy effectiveness and building a new financial system. With the development of the Internet, the cyber world is breaking through national geographical restrictions, expanding its territory, forming a broader space, and closely integrating with the real society, thus becoming a new field of international social rules and governance competition. Internet technology and ideas have a significant impact on the existing monetary system. Digital currency supported by Internet technology is fully possible to break through the constraints of existing currencies and become a unified currency widely circulated in the cyber world(Wang Yongli, 2016). With the emergence of the currency, private payment tool "to cash" trend, affect the national currency sovereignty, in the face of liberalism ideological trend of "decentralization" digital currency under the boom, at the same time, in response to zero or even negative interest rates monetary policy environment, countries are actively developing legal digital currency, for example, The Ubin project developed by the Monetary Authority of Singapore and the Stella project jointly developed by the European and Japanese central banks. China is also actively promoting the research and development of legal digital currency. In 2014, the People's Bank of China officially launched the research on legal digital currency. In 2017, with the approval of The State Council, the People's Bank of China started the distributed research and development of legal Digital Currency called DE/CP (Digital Currency/Electronic Payment). In January 2020, the People's Bank of China issued a document stating that China's legal digital currency has basically completed top-level design, standard formulation, functional research and development, and joint research and testing. Since April, the agricultural Bank of China, Didi Chuxing and other institutions have conducted closed testing in multiple locations.

On the one hand, relying on big data technology, legal digital currency can more conveniently and accurately analyze the implementation of monetary policy and financial stability from a medium and macro perspective(Yao Qian, 2019). Monetary policy, as one of the important means for the central bank to control the national economy and maintain steady growth, its core is to increase or reduce the money supply. However, because the ultimate flow of money cannot be controlled effectively, the ultimate effect of monetary policy will often deviate from the intended purpose. The digital currency of the Central Bank has the same distributed accounting characteristics as common digital currency(Zhang Guosen, 2020), which means that the whereabouts and transaction information of each fund can be monitored and queried in real time, thus providing a three-dimensional, complete and true data basis for the implementation of monetary policies. At the same time, legal digital currency after the merge with other broader financial infrastructure helps reduce cost efficiency society(Yao Qian, 2016), because of the high notes of cost is mainly composed of storage, transportation and damaged, the authenticity, and the manufacturing cost of the coin sometimes even exceed its value, in comparison of digital currency have natural cost advantage. Firstly, starting from currency issuance, theoretically, the cost of the central bank to build the digital currency operation platform of the Central Bank is a one-time investment. In the future, the issue

cost will gradually decrease and even approach zero, which greatly reduces the consumption of talents and materials in the issuance process of the existing currency. Secondly, from the perspective of currency circulation, the circulation of central bank's digital currency is through point-to-point asymmetric digital encryption transmission between the receiver and the payer. Theoretically, there is no possibility of damage, forgery and loss, so circulation cost and recovery cost can be ignored. In the long run, the total cost of digital money will be far less than that of current money, while improving circulation efficiency. On the other hand, the design attribute of legal digital currency determines its influence on monetary policy. If it is only used as a payment tool to replace M0 and not as an interest-bearing asset, its influence on money supply will be "neutral" under appropriate circumstances. If it is also used as an interest-bearing asset, it will help to improve the transmission efficiency of medium and long term credit interest rate of the central bank and break the zero lower limit of interest rate(Sheng Songcheng et al., 2016). In the traditional exchange model, exchanges mainly provide two kinds of services: information intermediary and credit intermediary. In block chain and intelligent contract based digital paper trading platform, because all the basic information is retained in the block chain, exchange information intermediary role will be weakened, and block the chain itself is good at solving the problem of trust, so the exchange business in block chain system, the more is to provide trading places, support services, and trade has occurred. At the same time, in the process of exchanging private data, the exchange can assume the role of information transfer. The clearinghouse is also a trading rule maker, responsible for offline identity authentication of participants, monitoring trading behavior on the chain, updating the smart contract template for issuing bills, etc. For complex trades, exchanges can help analyze trading conditions and offer services such as customized smart contracts. In addition, the bill exchange is also the builder and maintainer of the whole bill business platform(Xu Zhong et al., 2016).

However, issuing digital currency will not only take longer to improve the technical and cultural level of the whole population, but also cost more money in the construction of circulation environment. The central bank's digital currency is endorsed by national credit, and its supply is dynamically regulated by the central bank to ensure economic growth and currency stability. China may face the following problems in issuing central bank digital currency: First, there are many difficulties in the construction and transformation of circulation environment. Issuing digital currency is a challenge for developed countries, but for China, issuing central bank digital currency is a huge social project. China is a country with a large population, uneven regional development and obvious economic disparities. According to previous experience, it will take about 10 years for China to replace a version of RMB from promotion to full use(Shi Xinjie et al., 2018). Second, the financial system could face an unprecedented shock. On the one hand, the issuance of central bank digital currency may have adverse effects on bank finance and credit creation. On the other hand, the issuance of central bank digital currency will shock the existing financial management system. Central banks must

always be ready to transfer banks' assets and associated risks to themselves. That is, the central bank will have to bear the financial risks of commercial banks(Li Ying et al., 2019). Third, the necessary technical indicators for circulation are not easy to achieve. As the legal tender in the future, the digital currency of central bank is bound to become the mainstream transaction currency, which requires an efficient and complete transaction processing system. Block chain technology is similar to distributed record, which takes block as the basic unit to store transaction information. For every change, each trusted block can only be recorded after the whole network node completes enough computation. Therefore, the generation speed of block is relatively slow(Fan Yifei, 2016). Fourth, the security of the monetary system is not absolutely guaranteed. "Blockchain technology has programmable scalability. If the extended applications loaded on blockchain have backdoors or security loopholes, it will pose great security risks to the security of transactions"(Liu Xiangmin, 2016). Central bank digital money brings new opportunities for countries around the world. The emergence of central bank digital currency will protect the currency sovereignty and legal currency status of China's fiat currency in the coming of Libra and the miscellaneous situation of digital currency classification. In addition, the digital currency of the central bank can reduce the degree of dependence on accounts in the transaction process, and is conducive to the circulation and internationalization of RMB.

Digital currency will be an important battlefield in the competition in the field of digital finance between countries in the future. Whoever holds the global digital currency will have an important influence on the global payment and monetary system, and the countries that launch central bank digital currency earlier are expected to gain the first-mover advantage(Jiang Ouxiang et al., 2020). However, in the context of aging population, the elderly may not be able to adapt to new electronic things for a while, and the central bank reduces the use of digital currency, weakening the regulatory effect of issuing digital currency of the central bank on the economic system. In order to meet the requirements of the increasing of people a better life and not balance the contradiction between the inadequate development, needs to be targeted and effective policy Suggestions on aging trend, at present, the study of population aging on economic growth literature books, legal digital currency and chain block research also have sprung up sharply, but the combination of the two discuss the relative lack of literature. By establishing an extended Over Lapping Generation Model (OLG model), this paper introduces central bank digital currency and discusses the influence of the two on economic growth.

The rest of this paper is arranged as follows. The second part constructs the theoretical model of this paper. The third part solves and explains the model results. The fourth part elaborates the conclusions and puts forward policy suggestions.

## II. BUILDING THE THEORETICAL MODEL

Referring to the research methods of Liu Qiongzhi and He Qi (2012), this paper establishes an extended generation overlapping model, assuming that everyone in an iterative society survives in two stages: adulthood and old age. Typical

individuals work in adulthood and retire in old age. All representative individuals in each period are homogeneous and consume a same good.

### A. The Family

It is assumed that representative individuals provide labor force  $L_{it}$  during the adult working time of a unit, the wage rate and income tax rate are respectively  $w_t$  and  $\tau$ , and the after-tax income  $I_L$  consists of consumption  $c_t$  commercial banks deposits  $s_t$  and digital currency deposits  $m_t$  of the central bank:

$$I_L \equiv (1 - \tau)w_t = c_t + s_t + m_t \quad (1)$$

Assuming that the mortality rate in adulthood is zero, the elderly face uncertain survival rates  $\phi$  after retirement, which represents the degree of population aging(Evangelos, 2007). The elderly after retirement can get their adult savings  $s_t$ ,  $m_t$  and after-tax income  $(1 - \tau)r_{t+1}^B s_t$ ,  $(1 - \tau)r_{t+1}^D m_t$ , among which  $r_{t+1}^B$  is the bank commercial deposit interest rate and  $r_{t+1}^D$  is the central bank digital currency deposit interest rate. The income of the elderly  $I_R$  is:

$$I_R \equiv \phi c_{t+1} = s_t + (1 - \tau)r_{t+1}^B s_t + m_t + (1 - \tau)r_{t+1}^D m_t \quad (2)$$

At equilibrium, there must be  $r_{t+1} = r_{t+1}^B = r_{t+1}^D$ . Because capital is profit-driven. If  $r_{t+1}^B > r_{t+1}^D$ , it means that the interest rate of bank deposit is higher than that of digital currency of the central bank, people will withdraw their commercial bank deposits and deposit them in the digital currency deposit platform of the central bank. The central bank and commercial banks will adjust the interest rate until  $r_{t+1}^B = r_{t+1}^D$ ; If  $r_{t+1}^B < r_{t+1}^D$ , it means that the bank deposit interest rate is lower than the digital currency interest rate of the central bank. People will withdraw the digital currency deposit of the central bank and deposit it in commercial banks. The central bank and commercial banks will adjust the interest rate until  $r_{t+1}^B = r_{t+1}^D$ .

Let  $q_t = s_t + m_t$ .  $q_t$  is the total savings rate of each representative adult, so equations (1) and (2) are transformed into:

$$I_L \equiv (1 - \tau)w_t = c_t + q_t \quad (3)$$

$$I_R \equiv \phi c_{t+1} = q_t + (1 - \tau)r_{t+1} q_t \quad (4)$$

By integrating equation (3) and equation (4), assuming that  $\rho \in (0,1)$  measures the intertemporal time preference of representative individuals, the intertemporal utility function of representative individuals is:

$$U(c_t, c_{t+1}) = \ln c_t + \rho(1 + \alpha_t)\phi \ln c_{t+1} \quad (5)$$

Under the constraints of equation (3) and Equation (4), the optimal total personal saving rate  $q_t^*$  can be obtained by taking the maximum value  $U(c_t, c_{t+1})$ :

$$q_t^* = \frac{\phi \rho}{1 + \phi \rho} (1 - \tau)w_t \quad (6)$$

After a simple derivation of (6), it can be concluded  $\frac{\partial q_t^*}{\partial \phi} > 0$  which means that that population aging plays a role in promoting the optimal savings rate, because when rational actors are aware of changes in population structure, they will proactively increase savings and improve their pension income

in anticipation of a rainy day, which is also the source of inducing the "second demographic dividend".

Compared with those without the digital currency of the Central bank, the original optimal bank saving rate  $s_{told}^*$  without the digital currency of the Central bank can be obtained by calculation similar to the above:

$$s_{told}^* = \frac{\phi\rho}{1 + \phi\rho}(1 - \tau)w_t \quad (7)$$

It can be found that  $s_{told}^* = q_t^*$  which means the issuance of central bank digital currency will not change the optimal steady-state savings rate. When the digital currency of the Central Bank is used as a payment tool, it is equivalent to the variation of various traditional payment tools and is limited to the closed scenario of inter-bank payment, then its impact on the money supply is "neutral" and will not have too much impact on monetary policy and macro economy.

### B. The Enterprise

Suppose there is a market of  $N$  perfectly competitive homogeneous enterprises, each enterprise  $i$  producing with physical capital  $K_{it}$  and labor force  $L_{it}$ . Labor productivity  $h_t$  represents the level of technological progress. On the one hand, physical capital  $K_t$  promotes technological progress through "doing learning". On the other hand, the role of labor force  $H_t$  in promoting technological progress is self-evident, so  $h_t$  depends on labor force  $H_t$  and physical capital  $K_t$ .

Due to the issuance of central bank digital currency, on the one hand, it will expand the balance sheet of the central bank, release liquidity, influence the overnight lending rate through the interest rate corridor mechanism, and finally form a loose monetary policy, thus reducing the financing cost of enterprises. The rising money supply will stimulate the capital market and increase the value of enterprises, which will increase Tobin's Q value. That is, enterprises are more inclined to issue stocks to increase investment than to purchase new assets. At the same time, as the integration of fiat digital currency with other broader financial infrastructure helps to save costs and increase efficiency, all of these will increase the physical capital investment of enterprises. Therefore, this paper assumes that due to the issuance of digital currency, the physical capital of each enterprise  $i$  changes to  $(1 + \pi)K_{it}$ , and

$$\pi = \chi - \gamma\phi \quad (8)$$

$\chi \in (0,1)$  represents the total proportion of enterprise physical capital input increased due to the issuance of digital currency of the central bank;  $\gamma > 0$  means an ageing population for a central bank to digital currency increase enterprise physical capital investment effect coefficient, because the old digital currency compared to the central bank deposits are more likely to tend to bank deposits, digital currency will lead to a certain extent, central bank liquidity decreases, inhibition by issuing central bank digital currency and increase enterprise material capital investment to promote role;  $\pi$  represents the net percentage of increased corporate physical capital investment due to the issuance of central bank digital currency. The output of the enterprise  $Y_{it}$  can be expressed as:

$$Y_{it} = [(1 + \pi)K_{it}]^\omega (h_t L_{it})^{1-\omega} \quad (9)$$

And

$$h_t = \frac{[(1 + \pi)K_t]^\beta H_t^{1-\beta}}{L_t} \quad (10)$$

$\omega \in (0,1)$  reflects the share of physical capital and human capital in the production function, while  $\beta \in (0,1)$  measures the contribution of two types of technological progress to labor productivity. Enterprises pursue profit maximization, which can be calculated as follows:

$$r_{it} = \omega(1 + \pi)^\omega K_{it}^{\omega-1} (h_t L_{it})^{1-\omega} \quad (11)$$

$$w_{it} = (1 - \omega)[(1 + \pi)K_{it}]^\omega h_t^{1-\omega} L_{it}^{-\omega} \quad (12)$$

### C. The Government

Considering the aging of population, the fiscal expenditure affecting economic growth is mainly public education expenditure and health security expenditure. This paper divides the fiscal expenditure into public education expenditure  $H_t^E$  and health security expenditure  $H_t^M$ . It is set as tax rate  $\tau$  and  $\Phi$  is the proportion of health care expenditure in fiscal expenditure. With a balanced budget, government revenue  $I_G$  faces the following constraints:

$$I_G \equiv \tau Y_t = H_t^E + H_t^M \quad (13)$$

And

$$H_t^M = \Phi \tau Y_t \quad (14)$$

$$H_t^E = (1 - \Phi)\tau Y_t \quad (15)$$

Therefore, macro-control fiscal policy has two tools: one is to adjust the scale of fiscal expenditure by changing the tax rate  $\tau$ ; the other is to adjust the structure of fiscal expenditure by changing the proportion of health security expenditure  $\Phi$ .

If the current human capital stock  $H_{t+1}$  is divided into public education expenditure  $H_t^E$  and human capital stock  $H_t$  in the early stage, then public education expenditure reflects the incremental change of human capital stock[13]. At the same time, it is assumed that health security expenditure  $H_t^M$  affects the human capital stock  $H_t$  by reducing the depreciation rate  $\delta_t$  of the human capital stock in the early stage. Therefore, public education expenditure and health security expenditure have "flow effect" and "stock effect" on human capital accumulation respectively. Following Evangelos (2007) and considering the impact of population aging on human capital depreciation, we define the relationship between public education, health care expenditures and human capital as follows:

$$H_{t+1} = \theta H_t^E + (1 - \delta_t)H_t \quad (16)$$

And

$$\delta_t = \varepsilon \frac{H_t^M}{Y_t} + \eta\phi \quad (17)$$

Substituting equation (9) and equation (10) into equation (17), we can get:

$$\delta_t = \varepsilon\Phi\tau + \eta\phi \quad (18)$$



$\theta \in (0,1)$  represents the conversion rate of public education expenditure on human capital flow, while  $\varepsilon < 0$  and  $\eta > 0$  represent the influence coefficients of health security expenditure and population aging on human capital depreciation rate respectively. It can be seen from equation (16) and Equation (17) that although public education expenditure and health security expenditure are both beneficial to human capital accumulation, they have different ways of influencing human capital accumulation: On the one hand, public education expenditure mainly increases the flow of human capital without affecting the existing stock of human capital, while health security expenditure mainly promotes the accumulation of human capital by reducing the depreciation rate of human capital.

### III. THE RESULTS AND INTERPRETATION

#### A. Market Clearing and Dynamic Equilibrium

In a perfectly competitive market, when there are  $N$  adults, each individual solves the problem of maximizing intertemporal effects, each enterprise pursues profit maximization, and the total supply and demand of the market is balanced, the capital market and labor market clear:

$$K_{t+1} = q_t N_t \tag{19}$$

$$\sum_1^{L_t} L_{it} = L_t = N_t \tag{20}$$

Using the above equation, the growth rate of physical  $g_{tK}$  and human capital  $g_{tH}$  can be calculated:

$$g_{tK} \equiv \frac{K_{t+1} - K_t}{K_t} = \tag{21}$$

$$\frac{\phi\rho(1-\omega)(1-\tau)(1+\pi)^v \left(\frac{H_t}{K_t}\right)^{1-v}}{1+\phi\rho} - 1$$

$$g_{tH} \equiv \frac{H_{t+1} - H_t}{H_t} = \tag{22}$$

$$\theta(1-\Phi)\tau(1+\pi)^v \left(\frac{H_t}{K_t}\right)^{-v} - \varepsilon\Phi\tau - \eta\phi$$

Equation (21) is derived from equations (6), (12) and (19), and equation (22) is derived from equations (15) and (16). It can be seen from equation (21) and Equation (22) that both equations contain parameters representing population aging and digital currency. Therefore, digital currency has an impact on the accumulation of both physical capital and human capital. According to equations (9) and (10), the economic growth rate is actually determined by the growth rate of physical capital and human capital. From the formation of equations (21) and (22), it can be found that if  $g_K$  and  $g_H$  are not equal, then  $\left(\frac{H_t}{K_t}\right)$  will tend to 0 or  $+\infty$ , which makes  $g_K$  and  $g_H$  unable to achieve balanced growth. Therefore, in order to keep the economy on a balanced growth path, the economic growth rate must be  $g = g_K = g_H$ , so as to eliminate the difference between the return on investment of physical capital and human capital. After simple deduction of equations (8), (21) and (22), it can be obtained:

$$\frac{\partial g_K}{\partial \pi} > 0 \tag{23} \qquad \frac{\partial g_H}{\partial \pi} > 0 \tag{24}$$

$$\frac{\partial g_K}{\partial \phi} < 0 \tag{25} \qquad \frac{\partial g_H}{\partial \phi} > 0 \tag{26}$$

$$\frac{\partial g_K}{\partial \tau} < 0 \tag{27} \qquad \frac{\partial g_H}{\partial \tau} > 0 \tag{28}$$

Equation (23) and (24) reflects the issuing bank digital currency by influencing the physical capital investment which has a dual role on economic growth, accelerate the accumulation of physical capital and human capital accumulation, give attention to two or more things issuing bank digital currency impact on China's banking system and financial structure controlled, long-term environment contributes to economic growth. Equation (25) and (26) reflects the population aging has a dual effect on economic growth, because of the elderly live longer give young people the chance bequest income fell sharply, so much so that more than the savings increased life expectancy effect, resulting in a decline in output stable investment proportion and hinder the accumulation of physical capital, Inhibit economic growth; Second, it will accelerate the accumulation of human capital and promote economic growth, which is also in line with previous research results. Equations (27) and (28) reflect that the scale of fiscal expenditure also plays a dual role in economic growth. First, it accelerates the accumulation of human capital and promotes economic growth. Second, it will hinder the accumulation of physical capital and inhibit economic growth.

#### B. The Balanced Growth Policy

As  $\tau$  and  $\Phi$  are two major policy tools for government regulation and control, and  $\left(\frac{H_t}{K_t}\right)$  are also important variables restricting economic growth, the fiscal policies to ensure balanced growth can be obtained from the following equation:

$$\max g \left( \tau, \Phi, \frac{H_t}{K_t} \right) = \tag{29}$$

$$\frac{\phi\rho(1-\omega)(1-\tau)(1+\pi)^v \left(\frac{H_t}{K_t}\right)^{1-v}}{1+\phi\rho} - 1$$

Which the constraint conditions are as follows:

$$\frac{\phi\rho(1-\omega)(1-\tau)(1+\pi)^v \left(\frac{H_t}{K_t}\right)^{1-v}}{1+\phi\rho} - 1 = \tag{30}$$

$$\theta(1-\Phi)\tau(1+\pi)^v \left(\frac{H_t}{K_t}\right)^{-v} - \varepsilon\Phi\tau - \eta\phi$$

Then , construct the Lagrange equation:

$$\ell\left(\tau, \Phi, \frac{H_t}{K_t}\right) = \frac{\phi\rho(1-\omega)(1-\tau)(1+\pi)^v}{1+\phi\rho} \left(\frac{H_t}{K_t}\right)^{1-v} + \lambda \left[ \frac{\phi\rho(1-\omega)(1-\tau)(1+\pi)^v}{1+\phi\rho} \left(\frac{H_t}{K_t}\right)^{1-v} - 1 - \theta(1-\Phi)\tau(1+\pi)^v \left(\frac{H_t}{K_t}\right)^{-v} + \varepsilon\Phi\tau + \eta\phi \right] \quad (31)$$

And take the first derivative of  $\tau$ ,  $\Phi$  and  $\left(\frac{H_t}{K_t}\right)$  can be obtained:

$$-(1+\lambda) \frac{\phi\rho(1-\omega)(1+\pi)^v}{1+\phi\rho} \left(\frac{H_t}{K_t}\right)^{1-v} = \lambda[\theta(1-\Phi)(1+\pi)^v \left(\frac{H_t}{K_t}\right)^{-v} - \varepsilon\Phi] \quad (32)$$

$$\left(\frac{H_t}{K_t}\right)^{-v} = -\frac{\varepsilon}{\theta(1+\pi)^v} \quad (33)$$

$$(1+\lambda) \frac{\phi\rho(1-\omega)(1-\tau)(1+\pi)^v}{1+\phi\rho} \left(\frac{H_t}{K_t}\right) = -\lambda\nu\theta(1-\Phi)\tau(1+\pi)^v \quad (34)$$

Substitute equation (33) into equation (32) to obtain:

$$-(1+\lambda) \frac{\phi\rho(1-\omega)(1+\pi)^v}{1+\phi\rho} \left(\frac{H_t}{K_t}\right) = \lambda\theta \quad (35)$$

Substitute equation (35) into equation (34) to obtain:

$$\tau = \frac{1-\nu}{1+\nu(1-\Phi)(1+\pi)^v - \nu} \quad (36)$$

So

$$\frac{\partial\tau}{\partial\Phi} > 0 \quad (37)$$

By integrating equations (25) to (28) and (37), we can get the conclusion of the theoretical model:

In a balanced growth path, if  $\frac{\partial g}{\partial\phi} > 0$ , then  $\frac{\partial g}{\partial\tau} < 0$  and  $\frac{\partial g}{\partial\Phi} < 0$ ; If  $\frac{\partial g}{\partial\phi} < 0$ , then  $\frac{\partial g}{\partial\tau} > 0$  and  $\frac{\partial g}{\partial\Phi} > 0$ .

This is because if the growth effect of population aging on human capital accumulation is greater than its hindrance effect on physical capital accumulation, then the growth rate of human capital will be faster than the growth rate of physical capital. In order to achieve balanced economic growth, the government needs to reduce tax rates and fiscal spending to restrain the growth of human capital. At this time, the overall economy is in a relatively large state of human capital stock, so compared with human capital stock, the primary purpose of public finance is to increase human capital flow. So the government should spend less on health care and more on public education. If the growth effect of population aging on human capital

accumulation is not enough to offset its hindrance effect on physical capital accumulation, then the growth rate of human capital will be slower than that of physical capital. In order to achieve a balanced economic growth, the government needs to raise tax rates and increase the scale of fiscal expenditure to promote the growth of human capital and restrain the growth of physical capital. At this time, the overall economy is in a relatively small state of human capital stock, so the primary purpose of public finance is to maintain the only human capital stock, rather than increase human capital flow. Therefore, the government should increase the proportion of investment in the field of health security.

#### IV. THE CONCLUSIONS AND POLICY RECOMMENDATIONS

As of 2019, the number of people aged over 60 in China reached 250 million, accounting for 18% of the country's total population, and will enter moderate aging during the 14th Five-Year Plan period. Population aging will lead to expected economic slowdown, lower long-term real interest rates (Barro et al., 1995) and weaker monetary policy effectiveness (Schultz, 1997). This paper discusses the impact of population aging and central bank digital currency on economic growth by establishing an extended overlapping generation model and introducing central bank digital currency. The research finds that: (1) When the central bank's digital currency is used as a payment tool, it has a "neutral" impact on the money supply, thus confirming the results of previous studies; (2) Issuing central bank digital currency accelerates physical capital accumulation and human capital accumulation by influencing physical capital investment, which contributes to economic growth; (3) After the introduction of central bank digital currency, population aging can promote human capital accumulation, but hinder physical capital accumulation at the same time. When the increasing effect of population aging on human capital accumulation is greater than its hindering effect on physical capital accumulation, the government should reduce tax rate and increase the proportion of public education expenditure. When the growth effect of population aging on human capital accumulation is not enough to offset its hindering effect on physical capital accumulation, the government should increase the tax rate and reduce the proportion of public education expenditure, but increase the proportion of investment in the field of health security. Based on the above conclusions and previous research results, this paper puts forward the following policy recommendations:

##### A. Advance Financial Reform and Broaden the Transmission Channels of Monetary Policy

Population aging, to some extent, will lead to tightening of policy control space in China, increase the cost of policy implementation and weaken the stimulus effect of monetary policy on the economy (Li Hongjin et al., 2016). China should accelerate the financial reform, make full use of digital currency and other emerging financial tools of the central bank, build a sound transmission mechanism of monetary policy and interest rate, broaden the transmission channel of monetary policy, and further play an important role of interest rate in the allocation of financial resources.

The relationship between the central bank and commercial banks is guidance, coordination, supervision and inspection. After the central bank issues digital currency, social deposits will be easily transferred to the central bank, resulting in commercial banks becoming "narrow banks"(Li Jianqiang et al., 2018). The key to solve this hidden danger lies in eliminating deposit competition. The central bank could try to force non-bank institutions and individuals to link their digital currencies to commercial banks, in which the money in a digital wallet is equivalent to a zero-interest deposit in a commercial bank. This not only maintains the existing relationship between the central bank and commercial banks, but also does not affect the liquidity creation of commercial banks, and eliminates commercial banks' concerns about the digital currency of the central bank. At the same time, the central bank can carry out incentive assessment on the digital currency affiliation of commercial banks to stimulate the enthusiasm of commercial banks in promoting the digital currency of the central bank.

#### *B. Adjust the Economic Structure and Stick to the Basic Direction of Monetary Policy*

In an aging society, demand and supply are relatively insufficient. On the demand side, the increase in domestic and international life expectancy will lead households to reduce consumption and increase savings, which will restrain the growth of domestic and external demand. On the supply side, the increase in the number of elderly people increases the pressure on the government's health protection, which to some extent reduces the capital investment for real enterprises. Therefore, China should actively promote the reform of supply side structural, adjust the economic structure, at the same time adhere to the "overall sound" and "targeted easing" of the basic direction of monetary policy, supplemented by the central bank financial tools such as digital currency, continuously break through barriers to technology, meet people's growing material and cultural needs and promote the effectiveness of monetary policy regulation.

From the date when the central bank's digital currency is issued, the monetary system will shift from one yuan to a dual system. The financial system may suffer from the negative impact of digital currency with many new features, so it is suggested that the central bank focus on building a digital currency data center, so as to closely monitor the impact and impact of digital currency on the financial system. Data center is the heart of financial institutions' business operation, and also the front line of financial information system and network security. Strengthening the establishment of data centers will be of great significance for stabilizing the foundation of the financial system, consolidating the diversified development of the economy, deepening the reform of digital currency and ensuring the smooth operation of financial services. The focus of the data center should be on China's currency structure, currency circulation speed, credit money creation of commercial banks and the operational efficiency of financial infrastructure.

#### *C. Ensure Privacy Security and Strengthen Risk Prevention and Control of Digital Currencies*

As an emerging financial tool, security measures are particularly important for central bank digital currency. In practical application, the digital currency of central bank should be integrated with the existing financial system and apply modern technologies such as distributed ledger technology (DLT) to achieve the high degree of security demanded by consumers, and do a good job of risk control while innovating. At the same time, great attention should be paid to privacy protection and efforts should be made to achieve similar features to traditional paper money, that is, banks and merchants cannot track the transaction history and use of the central bank's digital currency without the willingness of the currency holder. In order to establish sufficient organizational and institutional guarantee, it is suggested that the People's Bank of China take the lead in establishing a multi-department joint leading group of digital currency promotion of the Central Bank to clarify the progress, determine the division of labor, and coordinate overall to ensure that the promotion of digital currency is carried out in an orderly manner.

It is suggested that special fiscal and tax policies be issued to support the issuance and circulation of digital currency by fully mobilizing and utilizing the support from all sectors of society and policies. For example, government departments and public institutions are required to choose central bank digital currency or open digital currency service channels when providing services related to capital transactions to the public. Exemption or preferential treatment shall be given to taxable activities involving digital currency production and operation. The People's Bank of China has established a digital currency risk monitoring mechanism, and established a digital currency risk monitoring group to clarify regulatory responsibilities, implement regulatory powers, and standardize the market application of digital currencies. Prepare digital currency risk contingency plans, in a financial storm impact or digital money market disorder, give full play to the function of digital currency risk watchdog group, digital currency application of rules and regulations, timely fill a hole in its market risk, protect the country and the people's property security, stability of financial system, the prevention and control financial risks.

We will guard against risks to financial stability, prevent a run on commercial banks, and strengthen liquidity management. In view of the possible risk of "run" in extreme situations during the conversion of bank deposits into DC/EP, before the official launch of DC/EP, China's relevant legislation and regulatory authorities should set up multiple layers of "friction" in the DC/EP conversion process by issuing new or revising existing cash management norms. We will further improve the reservation system for exchanging physical and electronic money into DC/EP, limit large-denominant exchange and other normative requirements, strengthen the liquidity management of commercial banks, ensure the stability of the financial system, and prevent the occurrence of risk events such as "Run".

#### REFERENCES

- [1]. [1]Romer P. "Increasing Returns and Long-Run Growth", *Journal of Political Economy*, 1986, 94(5), 1002-1037.
- [2]. [2]Lucas R."On the Mechanics of Economic Development", *Journal of Monetary Economics*, 1988, 22(1), 3-42.

- [3]. [3]Geng Zhixiang, Sun Qixiang, Zheng Wei."Aging Population Asset Price and Capital Accumulation", *Economic Research Journal* , 2016,(9):29-43.
- [4]. [4]Wang Wei."Population Aging, Fertility Policy Adjustment and China's Economic Growth",*China Economic Quarterly*, 2016,16(1):67-96
- [5]. [5]Sala X., G. Doppelhofer, and R. Miller."Determinants of Long-term Growth: a Bayesian Averaging of Classical Estimates(BACE) Approach", *American Economic Review*,2004, 94(4), 813-835.
- [6]. [6]Li H., J. Zhang, and J. Zhang."Effects of Longevity and Dependency Rates on Saving and Growth: Evidence from a Panel of Cross Countries", *Journal of Development Economics*,2007, 84(1), 138-154.
- [7]. [7]Fang Xiancang, Zhang Weifeng."Population Aging and Monetary Policy: Progress and Policy Implications", *Journal of Shanghai University of Finance and Economics*, 2019,21(1),28-50.
- [8]. [8]Wang Yongli."Significance of Central Bank Digital Currency",*China Finance* , 2016,(08)19-20.
- [9]. [9]Yao Qian."Analysis of the Economic Effect of Legal Digital Currency: Theory and Evidence",*Financial Theory and Policy*, 2019,1,16-27.
- [10]. [10]Zhang Guosen."Central Bank Digital Currency Exploration and Its Impact on Monetary Policy",*Contemporary Economics*, 2020,9,53-55.
- [11]. [11]Yao Qian, Li Liansan."Application of Big Data Analysis in Digital Currency".*China Finance*, 2016,(17),13-15.
- [12]. [12]Sheng Songcheng, Jiang Yile."Why Do Monetary Authorities Issue Central Bank Digital Currencies". *Tsinghua Financial Review*, 2016,(12),61-64.
- [13]. [13]Xu Zhong, TANG Yingwei, Lin Xue."A Theoretical Discussion on Central Bank Digital Currency".*China Finance*, 2016,(17),33-34.
- [14]. [14]Shi Xinjie, Wei Longbao, Fang Shile, Gao Xuwen."China Has Unequal Opportunities in Income Distribution",*Management World*, 2018,(3),27-37.
- [15]. [15]Li Ying, Lv Guangming."Study on the Generating Sources and Functional Channels of Opportunity Inequality in China",*China Industrial Economics*, 2019,(9),60-78.
- [16]. [16]Fan Yifei."Theoretical Basis and Framework Selection of China's Legal Digital Currency",*China Financ*, 2016,(17),10-12.
- [17]. [17]Liu Xiangmin."Legal Issues of Issuing Digital Currency by the Central Bank",*China Financ*, 2016 ,(17),17-19.
- [18]. [18]Jiang Ouxiang, Zhang Leilei, Liu Dezheng."Bitcoin, Libra, Central Bank Digital Currency Roundup",*Financial Technology Time*, 2020,(02),57-68.
- [19]. [19]Liu Qiongzhi, He Qi."Population Aging, Economic Growth and Fiscal Policy",*China Economic Quarterly*, 2012,12(1),119-134.
- [20]. [20] Evangelos V."On the Macroeconomic Implications of Population Aging for Health and Education Policies", *Explorations in Health Economics Paper*, iHEA 6th World Congress, 2007.
- [21]. [21] Barro R., N. Mankiw, and X. Sala."Capital Mobility in Neoclassical Models of Growth", *American Economic Review*, 1995, 85(1), 103-115.
- [22]. [22]Schultz T."Assesing the Productive Benefits of Nutrition and Health: An Integrated Capital Approach", *Journal of Econometrics*, 1997, 77(1), 141-158.
- [23]. [23]Li Hongjin, Su Naifang, Hong Hao."Real Interest Rate Anchor in Price - based Monetary Policy Control", *Economic Research Journal*, 2016,(1),42-54.
- [24]. [24]Li Jianqiang, Zhang Shucui."Does Population Ageing Affect the Effectiveness of Fiscal and Monetary Policy?", *Journal of Finance and Economics*, 2018,(7),16-32.