Population aging and inequality: evidence from China

Abstract

Population aging has significant economic and social costs, and this paper studies its impacts on inequality, both theoretically and empirically. First, we build a two-period overlapping generation (OLG) model with uncertain lifetime, and find that population aging has the overall effect of increasing income and consumption inequality within the society. For empirical analysis, we use household data from China Health and Nutrition Survey (CHNS) to assess the age effect on income and consumption inequality in China, and confirm the results predicted by the theoretical model.

Keywords: Population aging, income inequality, consumption inequality, overlapping generation model

I. Introduction

Population aging has become a major concern in many countries, mainly due to its accompanying economic and social costs. According to the United Nation's population projections, around 600 million people aged 65 or older are alive today, and by 2035 this figure is expected to exceed 1.1 billion, or 13% of the total population. This is a natural corollary of declining birth rate and growing life expectancy. The "old-age dependency ratio," i.e. the ratio of old people (aged 65 or above) to labor force (aged 15-64), will grow even faster. From 1960 to 2015, this ratio for the world population has increased more than 46%, from 8.611 to 12.338.[1] By 2050, this ratio is expected to increase to 25, while in rich countries it will be much higher. Japan will have 73 old-age people for every 100 work-age people by 2050, up from 35 in 2010.[2] Although the developing countries have benefited from young population structure, they now start to struggle with aging population as the fertility rates fall below the natural replacement level. For example, over the same time period the old-age dependency rate in China will more than double from 15 to 36, while Latin America will see a shift from 14 to 27 (The Economist, 2014).

Theoretically, the distributional effect of population aging triggered by low birth rate and high life expectancy can be explained through several channels. First, Friedman (1957)'s Permanent Income Hypothesis (PIH) and Modigliani (1966)'s Life Cycle Theory both predict that consumption and income dispersion for any cohort of people born at the same time should increase with age because an individual's income and consumption are affected by their own history of education, employment, health, idiosyncratic luck, family background, etc. Under PIH framework, Eden (1980) proposes that the variance of

[1] Data source: The World Bank. http://data.worldbank.org/indicator/SP.POP.DPND.OL
[2] Data source: The Economist. http://www.economist.com/node/13611235

consumption should increase over time within cohorts. The statistical evidence presented by Deaton and Paxson (1994a) shows that income inequality tends to increase with age in Taiwan, Great Britain, and the United States. Slower population growth, by raising the average age of the population, should raise aggregate inequality through this channel. Second, Higgins and Williamson (2002) suggest that slower population growth tilts the population age distribution toward mature, more experienced cohorts, possibly reducing the experience premium, and hence moderating aggregate inequality. Third, as stated by Bussolo, Koettl, and Sinnott (2015), "low or even negative population growth would increase wages relative to returns to capital. Since ownership of capital assets tends to be concentrated, this change in relative factor returns could reduce income inequality. Furthermore, capital holders, usually older people, are likely to lose while young workers gain."

Existing empirical studies have explored this relationship mainly within high income economies. Some findings suggest that population aging accounts for only a small fraction of overall increase of income inequality (e.g., Barrett, Crossley, and Worswick, 2000; Bishop, Formby, and Smith, 1997). Several studies show that aging population affects income inequality through public transfer systems, though empirical evidence is mixed. Gruber and Wise (2001) analyse the OECD data and conclude that aging has led to a decline in the share of resources going to the elderly; similarly, Razin et al. (2002) show that a rise in the overall dependency ratio leads to a decline in social transfers. In contrast, Preston (1984) contends that the elderly in the US can claim a disproportionate share of public resources as their number and political power grow. An increasing number of research focuses on exploring the linkage between aging population and inequality from the perspective of PIH. Storesletten et al. (2004) explore the US case, suggesting that age effects in income and consumption inequality within cohort are consistent with the theoretical predictions of an overlapping-generation general equilibrium model in which households face uninsurable earnings shocks throughout their life time. Ohtake and Saito (1998) show that half of the rapid increase in the consumption inequality in Japan during the 1980s results from population aging, while one-third due to the increasing cohort effect. Under PIH framework, there have been a number of new empirical studies that attempt to link changes in consumption inequality in high-income countries to models of partial insurance (e.g., Blundell et al., 2008; Krueger and Perri, 2006). More recently, empirical evidence from developed and aging countries concludes that age groups tend to become more vulnerable and unequal over their life cycle because across people within the same age group, some manage to accumulate more wealth over a longer working life while others risk falling into poverty with limited savings stretched over a longer retirement period (Attanasio and Pistaferri, 2016; Bussolo et al., 2015). Another trend of research has employed the regression-based inequality decomposition approach to examine the role of demographic change on income distribution. Using Taiwanese data, Chu and Jiang (1997) show that the pattern of Gini coefficients is significantly affected by the age composition factor.

Overall, evidence from high income economies is in line with PIH, according to which households can turn to insurance and credit markets to smooth their life time consumption against short-term shocks. However, little is known about situations in developing countries where financial markets are underdeveloped and liquidity constraints are pervasive. The population of East and Southeast Asia is aging rapidly as a consequence of demographic transition, triggered by the increase in life expectancy and aging of post-war baby boomers. If life cycle models are correct, population aging is likely to increase inequality. Whereas this largely mechanical effect may not pose direct threat to welfare, it is important to understand it, even if only to avoid the unnecessary imposition of corrective policies. Kurosaki, Kurita and Ligon (2009) provide evidence that within-cohort inequality in consumption decreases with age in Thailand, Pakistan, and India. However, Rougoor and Van Marrewijk (2015) forecast that global income inequality will reach its lowest level around 2017 and rise thereafter as a result of both economic and demographic forces.

China provides a compelling setting to study this issue for several reasons. Since the market-oriented reforms in early 1980s, China has experienced rapid economic growth, with double-digit annual growth rates for about three decades. However, this process has also been associated with rapid population aging and soaring inequality. Now the second largest economy in the world, China has witnessed its Gini coefficient increased from 0.30 in 1980 to 0.53 in 2010 (Xie and Zhou, 2014), currently among the highest in the world. Despite recent moderate decline in inequality, income distribution in China remains a serious issue, especially in comparison with countries at a similar stage of economic development. High and persistent income inequality can significantly weaken demand, impede growth, induce crises, and erode social cohesion (IMF, 2016; Berg and Ostry, 2011). At the same time, China is rapidly getting older as consequences of family planning policy and increasing life expectancy. The number of people aged over 60 has reached 185 million, or 14% of the total population at the end of 2011.[3] Moreover, its aging process would continue at a remarkable pace for the next few decades. China's Fiscal Policy Report projects that China will become the world's most aged society by 2030; and

[3] The figure is from the website of National Bureau of Statistics, available at http://www.stats.gov.cn/english/newsandcomingevents/t20120120_402780233.htm.

by 2050, the Chinese elderly will increase to 454 million, or 33% of total population (Chinese Academy of Social Sciences, 2010).[4]

Most discussion on inequality in China has been about inequality of income (Wan, Lu and Chen, 2006; Meng, 2004; Meng, Gregory and Wang, 2005), or different components of income. The enlarging income gap has been explained from the perspectives of international trade, property value, and even sociology. For example, Han et al. (2012) investigate the impact of globalization on wage inequality, and find that the WTO accession is responsible for the increase in the wage inequality. Li et al. (2017) find that in China, when inequality is measured by wealth that incorporates housing—rather than by income—it becomes a much more severe concern. Additionally, the work by Xie (2016) from a sociological perspective suggests that inequality in China has been greatly impacted by certain collective mechanisms, such as regions and work units, and that most Chinese view inequality as an inevitable problem accompanying economic growth.

Despite the strong links between demographic trend and inequality, as implied by the life cycle theory, there is still limited evidence of investigation of this topic within the Chinese context. Zhang and Xiang (2014) analyze four rounds of Urban Households' Income and Expenditure Survey (UHIES) data, and claim that aging contributes to around 10 percent of the rising consumption inequality in urban China between 2003 and 2009. Employing three waves of rural household surveys in China Household Income Project (CHIP) for the period of 1988-2002, Qu and Zhao (2008) investigate the consumption inequality between urban and rural households in China, and find that large consumption disparity exists in low income quantiles. Zou, Li and Yu (2013) explore the impact of birth cohort

[4] The elderly in China is defined as the population aged 60 and over by the Chinese government. The data are retrieved from the World Population Prospects, the 2012 Revision. See http://esa.un.org/unpd/wpp/Excel-Data/Interpolated.htm.

on consumption inequality, proxied by the use of electronic appliances, and show that consumption inequality is higher than income inequality in China. Using the China Health and Nutrition Survey (CHNS) data, Zhong (2011) examines the relationship between income inequality and population aging in rural China, and indicates that population aging has recently made a significant contribution to the sharp increase in income inequality in rural China.

In this study, we first build a two-period overlapping generation (OLG) model with uncertain lifetime to theoretically illustrate the overall effects of population aging on income and consumption inequality. In our model, young workers' different levels of productivity leads to income equality within their own age cohort. A young worker also decides on how to allocate his first-period income between consumption and saving, to maximize his life-time utility. For an unskilled old worker, the savings from his young age would be his only source of income (and consumption) in the second period; while a skilled old worker can still get employed and earn a wage, albeit at a discounted rate, to supplement his second-period income (and consumption). We find that population aging has an overall effect of increasing inequality within the society, and also that within the young cohort consumption inequality is higher than income inequality.

For empirical analysis, we employ Deaton and Paxson (1994a)'s approach to examine the age effect on income and consumption inequality in both urban and rural areas by using a dataset constructed from the nine waves of the China Health and Nutrition Survey (CHNS), conducted between 1989 and 2011. We first analyze how income and consumption inequality evolve with age in a period of dynamic economic growth accompanied with rapid population aging. Given the widely acknowledged regional disparity in China, we compare the age effect on inequality in rural and urban areas. We assume that skilled labor concentrate in urban area while labor in rural area are mainly unskilled. Regarding the importance of finance in smoothing consumption and income over the life cycle, we also examine the role of financial development in moderating the income inequality triggered by age effect. To enhance the statistical efficiency, control for changes in household demographics, and examine the impact of finance on inequality, we extend Deaton and Paxson (1994a)'s cohort-level model by conducting regression analysis at the household level. All our empirical findings are consistent with the theoretical predications.

We expand the research frontier by studying the age effect on both income and consumption inequality. The joint analysis of consumption and income inequality are informative in several ways. First, individuals' utility is related more closely with consumption and leisure than income. Several studies (Cutler and Katz, 1992; Johnson and Shipp, 1997; Blundell and Preston, 1998; Pendakur, 1998) have shown that compared to income, consumption is a direct and more accurate measure of welfare and long-term earnings capacity. Second, the difference between consumption and income reflects the efficiency of consumption smoothing mechanism under various credit or insurance arrangements (Attanasio and Pistaferri, 2016; Blundell et al., 2008; Krueger et al., 2010). Third, underreporting of income has been regarded as a serious challenge for household surveys in China because people are widely reluctant to report their income outside of regular jobs, like job-related benefits and "gray" income in particular. In contrast, consumption suffers less from such underreporting problems. By comparing the different dynamics of consumption and income inequality within a same cohort, we can gain insights on factors governing the intertemporal choice of Chinese people.

The rest of this paper is structured as follows. Section 2 presents the theoretical model; section 3 describes the data, construction of key variables and econometric methodology; section 4 shows descriptive statistics and empirical results; and section 5 concludes the paper.

II. Theoretical Model

We use a simple two-period overlapping generation (OLG) model with uncertain lifetime. For simplicity, we assume that each household has one individual person. The level of aptitude, hence productivity, is different among young workers, and is assumed to be exogenously given when born. The number of "skilled" young workers is n, and so is the number of "unskilled" young workers in the economy. Hence, we have a total size of $2n$ young population.

Each young adult born in Period t works during the first period and earns a wage, w_t^i, where $i = s, u$ that represents different types of worker in productivity. We have that:

$$w_t^u = w_t, \tag{1a}$$

$$w_t^s = ew_t, \tag{1b}$$

where $e > 1$ is exogenously given and reflects the productivity advantage on wage. Since we normalize the length of time in each period, the wage is also each individual worker's income during the first period. Naturally, if we wish to measure the degree of income inequality within the young cohort at Period t, we can conveniently use e for that purpose. A larger e indicates a higher degree of income inequality among the young workers.

While young, each adult would give birth to one child that would eventually replace him in the society, hence the size of young population remains constant at $2n$ over time. In this model, we assume that everyone lives a full young adulthood with certainty, while facing a probability of x, where $0 < x < 1$, of surviving into the old age, i.e. there is a probability of $1 - x$ of death at the beginning of the second period. This probability profile $(x, 1 - x)$ is exogenous and common knowledge. Hence, the size of old population in the society is $2xn$, and the total population is $2(1 + x)n$. The ratio of skilled labor to unskilled is at 1:1, for simplicity, within both young and old populations, as we assume that aging and labor productivity are two factors independent of each other. It should be clear that an increase in x represents an overall aging population in the society.

An unskilled old worker will not work in the second period, because his weakened physical condition no longer qualifies him a blue-collar job; as a result, his only income at this stage will come from his young-age savings. A skilled old worker, on the other hand, has the opportunity to take a light, white-collar job and supplement his income. Nonetheless, loss of cognitive ability as well as physical strength associated with aging means that his productivity remains at a fraction of his previous level when he was young. Thus, we have:

$$v_{t+1}^s = \lambda w_{t+1}. \tag{1c}$$

We use v_{t+1}^s to denote the wage of an old skilled worker in Period $t + 1$ (hence, he was a young skilled worker in Period t), where $0 < \lambda < 1$ is exogenously given and indicates his disadvantage competing with young workers on the competitive labor market.

A young worker needs to decide how to allocate his first-period budget/income between consumption and savings, to maximize his life-time utility. Such intertemporal decision making process of a representative young worker in Period t, and his preference, are described by the following utility function:

$$u_t^i = \ln c_t^i + \beta x \ln d_{t+1}^i. \tag{2}$$

For this young worker of type i in Period t, we use c_t^i to denote his consumption in the first period, and d_{t+1}^i his anticipated second period consumption. We factor in two additional considerations: x, the probability of surviving into the second period, and $\beta \in [0,1]$, the usual time discount. The budget constraint of this young worker of type i in Period t is as follows:

$$c_t^i + s_t^i = w_t^i. \tag{3}$$

We further assume that all savings are invested in the financial market, and the gross rate of return for those surviving to old is r_{t+1}/x, where r_{t+1} is the risk-free interest rate in the competitive capital market. The budget constraint for an old agent is therefore:

$$d_{t+1}^u = \frac{s_t^u r_{t+1}}{x}, \tag{4a}$$

$$d_{t+1}^s = \frac{s_t^s r_{t+1}}{x} + v_{t+1}^s. \tag{4b}$$

We now examine the optimization problem faced by the young worker in Period t. Combining (2)(3) and (4a), we first have the following objective function for an unskilled young worker, as follows:

$$\max_{s_t^u} u_t^u = \ln(w_t^u - s_t^u) + \beta x \ln\left(\frac{s_t^u r_{t+1}}{x}\right). \tag{2.u}$$

Deriving the first order condition (FOC), we arrive at the following results:

$$s_t^u = \frac{\beta x}{\beta x + 1} w_t, \tag{5a}$$

$$c_t^u = \frac{1}{\beta x + 1} w_t. \tag{5b}$$

It is straightforward that when β or x increases, c_t^u would decrease while s_t^u would increase, both of which make intuitive sense.

Next, combining (2)(3) and (4b), we have the following objective function for a skilled young worker, as follows:

$$\max_{s_t^s} u_t^s = \ln(w_t^s - s_t^s) + \beta x \ln\left(\frac{s_t^s r_{t+1}}{x} + v_{t+1}^s\right). \tag{2.s}$$

Deriving the first order condition (FOC), we arrive at the following results:

$$s_t^s = \frac{\beta x}{\beta x+1} e w_t - \frac{\lambda w_{t+1}}{(\beta x+1)\frac{r_{t+1}}{x}}, \tag{6a}$$

$$c_t^s = \frac{1}{\beta x+1} e w_t + \frac{\lambda w_{t+1}}{(\beta x+1)\frac{r_{t+1}}{x}}, \tag{6b}$$

If we compare (5b) and (6b), it is easy to see that

$$c_t^s / c_t^u = e + \frac{\lambda w_{t+1}}{w_t} \frac{x}{r_{t+1}}. \tag{7}$$

As long as the economy is growing, the consumption inequality has the following property:

$$c_t^s / c_t^u > w_t^s / w_t^u = e. \tag{8}$$

This result tells us that within the young cohort, consumption inequality is higher than income inequality. There is an intuitive explanation behind it: the unskilled young worker needs to save more today for the future, seeing that there will be no other source of income when he gets old.

As for the old cohort, it should be pointed out that due to the nature of this OLG model with no bequest motive, consumption should always equal income in their second stage, and we have:

$$d_{t+1}^u = \frac{r_{t+1}}{x} \frac{\beta x}{\beta x+1} w_t,$$

$$d^s_{t+1} = \frac{r_{t+1}}{x}\frac{\beta x}{\beta x+1} e w_t + \frac{\beta x}{\beta x+1}\lambda w_{t+1}.$$

We can fairly easily derive that:

$$d^s_{t+1}/d^u_{t+1} = e + \frac{\lambda w_{t+1}}{w_t}\frac{x}{r_{t+1}}. \tag{9}$$

This is not a surprising result in the context of intertemporal framework of making a decision.

The total population of young unskilled workers is n in the economy. The total size of young skilled workers is n as well, which provides a total of en, where $e > 1$, units of unskilled labor equivalent. We also know that skilled old workers in the economy provide a total of $\lambda x n$, where $0 < \lambda, x < 1$, units of unskilled labor equivalent, hence the total stock of labor available in this economy in Period t, for aggregation production, measured in unskilled labor equivalent, is as follows:

$$L_t = (1 + e + \lambda x)n. \tag{10}$$

As for the physical capital market, the total capital stock is funded through savings by young workers, both skilled and unskilled, in the previous stage, as follows:

$$K_{t+1} = n s^s_t + n s^u_t. \tag{11}$$

Conditions (10) and (11) also serve as the factor market clearing conditions when we later solve for the equilibrium in the economy.

Aggregate production is represented by the following Cobb-Douglas production function, on a perfectly competitive output market:

$$Y_t = A K^{\alpha}_t L^{1-\alpha}_t, \text{ where } 0 < \alpha < 1. \tag{12}$$

In this production function, $A > 0$ is the conventional technology level. As the firm rents inputs on perfectly competitive factor markets, where w_t and r_t are the respective factor prices in Period t, the optimization problem for the profit-maximizing firm is as follows:

$$\max_{K_t, L_t} \Pi_t = AK_t^{\alpha} L_t^{1-\alpha} - r_t K_t - w_t L_t \tag{13}$$

We let $k_t = K_t / L_t$ be the capital per worker (measured in unskilled labor equivalent), and have the following two FOCs:

$$w_t = (1-\alpha) A k_t^{\alpha} \tag{14}$$

$$r_t = \alpha A k_t^{\alpha - 1} \tag{15}$$

We now proceed to derive the equilibrium in this economy. Combining (5a)(6a)(10) and (11), we have the following dynamic equation for capital:

$$k_{t+1} = \frac{K_{t+1}}{L_{t+1}} = \frac{1}{1+e+\lambda x}\left(\frac{\beta x(e+1) w_t}{1+\beta x} - \frac{\lambda x w_{t+1}}{(1+\beta x) r_{t+1}}\right).$$

Next, we replace w_t, w_{t+1}, and r_{t+1} with (14) and (15), and have the following equation that represents the law of motion of capital per worker within the economy:

$$k_{t+1} = \frac{1}{1+e+\lambda x}\left(\frac{\beta x(e+1)(1-\alpha) A k_t^{\alpha}}{1+\beta x} - \frac{\lambda x (1-\alpha) k_{t+1}^{\alpha}}{(1+\beta x)\alpha k_t^{\alpha-1}}\right). \tag{16}$$

Assuming perfect foresight, the steady state is defined as follows:

$$k^* = \left(\frac{A(1-\alpha)\alpha(1+e)\beta x}{\alpha + \alpha e + \lambda x + \alpha\beta x(1+e+\lambda x)}\right)^{\frac{1}{1-\alpha}}. \tag{17}$$

We also have:

$$\frac{\partial k^*}{\partial x} > 0, \frac{\partial k^*}{\partial \beta} > 0, \frac{\partial k^*}{\partial e} > 0, \frac{\partial k^*}{\partial \lambda} < 0. \tag{18}$$

A simple proof can be seen in the Appendix. These results make intuitive sense. A longer life expectancy induces higher saving rate, hence higher capital per worker in the economy; similarly, the lower discount rate (i.e. a future value is worth more in present term) provides incentive for higher savings; a higher wage, albeit only to the skilled workers, allows higher savings on average. Of course, if an old skilled worker is expected to get paid more, his incentive to save while young would naturally go down.

Our main interest remains with the income/consumption inequality as well as how it is affected by an aging population in the society. For reporting convenience, we create an inequality index, denoted as Ψ, to measure the degree of income or consumption inequality at different age (young and old) within each cohort, defined as follows:

$$\Psi_{y,inc} = w_t^s / w_t^u, \Psi_{y,con} = c_t^s / c_t^u, \Psi_o = d_{t+1}^s / d_{t+1}^u. \qquad (19)$$

Combining (7)(9)(14) and (15), we have that $\frac{\partial \Psi_{y,con}}{\partial x} = \frac{\partial \Psi_o}{\partial x} = \frac{\partial}{\partial x}\left(e + \frac{\lambda w_{t+1}}{w_t} \frac{x}{r_{t+1}}\right)$, so we have that $\frac{\partial \Psi^*_{y,con}}{\partial x} = \frac{\partial \Psi^*_o}{\partial x} = \frac{\partial}{\partial x}\left(\frac{\lambda}{\alpha A}(k^*)^{1-\alpha} x\right) = \frac{\lambda}{\alpha A}\left(\frac{x(1-\alpha)}{(k^*)^\alpha}\frac{\partial k^*}{\partial x} + (k^*)^{1-\alpha}\right)$. Given (17) and (18), we have that:

$$\frac{\partial \Psi^*_{y,con}}{\partial x} > 0 \, , \frac{\partial \Psi^*_o}{\partial x} > 0.$$

(20)

This result suggests that the consumption inequality within the young population increases when an aging population is anticipated; the overall impact is similar within the old population for both income and consumption inequality.

To sum up results of our theoretical study, we have the following two key findings: (a) consumption inequality is higher than income inequality within the cohort of young workers; (b) an aging population has an overall impact of increasing inequality within the society. These theoretical results are largely in alignment with our empirical findings, presented in the next sections.

III. Data and Empirical Methodology

3.1 Data source and key variables

To investigate the intertemporal choice of consumers and its impact on inequality, an ideal dataset should be a panel data of income and consumption covering a large number of households for long period of time (Blundell, Pistaferri and Preston, 2008; Kurosaki, Kurita and Ligon, 2009). If no such ideal datasets are available, it is imperative to use a repeated cross-section dataset of household income and consumption expenditure covering as many years as possible (Deaton and Paxson, 1994a). In China, several household survey datasets have been used to study inequality, including China Family Panel Study (CFPS), Chinese General Social Survey (CGSS), China Household Income Project (CHIP), Chinese Household Finance Survey (CHFS), China Labor Force Dynamic Survey (CLDS). However, most of them cover very short period of time. For example, the launching years of CGSS, CFPS, CHFS and CLDS are 2003, 2010, 2011 and 2012, respectively. CFPS was launched in 1998, but it is not a longitudinal data and the respondents are different for each round of survey.

The data used in this paper come from an ongoing, open cohort, longitudinal study—China Health and Nutrition Survey (CHNS), a collaborative project by the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety at the Chinese Center for Disease Control and Prevention. Nine waves of survey[5] have been conducted since 1989 on 4,400 households

[5] Those surveys have been completed in 1989, 1991, 1993, 1997, 2000, 2004, 2006, 2009 and 2011, respectively.

with a total of 26,000 individuals in fifteen Chinese provincial units[6] that vary substantially in geography, economic development, public resources, and health indicators. Employing such data that represent a third of the country's population, we are released from the limitation of using data from an otherwise small, geographically restricted region that may be unrepresentative of the larger setting. Moreover, our data cover a long period of 22 years, allowing us to track the development process of inequality and aging population during a period of rapid economic growth in China. Counties in all provinces are stratified by income, and a multistage, random cluster process is then adopted to select four counties out of each province. The sample is made up of 36 suburban neighbourhoods and 108 towns. CHNS respondents are asked questions regarding individual and household demographics, education, health and nutrition, occupations and labor force participation, income, use of health services, housing and asset ownership, time use, etc. The characteristics of the households in the sample are found to be comparable to the national averages. One main advantage of CHNS data is that it provides detailed information about potential sources of household income, including wage income, retirement income, subsidies, earnings from sources of business, farming, fishing, gardening, livestock, and others. It has better coverage of urban subsidies, an important source of income for non-farm self-employment. Moreover, the longitudinal master files created by CHNS facilitate us to trace the evolution of respondents' income and consumption over time. In addition, CHNS data have a good number of overlapping cohorts across rounds, a great advantage in estimating age effects on inequality. Figure 1 plots the population pyramid of CHNS sample by age for the four

[6] The survey started with the nine provincial units of Liaoning, Heilongjiang, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi, and Guizhou in 1989. Three mega cities of Beijing, Chongqing, and Shanghai have joined this cohort since 2011. Three more provinces of Shaanxi, Yunnan, and Zhejiang have joined since 2015.

years of 1989, 1997, 2006 and 2011, and it clearly indicates the rapid process of population aging in China in the last three decades.[7]

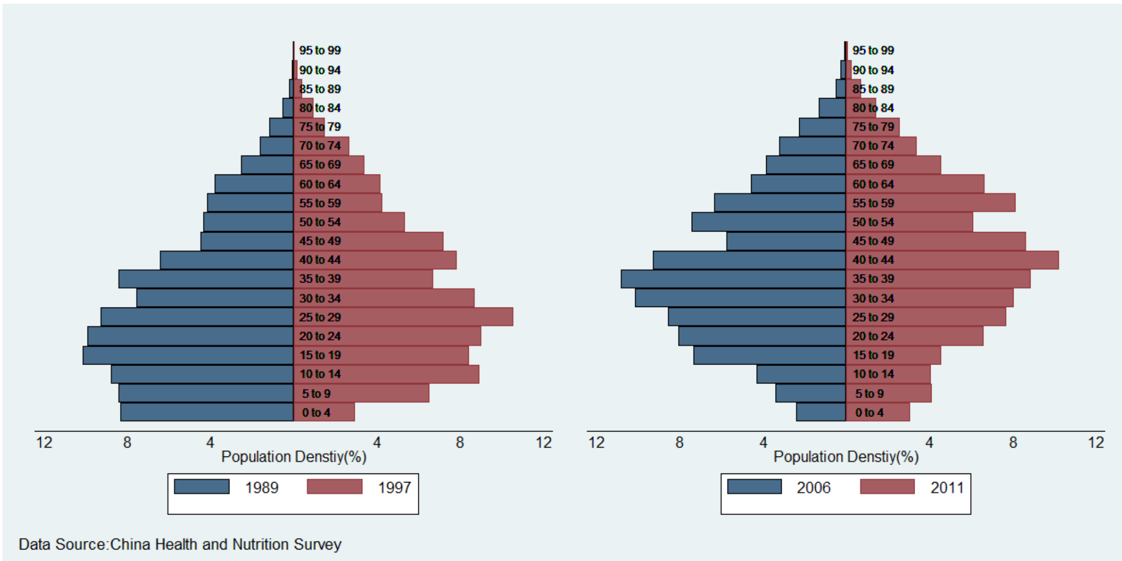


Figure 1 Population distribution by age in China, 1989-2011

However, CHNS does not contain data of nondurable consumption like expenditure on food (Benjamin et al., 2007). Hence, we pay special attention to the inequality of consumption on durable goods including electronic appliances and means of transportation. Consumption of durable goods is important in thoroughly assessing consumption inequality since it accounts for a large share of household expenses. While consumption categories involving small and infrequent purchases are more vulnerable to poor reporting, large expenses on durable goods are often reported sufficiently well. In addition, durable consumption relies heavily on the liquidity facilitated through

[7] To understand the representativeness of CHNS data, we compare the age distribution figures of CHNS in the years of 1989, 1997, 2006 and 2011 with those of China Census data in the years of 1989, 1990, 2000 and 2010 and find that the population pyramid of CHNS data is close to that of the census data and our analysis shall be able to reflect the real situation in China. The population pyramid of China Census data is available upon request.

financial institutions. Mckenzie (2005) shows that in the absence of household consumption data, household ownership of certain durable assets can be a reasonable proxy for inequality in living standards. Using Mexican data, he proves that inequality measured with asset indicators can predict the non-durable consumption inequality very well. Employing two alternative sources of data, Hassett and Mathur (2012) find that the trend of inequality measured on nondurable consumption is comparable to inequality measured on durable consumption in the US.[8]

To construct variables to be used in this study, we first select households that have valid and complete information on income, durable consumption, and are aged between 20 and 75. We then collect information on the household heads' age, gender, educational attainment, employment status, in addition to the household total disposable income, value of durable goods, household registration (*hukou*) status, province of residence, etc. Real income per capita for each household is calculated as the ratio of total net household income to the number of household members, adjusted by the consumer price index of 2011.[9] CHNS survey includes detailed information on the stock and current value of electronic appliances and means of transportation owned by each household.[10] Similarly, we compute the per capita real consumption of durables as the ratio of total value of

[8] Hassett and Mathur (2012) compute inequality on nondurable consumption with data from the Consumer Expenditure Survey (CEX) which provides a continuous and comprehensive flow of data on the buying habits of American consumers and contains detailed expenditure data on small and frequently purchased items such as food. They calculate inequality on durable consumption with data from the Residential Energy Consumption Survey which includes questions on household use of appliances such as microwaves, dishwashers, computers, and printers.

[9] The total net household income is the summation of net income from household business, farming, finishing, gardening, livestock, subsidies, pension, wage, and other sources.

[10] The electronic appliances listed in CHNS survey questionnaire include VCR, TV set, washing machine, refrigerator, air conditioner, sewing machine, electric fan, computer, camera, microwave oven, electric rice cooker, pressure cooker, telephone, cell phone, VCD or DVD, and satellite dish, while the means of transportation includes tricycle, bicycle, motorcycle, and automobile. In the survey, the respondents are asked questions such as "Does your household own this type of appliance/transportation?", "How many are owned?" "What is the total value of appliance/transportation?".

durable goods to the number of household, adjusted with the consumer price index of 2011.

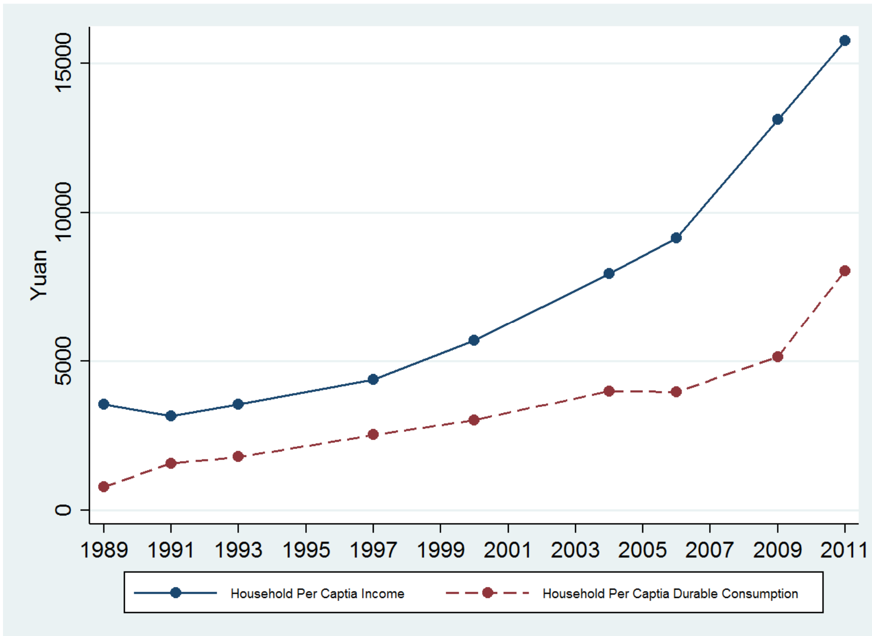


Figure 2 Income vs. durable consumption in China, 1989-2011

Figure 2 plots the growth paths of household income and durable consumption in China during the years of 1989-2011. Real income increased from 3528 yuan to 15933 yuan, while durable consumption grew considerably from 741 yuan to 8270 yuan. In terms of trend, the household income and durable consumption moved in tandem up to around 2004, but the gap seems widened thereafter.

3.2 Methodology

To assess the age and cohort effects on inequality, we construct age dummies for those household heads aged between 20 and 75. The dummy variable for the youngest group is dropped to avoid the multicollinearity among age dummies. Based on the birth year or age of respondents in 1989, we define cohort dummies based on 5-year age bands, i.e. 1920-24, 1925-29, 1930-34, 1935-39, 1940-45, 1946-49, 1950-54, 1955-59, 1960-64, 1965-69, 1970-74, respectively. Given age and time of survey, cohort is determined as b=a−t+1989, where a represents age and t represents the year of survey. Similarly, the dummy variable for the youngest cohort is dropped to avoid multicollinearity among cohort dummies.

We employ the variances of log consumption and log income as the main measures of inequality, a method that has been widely adopted (Deaton and Paxson, 1994a; Ohtake and Saito, 1998). With a dataset running for 22 years, we are able to observe earnings and consumption for a range of different cohorts and separate cohort effect from age effect. Following Deaton and Paxson (1994a), we estimate the household-level model as follows:

$$(logI_{ict} - log\bar{I}_{ct})^2 = \sum_c \alpha_c Cohort_{ic} + \sum_n \beta_n Age_{ict} + \gamma X_{ict} + \varepsilon_{ict}, \tag{21}$$

where $log\bar{I}_{ct}$ is the logarithm value of the average per capita real income or durable consumption for cohort c in year t, and $Cohort_c$ and Age_n are the cohort and age dummies respectively. In this regression, the coefficients α_c reflect the cohort effect, while the coefficients β_n represent age effect and trace the evolution of within-cohort inequality over the life time. X_{ict} is a vector of control variables that describe household *i*'s characteristics in year *t*, such as the gender of the household head or the size of the household. By including X_{ict}, we can directly control for the changes in household demographic features and sampling design of each survey so as to achieve the gains in statistical efficiency. Table 1 provides the summary statistics of key variables.

Table 1. Summary statistics of key variables

Variables	Defination	Obs	Mean	Std.Dev	RSD	Min	Max
Income	Household income per capita	27812	7892.82	9210.35	1.17	174.85	79066.27
Durables	Household durables per capita	27812	3633.51	8162.48	2.25	25.77	101683.30
hhsize	Household size	27812	3.67	1.44	0.39	1.00	13.00
gender	Dummy variable sets to 1 if the gender of household head is male	27812	0.85	0.35	0.41	0.00	1.00
Age	The age of household head	27812	49.97	12.07	0.24	20.00	75.00
DtoGDP	Deposit to GDP	27812	1.06	0.53	0.50	0.39	4.30
LtoGDP	Loan to GDP	27812	0.90	0.25	0.28	0.59	1.96
DLtoGDP	Summation of Deposit and Loan to GDP	27812	1.96	0.76	0.39	0.99	6.26
FI_Per_Thousand	Financial Institution per Thousand People	27812	0.05	0.04	0.74	0.00	0.17

One factor that is defined in equation (21) but not accounted for by either age or cohort effect is the presence of time effects (e.g., common macroeconomic shock) that impinge on all cohorts to a greater or lesser degree, but are located in real time and cannot be accounted for by cohort or age effect. The solution is to include fixed-year effects (θ_t), hence the equation becomes:

$$(logI_{ict} - log\bar{I}_{ct})^2 = \sum_c \alpha_c Cohort_{ic} + \sum_n \beta_n Age_{ict} + \gamma X_{ict} + \theta_t + \varepsilon_{ct} \qquad (22)$$

However, the unrestricted estimation would not be possible due to the dependency between age, cohort and year. In particular, given that cohort is age minus year plus a constant, the parameters of equation (22) are not identified. To overcome this difficulty, we apply the normalization method developed by Deaton and Paxson (1994b) for estimation.[11]

[11] In practice, all year dummies are constrained to be orthogonal to a time trend and add up to zero. The base year is set to be a timeless average of all years so that any time trend is attributed to cohort and age, not to time.

Considering that the age effect estimated by equations (21) and (22) might be linear,[12] and to assess the overall effect of population aging on inequality, we also estimate the restricted versions of (21) and (22) as follows:

$$(logI_{ict} - \overline{log}I_{ct})^2 = \beta Age_{ict} + \sum_c \alpha_c Cohort_{ic} + \gamma X_{ict} + \theta_t + \varepsilon_{ict}, \tag{23}$$

where parameter β represents the relationship between age and inequality. Regarding the importance of finance in smoothing consumption over the life cycle, we also include indicators of financial development as a control to examine its role in moderating inequality triggered by age effect in further analysis. Its sign and statistical significance will help us identify the role of financial inclusion in attenuating the age effect on inequality.

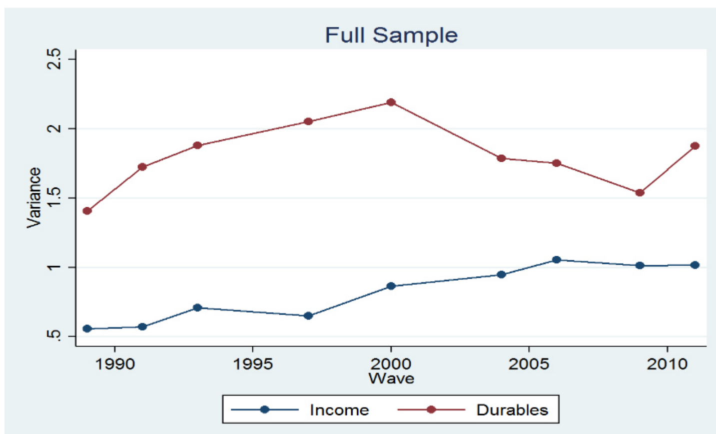
IV. Empirical Results

4.1 Evolution of income and consumption inequality

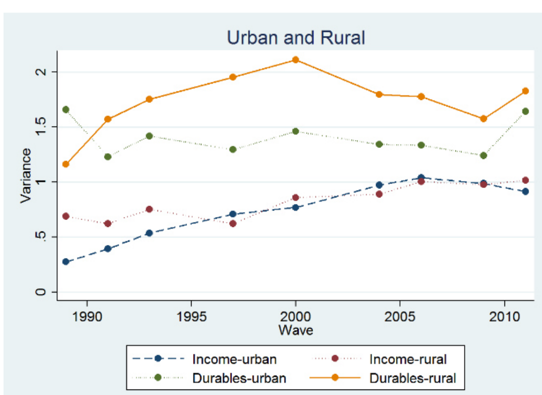
The figures below demonstrate how income and consumption inequality have evolved in China over the period of 1989-2011. The level of inequality is computed as variance of logarithm values. Figure 3(a) suggests that consumption inequality is higher than income inequality in all years although they seem to converge over time. Figure 3(b) shows that consumption inequality in rural area is higher than that in urban area, while income inequality is largely the same in rural and urban areas. Figure 3(c) shows that cohorts with low educational attainment tend to experience greater consumption and income inequality, compared to cohorts with high educational attainment. These facts are different from what are observed in advanced economies such as the US and the UK where income inequality is higher than consumption inequality (Krueger and Perri,

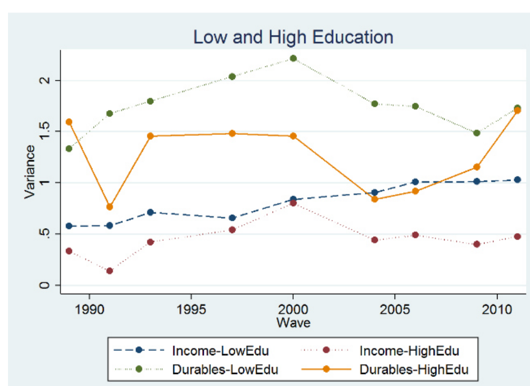
[12] Deaton and Paxson (1994a) find that age effects in Taiwan, Great Britain, and the United States are approximately linear.

2006). According to PIH, consumption inequality reflects idiosyncratic shocks that are insurable on the financial market while income inequality captures both insurable idiosyncratic shocks and uninsurable risks. Higher consumption inequality, especially for less-educated rural farmers in China, indicates the limited access to financial and insurance services to hedge against adverse shocks that may put their livelihood at risk. This is not uncommon in developing countries (Fafchamps, 2003; Dercon, 2005), where it is difficult for poor households to smooth consumption inter-temporally, also because that credit markets in those countries often lag behind economic development.



(a)





(b) (c)

Figure 3 Income and durable consumption inequality in China, 1989-2011

4.2 Inequality and age effect

We then test the lifetime profile of income and consumption inequality. Figures 4 and 5 plot the log variance of income and durable consumption for the same cohort in different survey year*s*. Denoting the year of observation on the horizontal axis and variances on the vertical axis, each panel shows the evolution of inequality of a single cohort specified by the age of household head. The last panel of each figure shows the aggregate inequality for all households in each survey year, as the sum of weighted average of within-cohort inequality and inequality across cohorts. An increasing age effect on income inequality is observed for most cohorts, although not linear. Overall income inequality also displays an upward trend over the years, particularly between late 1990s and mid-2000s when a spell of strong increase can be observed. However, the age effect on durable consumption inequality for most cohorts, except for the youngest cohort, assumes a pattern of inverse U-shape. The panel of full sample suggests that the inequality on durable consumption increases up to 2000 and declines thereafter. Comparing these two types of inequality, we find that consumption inequality is higher than income inequality, especially in young age.

Figure 4 Variance of log income, by age group

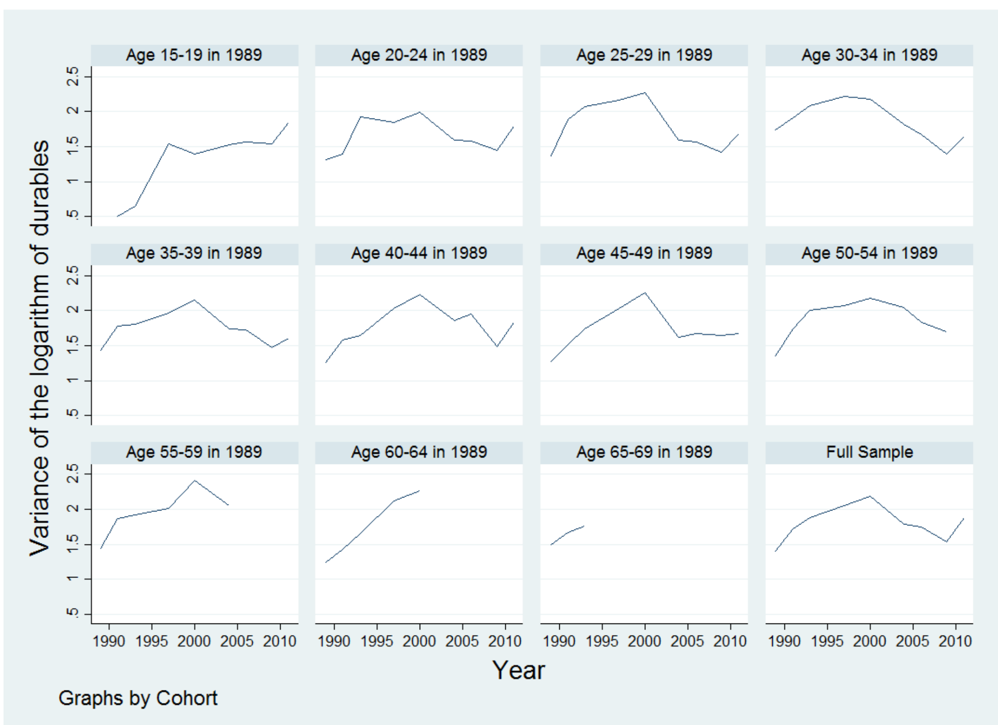
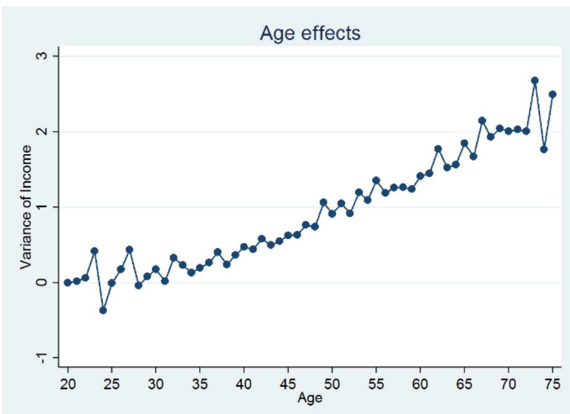


Figure 5 Variance of log durable consumption, by age group

The estimation results of equation (21) are not presented in numerical form, since there are multiple cohort and age effects. Following the method by Deaton and Paxson (1994a), we plot the age effect after controlling the cohort and year effect in Figure 6. Inequality in income increases with age throughout the whole life cycle, while inequality in durable consumption increases with age only during young periods and then remains stable.

Panel A: Income Inequality



Panel B: Consumption Inequality

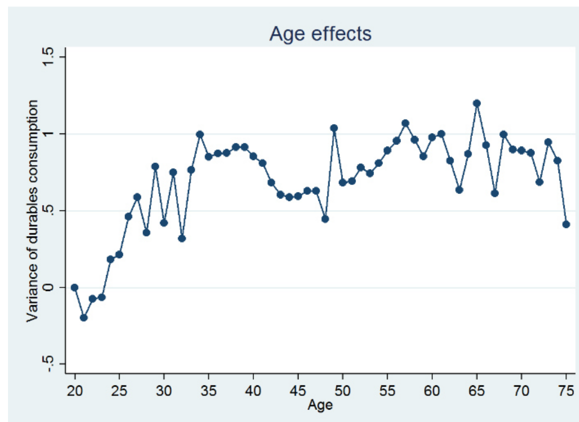


Figure 6 Age Effects and Inequality

Tables 2 and 3 present the estimation results of equation (23), regarding the overall effect of aging population on inequality. The coefficients on age, our main variable of interest, are significantly positive, indicating that aging population enlarges inequality in both income and durable consumption. The comparison on the magnitude of coefficient indicates that age effect is larger for consumption than income. This finding is consistent with our theoretical prediction. To test the impact of financial development on age effect, we expand our estimation by including an interaction term of *age effect* x *financial development*. The idea is that as the level of the financial development advances, it is more likely for households to leverage financial tools to smooth consumption over their life cycle, and hence, to attenuate the age effect on inequality. A statistically significant coefficient on the interaction term with a sign opposite to that of the coefficient on age effect would suggest that financial development helps moderate the size of age effect on inequality. We measure financial development with four indicators: loan to GDP, deposit to GDP, sum of loan and deposit to GDP, and number of financial institutions per 1000 residents. Tables 2 and 3 show that coefficients on the interaction terms are negative and statistically significant for consumption inequality but insignificant for income inequality in most cases. These findings confirm the positive role of financial sector in moderating the age effect on consumption inequality.

Considering the widely acknowledged urban-rural disparity in China, we divide households into urban and rural groups by their *hukou* status, and compare the age effects on income and consumption inequality across two groups. The results shown in Tables 4 and 5 indicate that age effects on both income and consumption inequality are stronger in urban area than in rural area. The statistically insignificant coefficient on the interaction term between age and financial indicators shown in Table 4 implies that financial development could hardly moderate the age effect on income inequality in either rural or urban area. However, coefficients on all interaction terms are significantly negative in Table 5, suggesting the important role of financial development in attenuating age effect on consumption inequality. Moreover, the impact of financial development is larger in rural area than in the urban area.

Table 2 Aging and Income Inequality

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Age	0.0285***	0.00356	0.0240***	0.0284***	0.0267***	0.0251***	0.0179***
	(18.05)	(0.505)	(5.305)	(4.678)	(5.664)	(4.573)	(2.971)
AgeSquare		5.86e-05					
		(0.841)					
gender			0.0358	0.0372	0.0370	0.0366	0.0334
			(1.124)	(1.168)	(1.160)	(1.147)	(1.048)
hhsize			0.101***	0.101***	0.101***	0.101***	0.104***
			(12.35)	(12.32)	(12.35)	(12.34)	(12.67)
LtoGDP				0.114			
				(0.495)			
AgeLtoGDP				-0.00558			
				(-1.340)			
DtoGDP					-0.0386		
					(-0.378)		
AgeDtoGDP					-0.00318		
					(-1.411)		
DLtoGDP						-0.0789	
						(-0.900)	
AgeDLtoGDP						-0.000145	
						(-0.0990)	
FI_Per_Thousand							-5.834***
							(-3.031)
AgeFI_Per_Thousand							0.110***
							(3.671)
Constant	-1.233***	0.614***	-1.570***	-1.443***	-1.222***	-1.116**	-1.116**
	(-8.118)	(3.569)	(-3.864)	(-2.800)	(-2.586)	(-2.189)	(-2.475)
Observations	27,812	27,812	27,812	27,812	27,812	27,812	27,812
R-squared	0.013	0.004	0.036	0.036	0.036	0.036	0.037
Wave Effect	No	No	Yes	Yes	Yes	Yes	Yes
Cohort FE	Yes	No	Yes	Yes	Yes	Yes	Yes
Province FE	NO	NO	Yes	Yes	Yes	Yes	Yes
Controls	No	No	Yes	Yes	Yes	Yes	Yes

Note: t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 3 Aging and Durables Inequality

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Age	0.108***	0.174***	0.0281**	0.0499***	0.0389***	0.0652***	0.0827***
	(22.27)	(6.099)	(2.083)	(2.756)	(2.772)	(3.986)	(4.616)
AgeSquare		-0.00183***					
		(-7.383)					
gender			1.413***	1.422***	1.420***	1.423***	1.427***
			(14.88)	(14.98)	(14.97)	(14.99)	(15.04)
hhsize			0.453***	0.453***	0.453***	0.448***	0.437***
			(18.53)	(18.53)	(18.56)	(18.30)	(17.80)
LtoGDP				0.170			
				(0.248)			
AgeLtoGDP				-0.0314**			
				(-2.529)			
DtoGDP					1.391***		
					(4.583)		
AgeDtoGDP					-0.0477***		
					(-7.102)		
DLtoGDP						0.497*	
						(1.905)	
AgeDLtoGDP						-0.0163***	
						(-3.741)	
FI_Per_Thousand							19.90***
							(3.473)
AgeFI_Per_Thousand							-0.514***
							(-5.758)
Constant	-4.173***	1.978	-2.638**	-0.765	-3.334**	-2.704*	-5.858***
	(-8.903)	(1.528)	(-2.178)	(-0.499)	(-2.369)	(-1.780)	(-4.362)
Observations	27,812	27,812	27,812	27,812	27,812	27,812	27,812
R-squared	0.021	0.046	0.109	0.110	0.111	0.110	0.110
Wave Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	NO	NO	Yes	Yes	Yes	Yes	Yes
Controls	No	No	Yes	Yes	Yes	Yes	Yes

Note: t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 4 Aging and Income Inequality, urban vs rural

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Urban			Rural		
Age	0.0364***	0.0299***	0.0301***	0.0226***	0.0207***	0.0243***
	(11.30)	(3.302)	(3.187)	(12.74)	(4.021)	(4.533)
gender		-0.132**	-0.131**		0.0447	0.0458
		(-2.487)	(-2.467)		(1.052)	(1.078)
hhsize		0.0731***	0.0731***		0.0871***	0.0872***
		(3.968)	(3.965)		(9.611)	(9.618)
DtoGDP			0.122			-0.150
			(0.588)			(-1.300)
AgeDtoGDP			-0.00315			-0.00206
			(-0.760)			(-0.760)
Constant	-1.999***	-2.165***	-2.295**	-0.546***	-0.530	0.0783
	(-7.254)	(-2.759)	(-2.469)	(-2.789)	(-1.054)	(0.137)
Observations	9,480	9,480	9,480	18,332	18,332	18,332
R-squared	0.016	0.043	0.043	0.010	0.033	0.033
Wave Effect	No	Yes	Yes	No	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	NO	Yes	Yes	NO	Yes	Yes
Controls	No	Yes	Yes	No	Yes	Yes

Note: t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 5 Aging and Durables Inequality**,** urban vs rural

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Urban			Rural		
Age	0.156***	0.161***	0.158***	0.0247	0.0263	0.0993***
	(7.121)	(8.838)	(6.764)	(1.030)	(1.532)	(4.541)
gender	-0.123	-0.114	-0.117	1.603***	1.599***	1.601***
	(-1.194)	(-1.115)	(-1.138)	(11.77)	(11.75)	(11.77)
hhsize	0.365***	0.362***	0.341***	0.213***	0.214***	0.192***
	(10.25)	(10.20)	(9.529)	(7.344)	(7.357)	(6.583)
LtoGDP	-1.017			-0.391		
	(-1.271)			(-0.411)		
AgeLtoGDP	-0.00536			-0.0212		
	(-0.404)			(-1.172)		
DtoGDP		1.437***			1.144***	
		(3.582)			(3.088)	
AgeDtoGDP		-0.0369***			-0.0455***	
		(-4.617)			(-5.236)	
FI_Per_Thousand			41.72***			19.67***
			(5.677)			(2.736)
AgeFI_Per_Thousand			-0.582***			-0.647***
			(-5.308)			(-5.628)
Constant	-9.912***	-14.31***	-13.76***	2.540	-0.204	-4.867***
	(-5.134)	(-7.979)	(-8.118)	(1.244)	(-0.111)	(-2.754)
Observations	9,480	9,480	9,480	18,332	18,332	18,332
R-squared	0.095	0.097	0.098	0.138	0.138	0.139
Wave Effect	Yes	Yes	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Note: t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1

V. Conclusion

This paper studies distributional effects of population aging. For theoretical analysis, we build a two-period overlapping generation (OLG) model with uncertain lifetime to assess the impacts of population aging on income and consumption inequality. We find that population aging has the overall effect of aggravating inequality. We also identify the pattern that consumption inequality is higher than income inequality within the young cohort. For empirical analysis, we use the household data from China Health and

Nutrition Survey (CHNS) to evaluate the age effect on income and consumption inequality, and our findings are largely in alignment with results predicted in the theoretical model. In addition, we find that age effect is larger for consumption inequality than for income inequality, and also that age effect on inequality is larger in urban area than in rural area. We also empirically investigate the role of financial sector in smoothing consumption over lifetime. Our conclusion is that financial inclusion helps attenuate the age effect on inequality, implying the importance of promoting financial access among citizens in a rapidly aging society.

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Appendix

$$\frac{\partial k^*}{\partial x}=\frac{A(1+e)\alpha^2\beta(1+e-x^2\beta\lambda)\left(\frac{A(1+e)x(1-\alpha)\alpha\beta}{(1+e)\alpha(1+x\beta)+x(1+x\alpha\beta)\lambda}\right)^{\frac{\alpha}{1-\alpha}}}{((1+e)\alpha(1+x\beta)+\lambda x(1+x\alpha\beta))^2};$$

$$\frac{\partial k^*}{\partial e}=\frac{Ax^2\alpha\beta(1+x\alpha\beta)\lambda\left(\frac{A(1+e)x(1-\alpha)\alpha\beta}{(1+e)\alpha(1+x\beta)+x(1+x\alpha\beta)\lambda}\right)^{\frac{\alpha}{1-\alpha}}}{((1+e)\alpha(1+x\beta)+x(1+x\alpha\beta)\lambda)^2};$$

$$\frac{\partial k^*}{\partial \beta}=\frac{A(1+e)x\alpha(\alpha+e\alpha+x\lambda)\left(\frac{A(1+e)x(1-\alpha)\alpha\beta}{(1+e)\alpha(1+x\beta)+x(1+x\alpha\beta)\lambda}\right)^{\frac{\alpha}{1-\alpha}}}{((1+e)\alpha(1+x\beta)+x(1+x\alpha\beta)\lambda)^2};$$

$$\frac{\partial k^*}{\partial \lambda}=-\frac{(1+x\alpha\beta)\left(\frac{A(1+e)x(1-\alpha)\alpha\beta}{(1+e)\alpha(1+x\beta)+x(1+x\alpha\beta)\lambda}\right)^{\frac{2-\alpha}{1-\alpha}}}{A(1+e)(1-\alpha)^2\alpha\beta}.$$

Because that > 1, $0 < x, \beta, \lambda < 1$, it is easy to see that $1 + e - x^2\beta\lambda > 0$, hence we have

$\frac{\partial k^*}{\partial x} > 0$. The other three results are straightforward to see.