Population aging and inequality: evidence from China

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Abstract

Population aging has been an international concern mainly because of its accompanying economic and social costs. This paper studies distributional effects of demographic change. First, we build a simple two-period overlapping generation (OLG) theoretical model to illustrate the overall effects of population aging on income and consumption inequality. We find that population aging tends to enlarge the inequality. Moreover, within the young cohort consumption inequality is higher than income inequality. 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 distribution effect predicted by the theoretical model.

I. Introduction

Population aging has been an international concern mainly because of 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. By 2035, this figure will rise to more than 1.1 billion, implying that 13% of the population will be above the age of 65. This is a natural corollary of the dropping birth rates and growing life expectancy. The "old-age dependency ratio"—the ratio of old people to those of working age—will grow even faster. In 2010, there were 16 people aged 65 and over per every 100 adults between ages 25 and 64, almost the same as it had in 1980. By 2035, the number is expected to increase to 26. In rich countries it will be much higher. Japan will have 69 old people for every 100 of working age by 2035 (up from 43 in 2010). Although the developing countries have profited from a beneficial age structure over the past decades, they are now starting 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. Latin America will see a shift from 14 to 27 (The Economist, 2014).

Theoretically, the distributional effect of population aging triggered by the low birth rate and long life expectancy can be explained by two competing 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 cohorts of people born at the same time should increase with age because an individual's income and consumption is affected by his own history of education, employment, health, idiosyncratic luck, family background, among others. Under the framework of PIH, Eden

(1980) originally proposes that the variance of consumption should increase over time within cohorts. The statistical evidence presented by Deaton and Paxson (1994) shows that within-cohort consumption and income inequality increase with age in three economies of Taiwan, Great Britain and the United States. Ohtake and Saito (1998) show that half of the rapid increase in the consumption inequality in Japan during the 1980s was the result of population aging, while one-third was due to the increasing cohort effect. Second, as argued by Higgins and Wiliamson (2002) slower population growth tilts the population age distribution toward mature, more experienced cohorts, possibly reducing the experience premium, and hence moderating aggregate inequality. The population of East and Southeast Asia is aging rapidly as a consequence of demographic transition, increase in life expectancy and the aging of postwar baby booms. If life cycle models are correct, population aging is likely to increase inequality. Whereas this largely mechanical effect offers no direct threat to welfare, it is important that it be understood if only to avoid the imposition of unnecessary policies designed to correct it.

The evidences found in developed countries of Japan, US and UK are in line with PIH, according to which a household can smooth its life time consumption against transient shocks in the short run by leveraging the credit market and over the life cycle in the long run. However, we still know little about the situation in developing countries where financial markets are underdeveloped and liquidity constraints are pervasive. The only evidence is provided by Kurosaki, Kurita and Ligon (2009) who show that within-cohort inequality in consumption decreases with age in the countries of Thailand, Pakistan and India.

China provides a compelling setting to study this issue for several reasons. The period after the market oriented reforms initiated in early 1980s in China has witnessed rapid economic growth, with double digit growth rates for about three decades. However, this process has been associated with soaring inequality and rapid population aging. China, now the second-largest economy in the world, has been experiencing rapid rises in income inequality. Its Gini coefficient has increased from 0.30 in 1980 to 0.53 in 2010 (Xie and Zhou, 2014), among the highest in the world, especially in comparison with countries with comparable level of economic development. Despite recent moderate declines in inequality in China, the issue of income distribution remains serious. High and persistent income inequality can significantly impede growth, weaken demand, cause crises and erode social cohesion (IMF 2015; Ostry and Berg, 2011). At the same time, China is rapidly getting older as a consequence of family planning policy, demographic transition, and increasing life expectancy. The number of people aged over 60 has reached 185million, or 14% of the total population.[1] Moreover, its aging process would continue at a remarkable pace in the next few decades. It is predicted that China will become the world's most aged society in 2030. By 2050, the Chinese elderly would increase to 454 million or 33% of total population.[2] In addition, the intergeneration inequality has triggered wide attention.

Despite the strong links between demographic trend and inequality implied by the life cycle theory, the investigation of this topic in the Chinese context is still limited. Using four rounds of Urban Households' Income and Expenditure Survey (UHIES) data between 2003 and 2009, Zhang and Xiang (2014) study the contribution of aging to the

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

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

rising consumption disparity in urban China. Employing three waves of rural household surveys in China Household Income project for the period of 1988-2002, Qu and Zhao (2008) investigate the effect of population aging on consumption and income inequality in rural China. Zou, Li and Yu (2013) explore the impact of birth cohort on the consumption inequality of electronic appliances in China. (their findings?)

In this study, we first build a simple two-period overlapping generation (OLG) model to theoretically illustrate the overall effects of population aging on income and consumption inequality. We find that population aging tends to enlarge the inequality. Moreover, within the young cohort consumption inequality is higher than income inequality.

In the empirical analysis, we employ Deaton and Paxon (1994)'s approach to examine the age effect on income and consumption inequality in both urban and rural area by using a data set constructed from the nine waves of the China Health and Nutrition Survey (CHNS) conducted between 1989 and 2011. CHNS is a data set measuring various dimensions of income and consumption that can be linked to changes in ages over time. Employing such data that represent a third of the country's population from nine provinces, we are released from the limitation of using data from a small, geographically restricted region that may be unrepresentative of the larger setting. Moreover, our data cover a long period of 22 years, enabling us to track the development process of inequality and aging population during the time of rapid economic growth in China.

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 versus urban area. 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 Paxon (1994)'s cohort-level model by doing regression analysis on the household level. All of our empirical evidences are consistent with the theoretical predications.

Most discussion over the growing inequality in China is phrased in terms of income (Wan, Lu and Chen, 2006; Meng, 2004; Meng, Gregory and Wang, 2005), or different components of income like wages and earnings. The enlarging income gap has been explained from the perspective of …. We extend 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 researches (Cutler and Katz, 1992; Johnson and Shipp, 1997; Blundell and Preston, 1998; Pendakur, 1998) have shown that consumption measures welfare and long-term earnings capacity more directly and precisely than income. Second, the difference between consumption and income reflect the efficiency of consumption smoothing mechanism and how the distribution of income shocks is transmitted to the distribution of consumption 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 out of regular jobs, like job-related benefits and "gray" income in particular. In contrast, consumption suffers less from underreporting problems. By comparing the dynamics of within-cohort consumption inequality with that of within-cohort income inequality, we can obtain insights regarding factors governing the intertemporal consumption choice of Chinese residents.

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 presets 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 so we use the two terms "household" and "individual" interchangeably in this paper. 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 on the other hand, each individual faces 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 allows him to work a blue-collar job as he did while young; as a result, his only income at this stage will come from his young-age saving. A skilled old worker, on the other hand, has the opportunity to work 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 saving, 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:

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

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

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

(2.s)

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

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

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

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 this: 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:

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

$$d_{t+1}^s = \frac{r_{t+1}}{x} \left(\frac{\beta x}{\beta x + 1} e w_t - \frac{\lambda w_{t+1}}{(\beta x + 1)\frac{r_{t+1}}{x}} \right) + \lambda w_{t+1} = \frac{r_{t+1}}{x} \frac{\beta x}{\beta x + 1} e w_t + \frac{\beta x}{\beta x + 1} \lambda w_{t+1}.$$

We can fairly easily derive that:

$$d_{t+1}^s / d_{t+1}^u = e + \frac{\lambda w_{t+1}}{w_t} \frac{x}{r_{t+1}}. \tag{9}$$

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 by the savings by the young workers, both skilled and unskilled, in the previous stage, as follows:

$$K_{t+1} = ns_t^s + ns_t^u. \tag{11}$$

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:

$$Y_t = AK_t^\alpha L_t^{1-\alpha}, \text{ where } 0 < \alpha < 1. \tag{12}$$

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:

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

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

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:

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

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 more saving; a higher wage, albeit only to the skilled workers, allows higher saving 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:

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

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 $\frac{\partial \Psi_{y,con}^*}{\partial x} = \frac{\partial \Psi_o^*}{\partial x} = \frac{\partial}{\partial x}\left(\frac{\lambda}{\alpha A}(k^*)^{1-\alpha}x\right)$, hence:

$$\frac{\partial \Psi_{y,con}^*}{\partial x} = \frac{\partial \Psi_o^*}{\partial x} = \frac{\lambda}{\alpha A}\left(\frac{x(1-\alpha)}{(k^*)^\alpha}\frac{\partial k^*}{\partial x} + (k^*)^{1-\alpha}\right) > 0. \tag{20}$$

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 based on our theoretical study in this section, 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 compliance with our empirical findings, presented in the next sections of this paper.

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 datasets 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 Paxon, 1994). In China, several household survey datasets have been used to study the income distribution, 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), which is a collaborative project between 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[3] have been conducted since 1989 on 4,400 households with a total of 26,000 individuals in nine Chinese provinces (Liaoning, Heilongjiang, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi, and Guizhou) that vary substantially in geography, economic development, public resources, and health indicators. 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 neighborhoods and 108 towns. CHNS respondents were 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 were found to be comparable to the national averages. One of the advantages of CHNS data is that it provides detailed information about potential sources of household income, including wage income, retirement income, subsidies, income from sources of business, farming, fishing, gardening, livestock, and others. Moreover, the Longitudinal Master files created by CHNS facilitate us to trace the evolution of responds' income and

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

consumption over time. In addition, CHNS data have a good number of overlapping cohorts across rounds, a great advantage in estimating age effects by using equation (22) and (24) described below. Figure 1 shows the distribution of our sample by age for the three years of 1989, 2000 and 2011. The skewness towards right clearly indicates the rapid process of population aging in China in the last two decades.

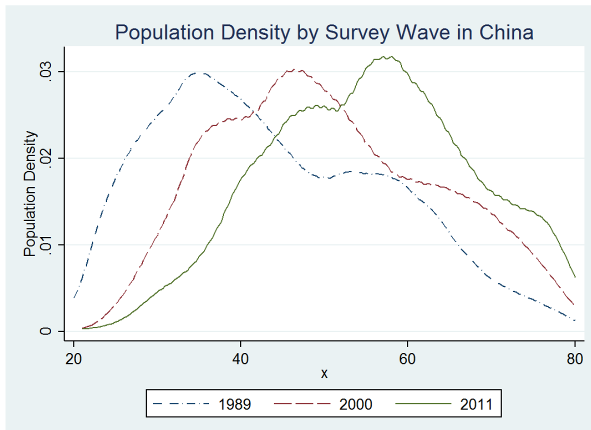

Figure 1 Population distribution by age, 1989-2011

Given the limitation of CHNS consumption data (Wang, Benjamin, Brant and Giles, 2007), we pay special attention to the inequality of consumption on durable goods including electronic appliance 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. The consumption categories that tend to be reported poorly are those that involve small and infrequent purchases, while large expenses on durable goods are reported sufficiently well. In addition, durable consumption relies heavily on the liquidity facilitated through financial institutions.

To construct the variables to be used in this study, we first select households that have valid and complete information on income, durable consumption and age between 20 and 75. We then collect the information on a household head's age, gender, education attainment, employment status, in addition to household's total disposable income, value of durable goods, household registration (*hukou*) status, provinces of residence, etc. Per capita real income for each household are calculated by dividing total household income by the number of household members and adjusted by the consumer price index. CHNS survey includes detailed information on the stock and current value of electronic appliances and means of transportation owned by each household.[4] We compute the real per capita consumption of durables by dividing total value of durable goods by the number of household members and adjusting with the consumer price index of 2011.

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. We define the cohort dummies to be 5 year age band; that is, those born in 1920-24, 1925-29, 1930-34, 1935-39, 1940-45, 1946-49, 1950-54, 1955-59, 1960-64, 1965-69, 1970-74. Similarly, the dummy variable for the youngest cohort is dropped to avoid multicollinearity among cohort dummies.

Table 1 reports the summary statistics of per capita real income and durable consumption measured at the household level. Figure 2 visually compares the growing trend of household income versus durable consumption in the years of 1989-2011. The household income and durable consumption moved in tandem up to 2004, but the divergence was enlarged thereafter.

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[4] The electronic appliance listed in CHNS survey questionnaire includes VCR, TV sets, 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 the questions of "Does your household own this type of appliance/transportation?", "How many are owned?" "What is the total value of appliance/transportation?".

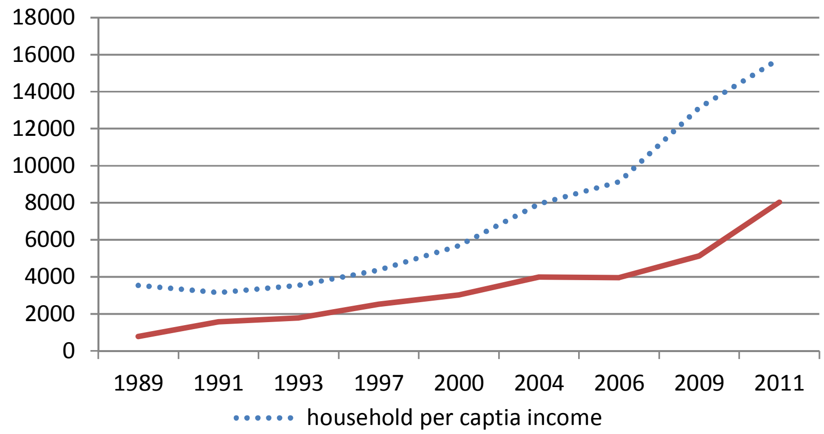


Figure 2 the growing trend of income and durable consumption, 1989-2011

TABLE 1 Summary statistics of income, wage and durable consumption

Wave	Obs	Mean	Std. Dev.	RSD	Min	Max
			Per capita real income			
1989	1,193	3537.54	2182.97	0.62	1047.91	12928.20
1991	2,799	3151.26	2062.39	0.65	891.48	11465.46
1993	2,627	3546.53	2663.99	0.75	884.79	14679.33
1997	2,913	4372.32	3088.01	0.71	1218.85	16229.17
2000	3,312	5688.79	4607.19	0.81	1231.05	27269.51
2004	3,086	7944.17	7393.87	0.93	1443.73	41952.38
2006	3,060	9134.18	8886.34	0.97	1586.23	51051.45
2009	3,128	13131.12	12304.10	0.94	2440.64	74902.52
2011	3,835	15766.95	13528.30	0.86	2779.87	80807.81
			Per capita real durable consumption			
1989	1,193	786.35	1520.84	1.93	17.64	20351.16
1991	2,799	1573.53	2435.34	1.55	3.46	42051.34
1993	2,627	1787.06	3463.04	1.94	0.53	67157.44
1997	2,913	2524.81	6699.84	2.65	6.41	258159.10
2000	3,312	3021.28	6718.22	2.22	6.84	159024.40
2004	3,086	3991.67	16410.34	4.11	12.55	603781.80
2006	3,060	3959.58	9889.45	2.50	6.06	224462.40
2009	3,128	5134.28	13056.94	2.54	10.81	395596.90
2011	3,835	8040.78	19620.07	2.44	8.33	347150.00

3.2 Methodology

Following the Deaton and Paxson (1994)'s method, we employ the variance of log consumption and log income as the main measure of inequality:

$$Variance_{i \in C}(logI_{ict}) = \frac{1}{N}\left[\sum_{i=1}^{N} logI_{it} - \frac{1}{N}\sum_{i=1}^{N} logI_{it}\right]^2$$

where N represents the population of a cohort; I_{ict} is per capita real consumption or income of household i, belonging to cohort c [5] in survey wave t. We define c_{ict} (or y_{ict}) as per capita real durable consumption (or income).

Given that the inequality of each cohort might be related to some degree with the inequality specific to its cohort, we identify the age effect of the within-cohort inequality by the regression proposed by Ohtake and Saito (1998):

$$Variance_{i \in C}(logI_{ict}) = \sum_c \alpha_c Cohort_c + \sum_n \beta_n Age_n + \varepsilon_{ct} \quad (21)$$

where $Cohort_c$ is the cohort dummy constructed for every 5-year age band for the head of households born between 1920 and 1974. $Age_n$is age dummy spanning the range of 20 to 69 years old. 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. In addition to the cohort level regression, we estimate the household-level model as follows

$$(logI_{ict} - \overline{log}I_{ct})^2 = \sum_c \alpha_c Cohort_c + \sum_n \beta_n Age_n + \gamma X_{ict} + \varepsilon_{ict} \quad (22)$$

where $\overline{log}I_{ct}$ is the average logarithm value of per capita real durable consumption or income for the cohort c in year t, X_{ict} is a vector of control variables that describe the household i's characteristics in year t including the size of the household and the province in which the household is living in. By including X_{ict}, we are able to directly control the changes of household demographic features and sampling design of each survey so as to achieve the gains in statistical efficiency. After estimation, we will plot

[5] This paper define cohort by the age of household head.

the fitted value of the age fixed effects, $\widehat{\beta_n}$, to show the dynamics of within-cohort inequality across age.

Considering that the age effect estimated by equation (21) and (22) might be linear[6] and to assess the overall effect of population aging on inequality, we also estimate the restricted versions of (21) and (22) as follows:

$$Variance_{i \in C}(logI_{ict}) = \sum_c \alpha_c Cohort_c + \beta Age_n + \varepsilon_{ct}, \quad (23)$$

and

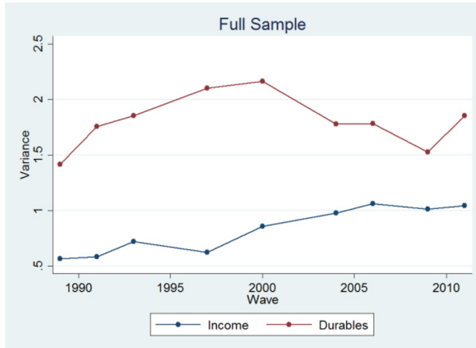
$$(logI_{ict} - \overline{log}I_{ct})^2 = \sum_c \alpha_c Cohort_c + +\beta Age_n + \gamma X_{ict} + \varepsilon_{ict} \quad (24)$$

where parameter β represents the relationship between age and inequality. Regarding the importance of finance in smoothing consumption and income over the life cycle, we also include the indicators of financial development as a control to examine the its role in moderating the inequality triggered by age effect. Its sign and statistical significance would help us to simply test the relationship between aging population and inequality.

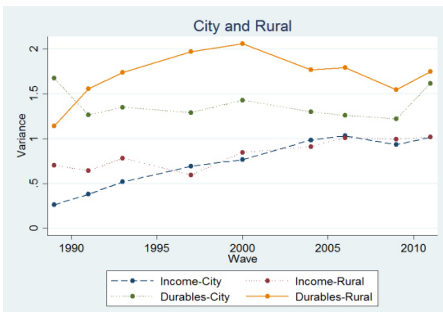
IV. Empirical Results

We first plot the figures to show value of inequality computed by the variance of log durable consumption and variance of log income in different survey years. Figure 3 indicates that consumption inequality is higher than income inequality in all years.

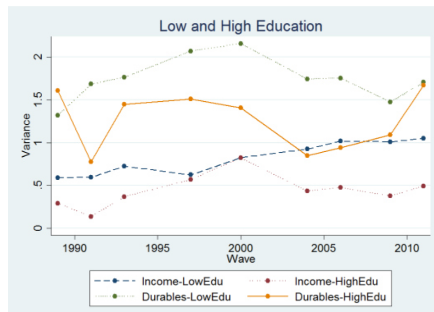
[6] Deaton and Paxon (1994) found that the age effect in Taiwan, UK and USA are approximately linear.



(a)



(b)



(c)

Figure 3 Income inequality versus nondurable inequality, 1989-2011

We then test the lifetime profile of income and consumption inequality. Figure 3 and 4 plot the log variance of income and durable consumption for the same cohort *c* but in different survey years *t*. Denoting the year of observation on the horizontal axis and variance 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. It is a weighted average of within-cohort inequality plus inequality across cohorts. An increasing age effect on income inequality is observed for most cohorts, although not linearly. The overall income inequality is relatively stable up to the late 1990s but speeds up until 2006 and then slows down again. However, the age effect on durable consumption inequality for most cohorts (except the youngest cohort) is reversed U-shaped. It initially increases but then fall. The panel of full sample suggests that the inequality on durable consumption increases up to 2000 and decline thereafter. Comparing the two types of inequality, we find that consumption inequality is higher than income inequality, especially in young age.

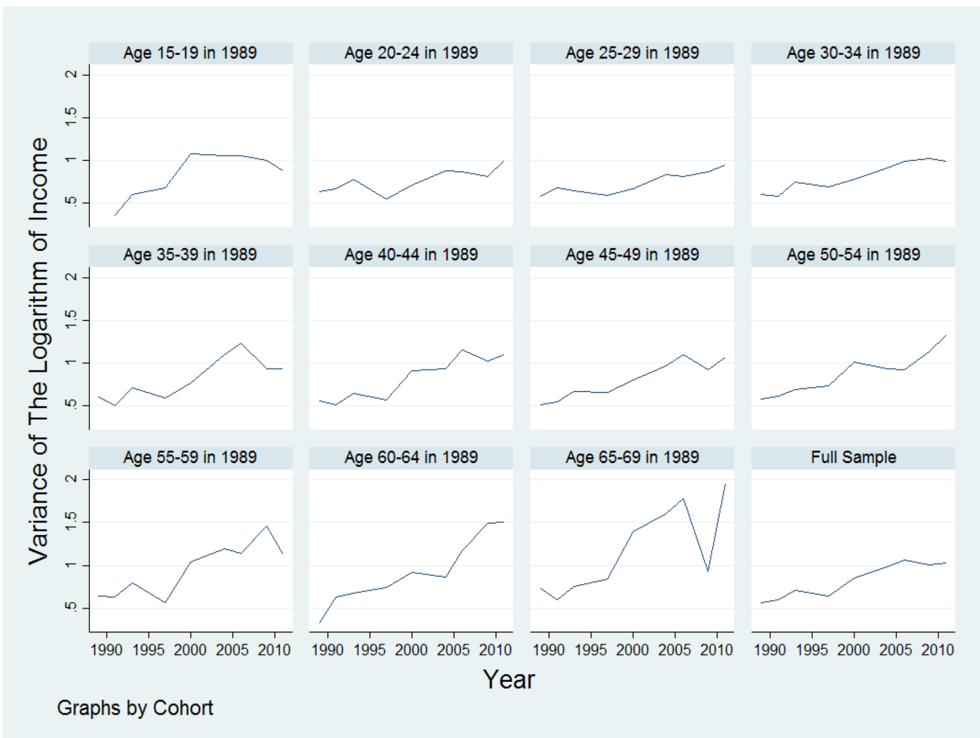


Figure 3 Variance of log income and age

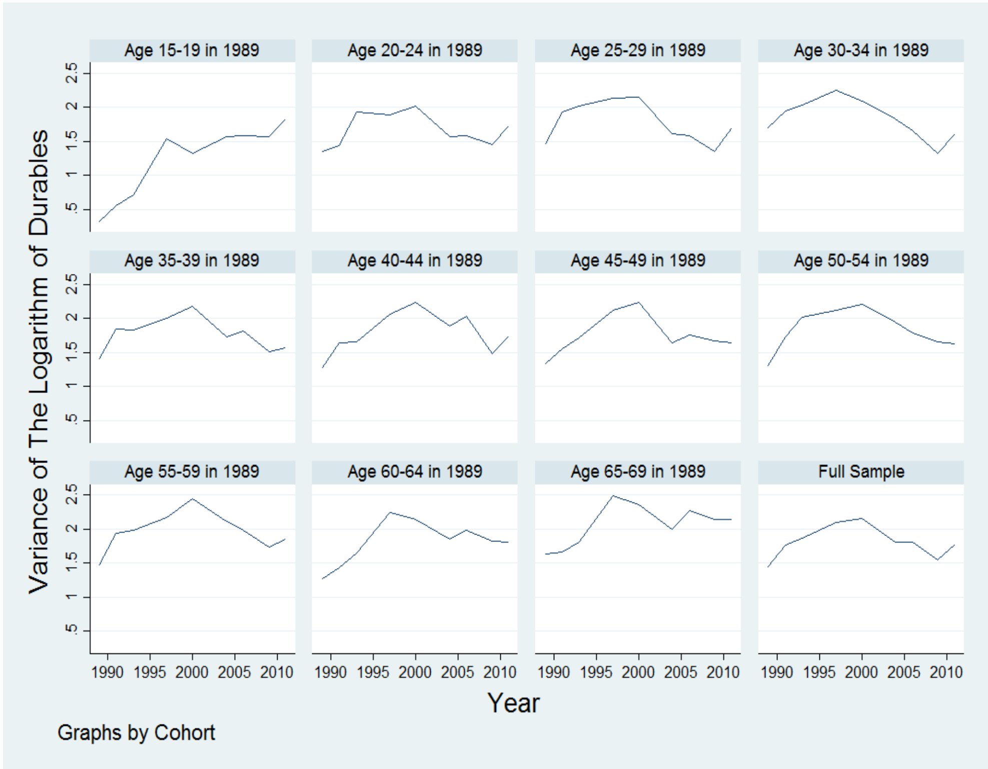


Figure 4 Variance of log durable consumption and age

Figure 5 shows the age effect after controlling the cohort-specific effect. It is the coefficient α_c estimated by equation (22), a regression of inequality on age fixed effects and cohort fixed effects. The figure smoothly connects the shapes of younger, middle and older cohorts. The inequality in durable consumption increases with age only during very young periods and then gradually declines, resulting in a hump shape. On the other hand, inequality in income increases with age during the whole life cycle, in line with the predictions of our theoretical model.

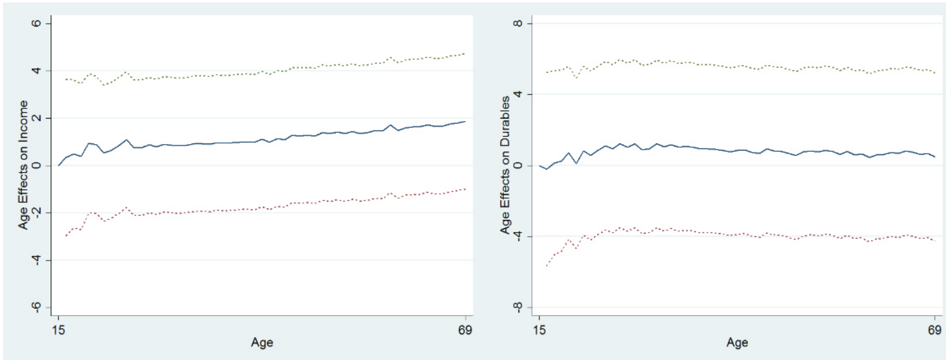
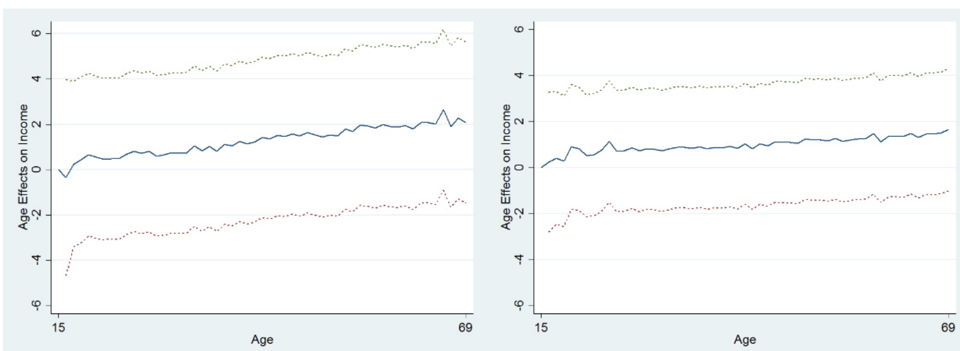


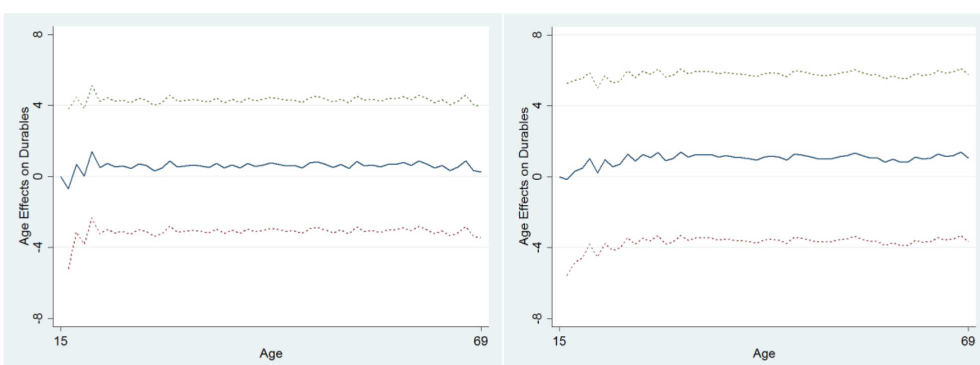
Figure 5 Age effects in income and consumption inequality

Figure 6 and 7 compare the age effect on income and consumption inequality across urban versus rural area. In urban areas, income inequality increases with age steadily until the age of fifties. It stabilizes thereafter but at higher level than young age. In rural area, income inequality increases with age steadily but in a much lower scale.



(a) urban area (b) rural area

Figure 6 Age effect in income inequality, urban versus rural areas



(a) urban area (b) rural area

Figure 7 Age effect in consumption inequality, urban versus rural areas

Table 2 Aging and income inequality

	(1)	(3)	(4)	(6)	(7)	(9)	(10)	(11)
VARIABLES	Log_Income	Log_Income	Log_Income	Log_Income	Log_Income	Log_Income	Log_Income	Log_Income
Age	0.0255***	0.0257***	0.0257***	0.0257***	0.0257***	0.0257***	0.0257***	0.0257***
	(18.79)	(18.60)	(18.60)	(7.421)	(7.421)	(7.421)	(7.421)	(7.421)
gender	0.0185	0.0183	0.0183	0.0183	0.0183	0.0183	0.0183	0.0183
	(0.692)	(0.686)	(0.686)	(0.685)	(0.685)	(0.685)	(0.685)	(0.685)
Household size	0.00309	0.00310	0.00310	0.00310	0.00310	0.00310	0.00310	0.00310
	(0.457)	(0.459)	(0.459)	(0.459)	(0.459)	(0.459)	(0.459)	(0.459)
Loan to GDP		-0.0384			-0.0383		-0.0383	
		(-0.532)			(-0.528)		(-0.528)	
Deposit to GDP			-0.0384	-0.0383		-0.0383		-0.0383
			(-0.532)	(-0.528)		(-0.528)		(-0.528)
FI_Per_Thousand				-0.0102	-0.0102	-0.0102	-0.0102	-0.0102
				(-0.0135)	(-0.0135)	(-0.0135)	(-0.0135)	(-0.0135)
Constant	-0.129	-0.0586	-0.0586	-0.0587	-0.0587	-0.0587	-0.0587	-0.0587
	(-1.123)	(-0.334)	(-0.334)	(-0.334)	(-0.334)	(-0.334)	(-0.334)	(-0.334)
Observations	25,192	25,192	25,192	25,192	25,192	25,192	25,192	25,192
R-squared	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023

Note: t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1
FI_Per_Thousand: number of financial institutions per 1000 person

Table 3 Aging and consumption inequality

	(14)	(16)	(17)	(19)	(20)	(22)	(23)	(24)
Age	-0.0106***	-0.0108***	-0.0108***	0.0186***	0.0186***	0.0186***	0.0186***	0.0186***
	(-4.716)	(-4.758)	(-4.758)	(3.243)	(3.243)	(3.243)	(3.243)	(3.243)
gender	-0.0847*	-0.0844*	-0.0844*	-0.0877**	-0.0877**	-0.0877**	-0.0877**	-0.0877**
	(-1.916)	(-1.908)	(-1.908)	(-1.984)	(-1.984)	(-1.984)	(-1.984)	(-1.984)
hhsize	-0.0343***	-0.0343***	-0.0343***	-0.0342***	-0.0342***	-0.0342***	-0.0342***	-0.0342***
	(-3.069)	(-3.070)	(-3.070)	(-3.060)	(-3.060)	(-3.060)	(-3.060)	(-3.060)
LtoGDP		0.0779			0.143		0.143	
		(0.652)			(1.196)		(1.196)	
DtoGDP			0.0779	0.143		0.143		0.143
			(0.652)	(1.196)		(1.196)		(1.196)
FI_Per_Thousand				-7.025***	-7.025***	-7.025***	-7.025***	-7.025***
				(-5.603)	(-5.603)	(-5.603)	(-5.603)	(-5.603)
Constant	3.671***	3.528***	3.528***	3.459***	3.459***	3.459***	3.459***	3.459***
	(19.31)	(12.15)	(12.15)	(11.91)	(11.91)	(11.91)	(11.91)	(11.91)
Observations	25,192	25,192	25,192	25,192	25,192	25,192	25,192	25,192
R-squared	0.013	0.013	0.013	0.014	0.014	0.014	0.014	0.014

Note: t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1
FI_Per_Thousand: number of financial institutions per 1000 person

V. Conclusion

This paper studies distributional effects of population aging. First, we build a simple two-period overlapping generation (OLG) theoretical model to illustrate the overall effects of population aging on income and consumption inequality. We find that population aging tends to enlarge the inequality. Moreover, within the young cohort consumption inequality is higher than income inequality. 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 distribution effect predicted by the theoretical model. The empirical evidence indicates that income inequality increases

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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 are straightforward to see.