The Effects of Unexpected Longevity on Saving: Evidence from Korea

Seok Ki Kim*

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Abstract

Unexpected longevity later in life can have a markedly different impact on older people from expected one. While both can increase savings, the sudden longevity makes them rein in their current consumption more dramatically because there is less time to spread their savings for future consumption. As a result, the increase in savings is concentrated at older ages. This effect may not arise when people can foresight longevity and be ready beforehand. I build a simple life-cycle model to show this effect of unexpected longevity shocks on saving rates. With the exceptional speed of longevity in Korea, the model replicates increased saving rates, particularly among older households.

JEL Codes: D14, D91, J10
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*Macroeconomic Research Division, Korea Institute of Finance, Seoul, Korea (e-mail: skkim@kif.re.kr, Tel: +82-2-3705-6367)

1 Introduction

An increase in life expectancy has been a global trend over the last few decades. According to the World Bank, life expectancy of the global population was 52.5 years in 1960 but 70.5 years in 2010. Among the countries where life expectancy increased, the Korean case is particularly exceptional. It rose by 27.6 years during the same period, from 53.0 years to 80.6 years, making Korea one of the countries with the highest life expectancy in the world.

More interestingly, there was a change in the pattern of increasing life expectancy. Before 2000, the drop in child mortality was the main reason for the increase in life expectancy. Recently, however, extended life at older ages has become the dominant factor. Life expectancy of a 65 year old has increased by 4.1 years from 1971 to 2000. That is a 1.4-year increase per decade. But from 2001 to 2010, the increment was 2.9 years.[1] This means that the speed of increase in life expectation at age 65 more than doubled during the past decade.

At the same time, saving rates in Korea have increased significantly. Saving rate, measured by one less the Average Propensity to Consume (APC), increased by 5.4 percentage points, from 20.5% in 2001 to 25.9% in 2012. More interestingly, the size of the rise in saving rates depicts a certain pattern by age: the older the head of household, the larger the increase in saving rate. For instance, while ages 30–39 increased their saving rate by only 3.2 percentage points, ages 60 and above increased their saving rates as much as 14.1 percentage points.[2]

In this paper, I argue that the increase in saving rates, particularly among older households, can be explained by the unexpected drop in mortality at older ages. While the savings motive from reduced mortality exists at all ages, older households do not have enough time to accommodate additional future consumption, and thus reduce their current consumption more dramatically in response to longevity shocks. This results in a large increase in saving rate among the elderly. Meanwhile, younger households can smoothly prepare and secure required savings during their working periods, and thus do not show such a steep hike in saving rates.

Such a suddenness of an increase in life expectation is the key element that creates this uneven increases across age groups and distinguishes my work from other channels which relate life extension and saving. When longevity is anticipated, saving rates would start to increase not at the time of life extension but at the arrival of such information. At the moment of learning it, older generations might not increase savings at all if the time difference between the arrivals of news and real mortality changes is large enough. Young generations, however, would increase saving if such changes affect their mortality later in life. They can accumulate more saving as time passes

[1] Source: Life Tables, Statistics Korea

[2] Source: Household Expenditure Survey, Statistics Korea

and at the time of real life extension all generations would be depicted as increasing savings more equally as even older generations increase it not as much as the case of unexpected longevity from their increased savings during the time between learning longevity and actually experiencing it.

In the literature, it is repeatedly shown that anticipated longevity can increase saving. For example, recently Zhang and Zhang (2005) and Li et al. (2007) find that longevity has a positive effects in saving and Bloom et al. (2003) show that longevity increase aggregate savings using cross-country panel data. In these studies, unexpected longevity is not identified separately from expected one in empirical estimations and longevity is described by changes in parameter in two different steady states where agents can forecast their correct mortality. Therefore, agents in the models of those papers face expected longevity only.

To quantify the longevity shock channel, I build a simple stochastic life-cycle model. The model incorporates uninsurable earnings, a borrowing constraint, a fixed retirement age, and public pensions. More importantly, there is end-of-life uncertainty. Individuals in the model survive into the next period with some probability. I then simulate the model which is calibrated to the Korean economy with unexpected reduction in mortality rates. The model can successfully replicate the age profile of savings. When the size of the decrease in mortality rate is set to match the reduction in mortality rates in Korea from 2001 to 2012, these longevity shocks can potentially account for at least 35% of the increase in saving ratio during this period.

The result is robust to changes in the initial level of saving rates for different age groups. Similar to Taiwan's case documented in Mason and Miller (1998), Korean household saving rates, by age of household head, exhibits a dip in the middle age. Even when the model is adjusted with educational spending to generate this dip, simulation results remain similar and still generate a significant increase in saving rate, particularly at older ages.

The increase in saving rates in East Asia is not new, and its surge from 1950 to 1990 has been attributed to various factors including financial reforms, the growth rate of income, and even the change in measurement accuracy.[3] Deaton and Paxson (2000) analyze Taiwan's case and conclude that changes in demographic structure explains only a small part of the increases in saving rates. Lee et al. (2000) simulate a life-cycle model and find that declining mortality can account for a large part of increased savings. They assume that individuals have correct information about future mortality rate and there is no stark age variation in saving rates. For the case of Korea, Park and Rhee (2005) study the rise in saving rates in the 1970s and 1980s. They found that this increase cannot be explained by the change in relative size of population and the common increases across all age cohorts. Besides, prior studies such as Deaton (1992), Deaton and Paxson (1994b) and

[3] See Lee et al. (1997) for a survey.

Deaton and Paxson (2000) also report an increase in saving ratio at every age, which is in contrast to what we observe in Korea in the 2000s.

More recently, the surge in saving rates in China has been documented. Chamon and Prasad (2010) note that the urban household saving rate has increased and that saving rates over the life cycle is U-shaped. They argue that it can be explained by the increase in privately paid expenditures such as housing, education and health care. On the other hand, Wei and Zhang (2011) argue that a competitive saving motive for the marriage of sons can account for about half of the actual increases in saving rates. These explanations are not valid for Korea in the 21st century, however, because the Korean economy has been a market economy for more than 60 years and the rise in saving rates are pronounced among the elderly whose sons are usually already married.

This paper also belongs to the vast literature on life-cycle models of consumption. The model includes both the permanent income hypothesis feature with fixed retirement age, and the buffer stock saving feature from uninsurable earnings and a borrowing constraint. There are many papers which adopt these two features. For example, Scholz et al. (2006) study whether or not the current saving by Americans is optimal for their retirement using a similar framework. Hansen and Imrohoroglu (2008) study the role of annuities on consumption profiles when there is an end of life uncertainty. Storesletten et al. (2004) also adopt a similar consumption-saving choice in a general equilibrium setting and study risk sharing in the economy. Kim and Lim (2015) use a life-cycle model to seek policy tools for mitigating unexpected side effects from longevity in Korea.

Cocco and Gomes (2012) are more closely related to this paper in that they calculate the value of longevity bond in a life-cycle model where individuals face end-of-life uncertainty and stochastically changing mortality rates. They also observe that life extending at older ages has been more rapid since 2000 compared to the past. Given the similar setting, however, they focus on the portfolio choice problem and argue that the adoption of longevity bond would result in a substantial benefit if longevity risk from forward-looking projections is valid.

The remainder of this paper is organized as follows. Section 2 presents related statistics in Korea. Section 3 introduces and parameterizes the life-cycle model. Section 4 reports the simulation results with longevity shocks. Finally, Section 5 concludes.

2 Related Statistics in Korea

2.1 Longevity

Life expectancy in Korea has increased rapidly during the past few decades. Table 1 presents the change in life expectancy in several countries including Korea. The data, except for Korea, is from the Human Mortality Database (HMD), provided by the University of California at Berkeley. Because the HMD does not provide corresponding data for Korea, I use the official life table statistics released by Statistics Korea.

Table 1: Average Annual Increase in Life Expectancy

Period	Korea	US	Canada	England	Sweden	Germany	France	Italy	Japan
Panel A: at Age 0									
1970 - 1980	0.38	0.30	0.25	0.17	0.11	0.28	0.21	0.24	0.41
1980 - 1990	0.56	0.17	0.24	0.21	0.19	0.26	0.26	0.29	0.28
1990 - 2000	0.47	0.14	0.18	0.21	0.21	0.27	0.22	0.26	0.22
2000 - 2010	0.48	0.19	0.22	0.26	0.18	0.20	0.24	0.25	0.18
Panel B: at Age 65									
1970 - 1980	0.05	0.13	0.11	0.08	0.05	0.15	0.12	0.07	0.22
1980 - 1990	0.16	0.09	0.11	0.11	0.11	0.14	0.17	0.17	0.21
1990 - 2000	0.21	0.04	0.09	0.13	0.12	0.16	0.12	0.16	0.18
2000 - 2010	0.31	0.15	0.17	0.20	0.12	0.13	0.17	0.16	0.13

Note: Panel A reports the average annual increase in life expectancy in number of years for a 0 year old over time in different countries. Panel B reports the corresponding increases for a 65 year old. The data are from the Human Mortality Database except Korea. Korean data is from Statistics Korea.

Table 1 Panel A reports the increases in average life span, i.e. the life expectancy at age 0. Compared with other advanced countries, the speed of increase in lifespan is notable in Korea. With historic economic growth, newborn Koreans could expect to live almost a year more for every two years from 1970 onwards, and the trend continues to the 2000s, although the increment becomes slightly smaller after the peak in the 1980s.

As Cocco and Gomes (2012) emphasize, the pattern of life extension can vary by age. Table 1 Panel B shows increase in life expectancy at age 65 over the same time period. Countries except Japan and Germany experienced the largest increase in life expectancy at age 65 during the most recent decade. Especially, in the case of Korea, the speed continued to increase from the 1970s, and it even reached 0.31 years (per year) during the past decade. In 2000, the life expectancy at age 65 was 16.6 years but it is 19.7 years in 2010. The difference is more than three years. This means that retirement funds would need to increase by 18.7% to accommodate consumption in additional life time if required retirement funds are proportional to the span of extended life. Such level of increase is quite high considering that life expectation has been made at a considerably old age of 65. Unlike the case of the average life span at age 0, a high increase in life expectancy at an old age requires much more significant reductions in death rates at each age 65 and over, because the remaining life span is relatively short.

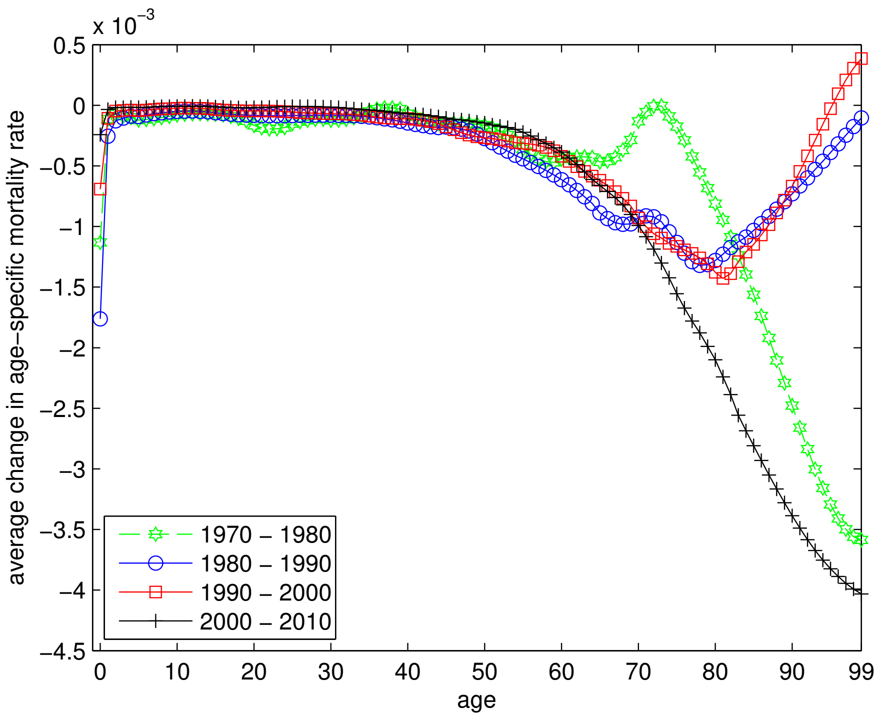


Figure 1: Average Changes in Age-specific Mortality

The dramatic reduction in death rate at older ages in Korea can be observed more vividly in Figure 1, which plots the average change in age-specific mortality rates during the past four decades. First, the average change in mortality rates are negative for all periods and ages, as life expectancy of Koreans continuously increased. More interestingly, however, the decrease in mortality rates shows a different pattern by age. Up to age 30, the size of the reduction in mortality rates in general decreases with time. From age 30 to 70, the largest reduction was made in the 1980s. After age 70, the most significant reduction occurred in the most recent decade. The life extension at older age in the 2000s is a more noticeable change than those in the 1980s and the 1990s. In the 1990s, the mortality rate even increased slightly for those near age 100.

2.2 Saving Rates

The saving rate in Korea has increased significantly from 2001. Savings are measured as the difference between disposable income and consumption expenditures, as in Chamon and Prasad (2010). Consumption and income data are from the Household Expenditure Survey (HES) provided by Statistics Korea. The HES is a quarterly national survey conducted on 9,000 households. Households with just one member are discarded as the official statistics of the HES are calculated. The survey provides detailed information on consumption plus demographic characteristics of the householder (sex, age, education level, employment conditions, etc.), the size and ownership of residence, and type of income. When there are multiple members earning positive income, household income represents the total income of agents in the household. The sample period is from 2001 to 2012.[4]

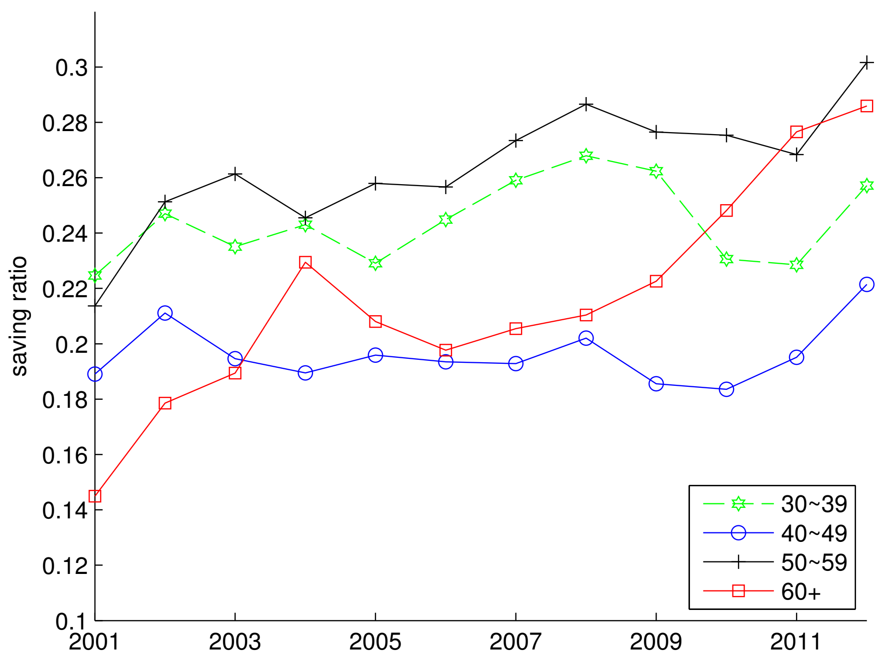


Figure 2: Savings Ratio by Age Group

Given the consumption and income data, Average Propensity to Consume (APC) is calculated from dividing consumption by after-tax income. The saving rate is then defined as 1-APC. Figure 2 plots the saving ratio by age group. The saving rate in Korea has increased for all age groups when they are measured by the difference between the levels in 2001 and 2012. This trend can be verified with other statistics as well. According to the National Accounts, the aggregate private

[4]Thus I avoid any potential structural break due to the 1997–1998 Asian financial crisis.

saving rates has increased from 22.2% in 2001 to 26.6% in 2012.[5]

The more interesting feature in Figure 2 is that the growth in saving rates increases with age. From 2001 to 2012, the saving rates of individuals in their 30s and 40s increased by 3.2 percentage points, respectively. However, the saving rate of individuals in their 50s increased by 8.8 percentage points and 60 and older by 14.1 percentage points.

3 The Model

3.1 Setup

I solve a simple life-cycle buffer stock saving model with uncertain lifetime, uninsurable earnings, and borrowing constraints. Individuals in the model also have retirement periods, and thus have no earning after reaching a certain age.[6] The model is similar to that of Cocco and Gomes (2012), because the model contains not only buffer stock and retirement saving motives, but also the survival probabilities of individuals which are determined exogenously.[7] However, there is no stochastic process of survival probabilities in this model; individuals are assumed to believe that they would not change. But survival probabilities *do* change in the simulations, and individuals take them as an unexpected shock.

One period in the model corresponds to one year of calendar time. Age is denoted by h and agents can live up to age H. Individuals can die at the beginning of each period. The probability of living up to age h is denoted by ϕ_h. The conditional probability of survival at age h given the fact that the individual is alive at age $h-1$ is defined by $\xi_h = \frac{\phi_h}{\phi_{h-1}}$. The individuals' preferences are

[5] Although the National Accounts also report household saving rates, it is misleading to compare them directly with the HES. As documented in Chamon and Prasad (2010) and Deaton (2005), there is a discrepancy between the two rates due to issues related to definition, sampling, and truthfulness in survey responses. In Korea, the problem is more complex, because most of the income from high-income self-employed is categorized as corporate income in the National Accounts. The self-employed make up a significant portion of the labor force in Korea. Korea's ratio of self-employed people to its working population recorded 28.8% in 2010, one of the highest among OECD countries. The omission thus lowers the level of overall household income and results in lower saving rate in the National Accounts. The trend of widening gap between high-income and low-income self-employed makes it even more difficult to measure accurate households saving rates from the National Accounts.

[6] Using a life-cycle model, Bloom et al. (2007) show that the optimal response to a longer life span is to increase working lifetime, rather than to increase savings. However, the retirement age in Korea during the sample period is the second highest among OECD countries. Additional earnings during extended working lifetime would be trivial compared with that in the middle age, considering that earnings decrease rapidly with age after mid-50s in Korea.

[7] The model can also be considered as the partial equilibrium version of Storesletten et al. (2004) with exogenous survival probabilities.

represented by

$$E_t \sum_{h=1}^{H} \beta^h \phi_h U(c_h),$$

where β is the discount factor, c_h is the level of consumption at age h, and $U(c) = c^{1-\gamma}/(1-\gamma)$, where γ is the coefficient of relative risk aversion. The expectation operator E stands for the expectation over uncertainties—future earnings uncertainty and lifetime uncertainty.

Individuals start working at age 30 and they can work up to age R. To describe Koreans working at old age even after being qualified for public pensions, I set up a separate age, P, at which agents begin to receive pensions. While they work, they receive a labor endowment n_h, which is determined exogenously. The labor endowment process is composed of four parts:

$$log(n_h) = \alpha + \kappa_h + z_h + \epsilon_h,$$

where $\alpha \sim N(0, \sigma_\alpha^2)$ is a fixed effect determined at agent's birth, κ_h represents the average earning of age h, $\epsilon_h \sim N(0, \sigma_\epsilon^2)$ is a transitory shock and z_h denotes persistent shock. z_h follows a first-order autoregression:

$$z_h = \rho z_{h-1} + \eta_h, \quad z_{30} = 0,$$

where $\eta_h \sim N(0, \sigma_\eta^2)$. After age P, individuals are entitled to receive pensions. The payment of pension, $B(\bar{n})$, is determined by the average lifetime labor earning, $\bar{n}$.

If I denote the value function of a h year-old individual by V_h, the optimization problem can be represented recursively as

$$V_h(\alpha, z_h, \epsilon_h, a_h, \bar{n}_h) = \max_{c_h} U(c_h) + \beta \xi_{h+1} E[V_{h+1}(\alpha, z_{h+1}, \epsilon_{h+1}, a_{h+1}, \bar{n}_{h+1})].$$

Individuals decide the optimal amount of consumption subject to a budget constraint.

The budget constraint takes a different form depending on the agent's age. Individual can be a worker without a pension ($h < P$), a worker with a pension ($P \leq h < R$), or a retiree ($R \leq h$). Before the pension age, the optimization problem is subject to the following budget constraint, which includes labor income:

$$
\begin{aligned}
c_h + a_{h+1} &\leq a_h(1+r) + wn_h \\
a_{h+1} &\geq \underline{a} \\
\bar{n}_{h+1} &= \frac{\bar{n}_h h + n_h}{(h+1)},
\end{aligned}
$$

where a_h is the individual's asset holdings, r is the real interest rate, w is the real wage per effective labor unit, and $\underline{a}$ is the borrowing limit. The average earning up to age h is denoted as $\bar{n}_h$.

When agents still work but start to receive pensions, the budget constraint is as follows:

$$
\begin{aligned}
c_h + a_{h+1} &\leq a_h(1+r) + wn_h + wB(\bar{n}_h) \\
a_{h+1} &\geq 0 \\
\bar{n}_{h+1} &= \bar{n}_h
\end{aligned}
$$

Note that the average earning does not change between periods.

Finally, after retirement, individuals do not have any labor income. The budget constraint is thus given by

$$
\begin{aligned}
c_h + a_{h+1} &\leq a_h(1+r) + wB(\bar{n}_h) \\
a_{h+1} &\geq 0 \\
\bar{n}_{h+1} &= \bar{n}_h
\end{aligned}
$$

To aggregate consumption and saving, it is assumed that the total population does not change. That is, the number of new individuals who enter the economy is equal to the number of individuals who die at that period.

3.2 Parameterization

3.2.1 Longevity Shocks

The calibration of longevity shocks is particularly important in fitting the model because it forms the individuals' expectations about the span of their lives. If agents can correctly anticipate future longevity early on, they can start to prepare for additional consumption. The size of changes in saving rates would be small (large) if the time distance between the two events—the arrival of news and the arrival of longevity shocks—is long (short).

Instead of using a stochastic process to describe changes in mortality rates, I use actual changes in mortality rates between t and $t-1$ as unexpected shocks. There are some benefits of adopting this procedure over estimating a stochastic process. First, a stochastic process typically uses a scalar or a vector to describe the level of mortality rates at all ages. Although convenient, this does not reflect accurate age-specific changes in mortality rates. Since reduction in mortality rates at older ages, not throughout the whole age spectrum, is the main focus of this paper, using a stochastic process would not be appropriate. Second, by using actual changes in mortality rates, state space can be saved and calculation burden can be mitigated. Lastly, since reduction in mortality rates at older ages suddenly precipitated from 2000, it would have been difficult for agents to anticipate such large changes in mortality.

To elaborate on the last point, I compare actual changes with forecast errors by estimating the Lee and Carter (1992) model. The Lee and Carter model is one of the most widely used models for the evolution of mortality rates in the literature (e.g., Cocco and Gomes, 2012 and Lee et al., 2000). According to the Lee and Carter model, the mortality rate at age x in period t ($m_{x,t}$) is as follows:

$$\ln(m_{x,t}) = a_x + b_x \times k_t + \epsilon^m_{x,t},$$

where k_t is an index which captures the evolution of mortality over periods, and a_x and b_x are age-specific parameters. To estimate this model, the Single Value Decomposition (SVD) is used because there are no given regressors.

Lee and Carter (1992) also argue that a random walk with drift would explain the evolution of k_t well among ARIMA time series models. The stochastic process for k_t is then:

$$k_t = \mu^k + k_{t-1} + \epsilon^k_t$$

I estimate the process above with the official life tables provided by Statistics Korea, on a rolling basis by using 30 years of the data prior to the year of forecast. It turns out that the forecast errors and the actual decrease in mortality rates are comparable, especially under age 80. Figure 3 plots the average forecast errors and average changes in mortality rates from 2001 to 2012. Up to age 73, the average forecast errors are slightly smaller in absolute magnitude than the average of actual changes. However, beyond that age, forecast errors are larger than actual changes in absolute magnitude. After age 90, the size of average forecast errors are 50% larger than the size of average changes in actual mortality rates. In sum, the two lines are close to each other between age 60 and 90 where longevity shocks can affect saving rates substantially. In this age range, there

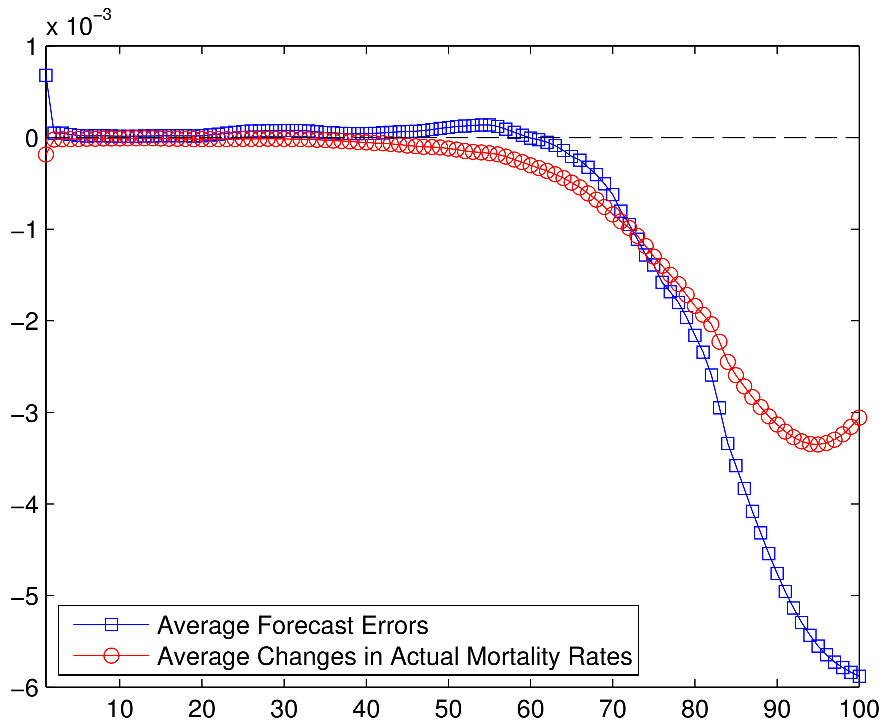


Figure 3: Average Forecast Error and Average Changes in Mortality Rates

is almost no earning and the survival probabilities are significantly higher than after age 90.

3.2.2 Income

Individuals in the model start working at age 30, receive pensions at age 65 and become retirees at age 70. Korean men enter the labor market at a relatively old age because of mandatory military service, which can take up from two to five years depending on the type of service. The average effective age of retirement for Korean men is documented as 70.1 according to OECD data during the sample period from 2001 to 2012.

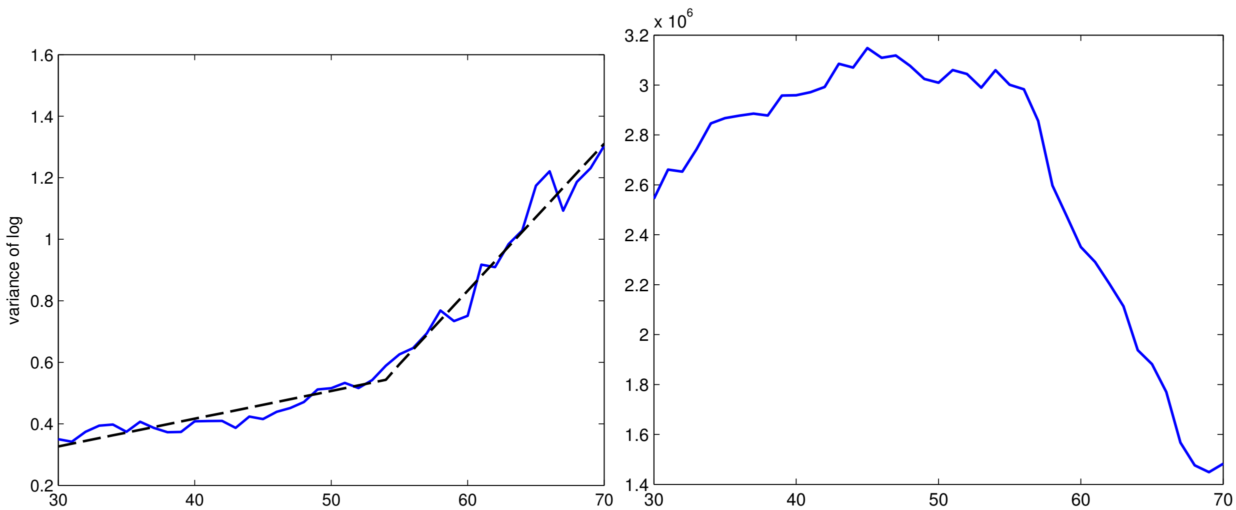
The calibration procedure for earnings process is similar with that of Storesletten et al. (2004). From the logarithm of annual real earnings data (y_{ih}), the idiosyncratic component of earnings (u_{ih}) can be derived by the dummy-variable regression as in Deaton and Paxson (1994a). Specifically, u_{ih} is defined by

$$u_{ih} = \alpha_i + \epsilon_{ih} + z_{ih}.$$

Then the variance of u_{ih} can be decomposed as

$$Var(u_{ih}) = \sigma_\alpha^2 + \sigma_\epsilon^2 + \sigma_\eta^2 \sum_{j=0}^{h-1} \rho^{2j}. \tag{1}$$

In the HES, there are four sources of income: labor, business, wealth, and transfer. Labor income is straightforward. Business income is the flow of income from running individuals' own business. Wealth includes interests, dividends and personal annuity. Transfer includes public pension benefits and other social security benefits. Earnings is defined as the sum of (after-tax) labor, business, and transfer, minus public pension benefits. Because saving is determined endogenously in the model, wealth is excluded from earnings. Public pension benefits are also excluded because it is modeled as a separate income source.



(a) Earning Variance by Age

(b) Average Earning by Age

Figure 4: Earning Variance and Average Earning by Age

Figure 4a presents the cross-sectional variance of the logarithm of earnings by age (solid line) and the linear approximation of it (dashed line). One particular characteristic in the earnings variance of Korean households is the existence of a kink; the slope of the graph is steeper after mid-50s. It reflects a unique aspect of the Korean labor market in which many find a second job after retiring from one's "lifetime job." According to the Economically Active Population Survey, the average age of leaving the lifetime job was 53 in 2005. However, people do not retire at that time, instead they get a second job and work until almost 70. Insufficient public pension scheme is known to have contributed to such late retirement.

The second job usually pays much less than the first lifetime job. Figure 4b shows the profile of average earnings by age. It is over 3 million won (approximately 2,700 USD) by mid-50s, but it drops significantly after that. This sudden fall in average earnings around mid-50s causes a rise in the variance of earnings when it is in logarithmic form. Because the slope of a logarithmic function increases as the domain gets smaller, the variance of log earnings would become larger as the average earnings becomes smaller. To account for the increase in variance from the mid-50s, the graph in Figure 4a is thus approximated with two different slopes instead of one line as in Storesletten et al. (2004).[8]

Given equation (1), $\sigma_\alpha^2 + \sigma_\epsilon^2$ corresponds to the vertical intercept in Figure 4a, σ_η^2 is the slope, and ρ is the curvature of the graph. Estimation results are $\sigma_\alpha^2 + \sigma_\epsilon^2 = 0.3266$, $\rho = 1$, and $\sigma_\eta^2 = \{0.0090, 0.0478\}$. To estimate σ_α and σ_α separately, a panel data set is required. The HES does not track each household, however, and hence I use the corresponding ratio in Storesletten et al. (2004), which is calibrated with the Panel Study on Income Dynamics (PSID) data: $\sigma_\alpha^2 = 0.2485$ and $\sigma_\epsilon^2 = 0.0756$. The age earnings profiles (κ_h) are set to the average of earnings at each age.

Public pension payment starts at age 65 and continues until the death of individuals in the model. Pension payments are assumed to be as follows:

$$B(\bar{n}_h) = bn_h$$
$$B(\bar{n}_h) \geq \underline{b}$$
$$B(\bar{n}_h) \leq \bar{b}.$$

The public pension system in Korea is composed of two pension plans—Basic Pension Service and National Pension Service. Basic Pension Service targets people aged 65 and above who are below 70% in recognized income. The formula for calculating recognized income includes earnings, wealth, and personal information such as the location of residence, marital status, etc. In 2010, this system covered 67.7% of the total population aged 65 and above and the maximum monthly payment was about 90 thousand won (approximately 80 USD) for singles and 144 thousand won (approximately 130 USD) for households of two. To reflect the Basic Pension, $\underline{b}$ is set to correspond to 100 thousand won (approximately 90 USD).

The National Pension Service, on the other hand, is a mandatory public pension fund for salary workers. According to the press release by the Ministry of Health and Welfare in 2010, which oversights the National Pension Service, the effective replacement rate of the National Pension Service is between 12.8% and 25.5%. Given this, b is set to 0.2. $\bar{b}$ is set to correspond to 3.6 million won per month (approximately 3,200 USD), which is the highest income level recognized

[8]Simulations using one line to approximate earnings variance, by extending the first segment of the line till age 70, do not generate significantly different results.

by the National Pension Service in 2010. If people work after age 65 and earn labor or business income, there is a slight discount in the pension payment. This discount is just 5% of the portion of earned income beyond the average income of all members. Furthermore, the penalty for earnings stops after age 70.[9] Refer to Table 2 for a list of all calibrated parameters related to income.

Table 2: Calibrated Parameters Related to Income

Parameter	Value	Notes:
ρ	1	Persistence Parameter for Individual Earning Process
σ_η^2	{0.0090,0.0478}	Variance of Persistence Earning Shock
σ_ϵ^2	0.0756	Variance of Transitory Shock
σ_α^2	0.2485	Variance of Fixed Effects
$\underline{b}$	6.215	Minimum Average Income
$\underline{b}$	8.175	Maximum Average Income
b	0.2	Replacement Rate

3.2.3 Other Parameters

I assume that the maximum age, H, equals 100. For discount rate β, I use 0.962 as in Storesletten et al. (2004). The interest rate is set to $r = 0.047$, which is calibrated to the average deposit interest rate from the Bank of Korea during the sample period.[10] A coefficient of relative risk aversion, γ, is set to 2.

4 Results

4.1 Initial States

At the initial state, with the fixed survival rates of year 2001, individuals repeat the same consumption-saving decision problem according to their states: age, asset level, earnings (which depends on transitory and persistent earnings shocks), and the average lifetime earnings. Because the number of individuals who enter the economy is the same as the number of people who die at each period, the population pyramid is stationary in the initial state. The age pyramid using the age of the household head in the HES data is depicted in Figure 5. The distribution is bell-shaped.

[9]Because earned income from age 65 to 70 is small and the replacement rate is close to 0, equating the two ages, R and P, does not significantly alter the main results.

[10]A closed economy version of this model can be found in Storesletten et al. (2004). With similar parameters as in this paper, the endogenous market clearing interest rate is 0.04.

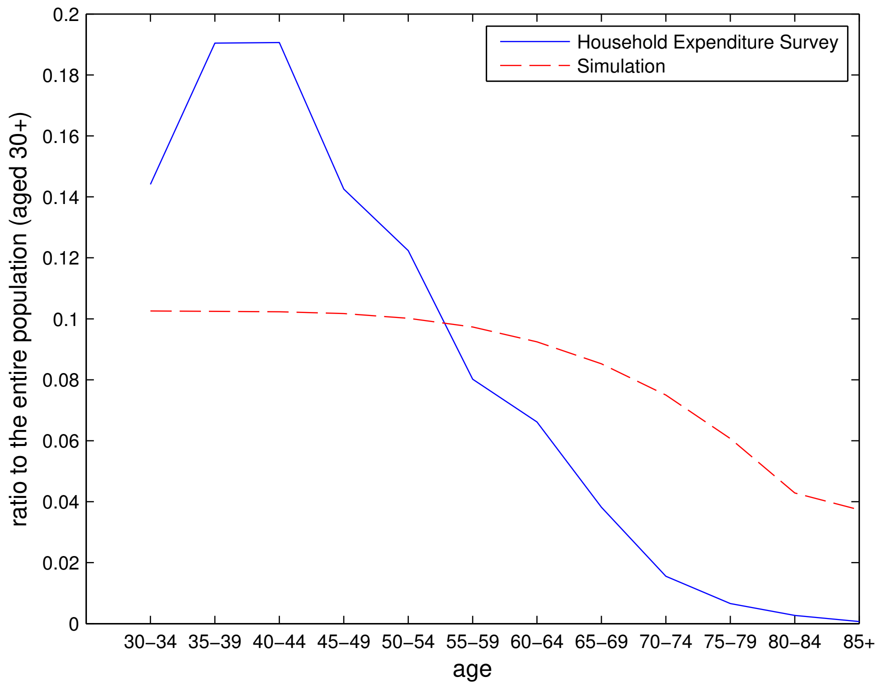
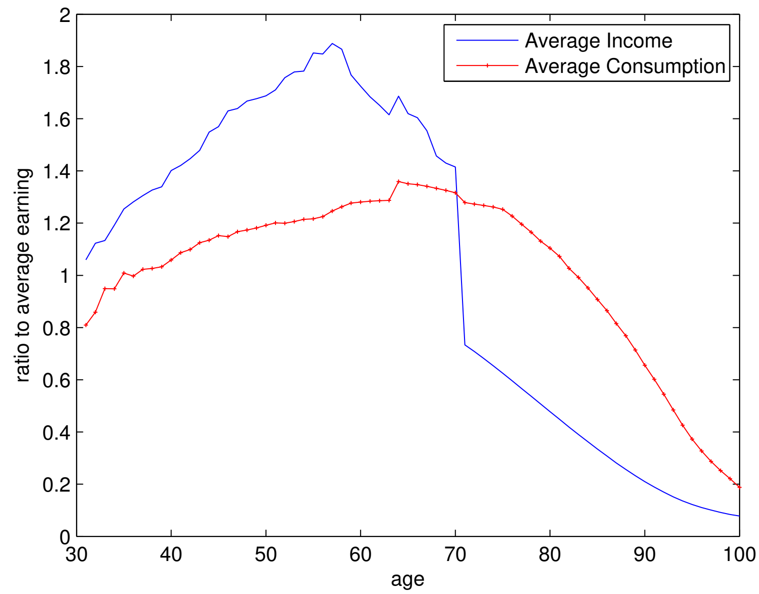


Figure 5: Age Pyramid

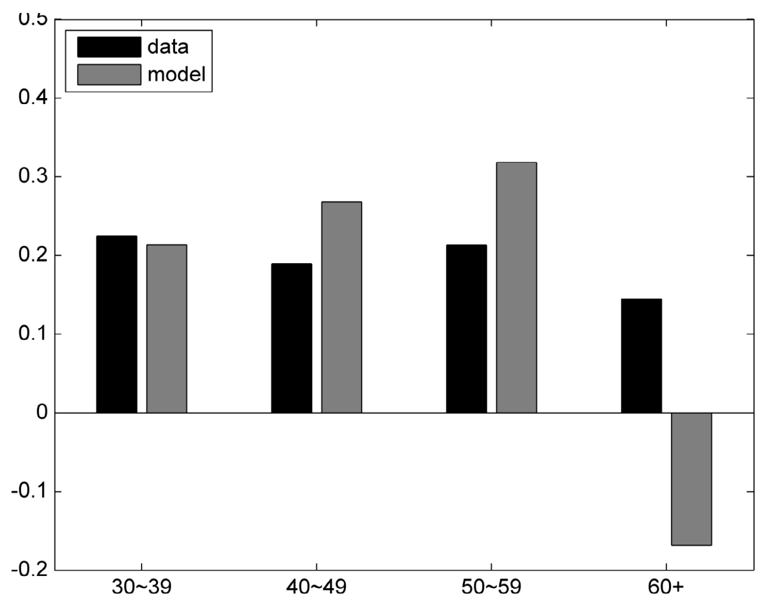
After the 1950–1953 Korean war, there was a baby boom and a significant drop in child mortality rate ensued from rapid economic growth. Thus, the Korean population pyramid in 2001 is in general more expansive than the simulation result except for ages 30 to 39, in which the younger group 30–34 takes a relatively smaller portion. This implies that older people are overrepresented in the aggregated result of the simulation. By reporting results by age decades, I try to scale such distortions down.

Figure 6a shows the simulated profiles of average income and consumption over the life cycle. Here income means earnings (plus pension) and returns from assets. These profiles are similar to the results from standard life-cycle models of consumption and savings decision such as Cocco and Gomes (2012) and Gourinchas and Parker (2002). Two well-known motives for savings, which are built into the model, can be found in Figure 6a. The first is saving for retirement while individuals are working. The other is the precautionary savings motive, which is represented by the increase in income followed by increase in consumption.

Despite the fact that consumption follows income growth from age 30 to 55, consumption continues to increase for some years after the peak in income. The weak co-movement of the two variables is due to the steep decline in income after retirement. A large reduction in income without proper alternative source, such as pensions, generates a strong retirement saving motive. Thus, compared to the results in prior studies mentioned above, consumption behavior in the simulated



(a) Simulated Profiles over the Life Cycle



(b) Savings Ratios by Age Decades in Initial State

Figure 6: Consumption-Saving Choice in Initial State

model based on Korean earnings data seems to be largely affected by the retirement savings motive than the precautionary savings motive.

Figure 6b shows the average saving ratios by age in the initial state of the model and the corresponding saving ratio with the 2001 data. The saving rate of individuals aged 30 – 39 in the model is 21.3%, which is similar to the actual saving rate (22.5%). However, the difference between the data and the model increases with age. The average saving rate in the model are 25.5%, 30.6% and −19.7% for people aged 40 – 49, 50 – 59, and 60 and above, respectively. The corresponding ratios in the data are 18.9%, 21.3%, and 14.5%. The stark difference in saving ratio at later ages comes from the dissaving in the model. This is a common failure of life-cylcle models as discussed in Lee et al. (2000).

4.2 Responses to Longevity Shocks

Given the initial state, I simulate the model to measure the changes in consumption-saving choices as survival probabilities (mortality rate) increases (decreases) unexpectedly. As explained above in Section 3.2.1, individuals consider changes in survival rates between the two adjacent years as unexpected shocks.

When a longevity shock arrives, individuals face increased chances of surviving in the next period. Considering that the calibrated longevity shocks to Korean life tables from 2001 to 2012 are mainly about increased survival probabilities at older ages, it can be said that individuals expect themselves to live for a longer period, especially after retirement. They realize that their consumption-saving choices, which were planned under the past survival probabilities, are no longer optimal. Because retirement age is assumed to be constant, they start to increase savings for consumption during the extended periods with no labor income.

The saving motive is stronger for older people because they do not have much time to smooth out the required increment of savings whereas younger people have a relatively long period to distribute the amount. Thus, the increase in saving rates at older ages is significantly larger compared to younger ages. Because death is assumed at age 100, there is no increase in saving rates at ages near 100, however. This also implies that individuals who are sufficiently old would start to consume more in 2012 than in 2001, based on larger savings they accumulated during the period between those years.

Figure 7 plots simulated profiles of average income and consumption in the initial state, which is labeled as 2001, and in the last year of simulation, which is labeled as 2012. The average consumption in 2012 is smaller at every age younger than 76 compared to the average income at the same age in 2001. Again, increased savings are for consumption during extended lifetime. After age 76, however, individuals start to consume more in 2012 from their increased interest income based on boosted savings. In terms of average income, it is always larger in 2012 than in 2001. The increase of income from 2001 to 2012 grows with age at first, but diminishes to zero as age nears 100.

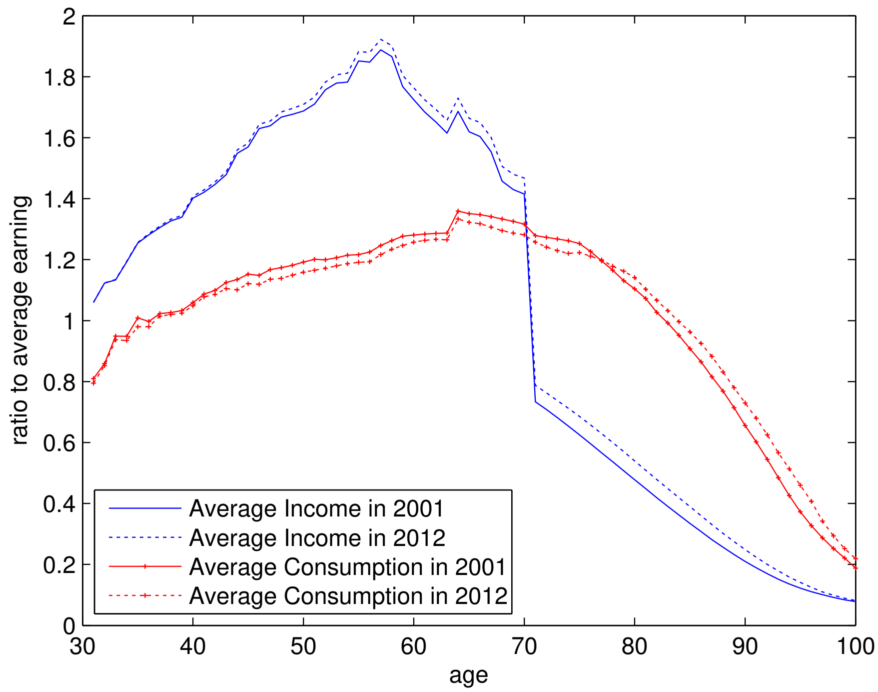
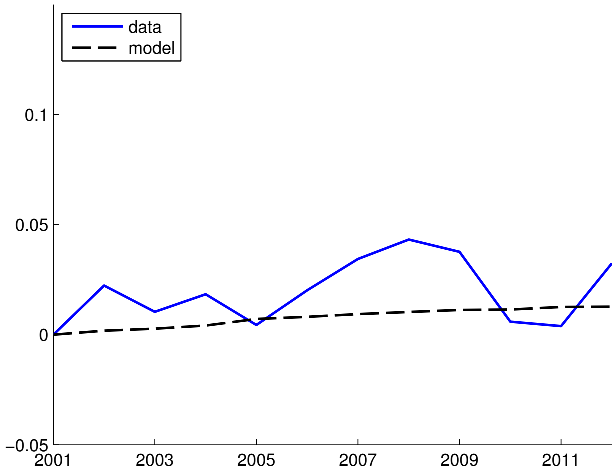


Figure 7: Simulated Profiles over the Life Cycle in 2001 and 2012

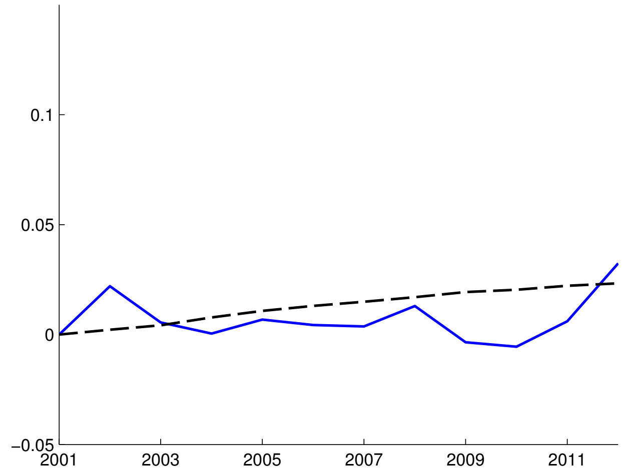
Figure 8 shows the dynamic pattern of changes in saving rates. Each panel plots simulated saving rates and corresponding values in the data by age group. The increments are measured by the level in 2001 and each panel uses the same vertical axis for ease of comparison. As explained above, each age group presents a different slope of saving rates. The simulation results mimic the patterns in the data where saving rates grow faster with age. In the simulation, the maximum increment in saving rate during the sample period is 1.3 percentage points for the youngest group and 6.0 percentage points for the oldest.

The simulation results track data more closely for the age groups 30 – 39 and 40 – 49 than older groups. In the older groups, increase in saving rates from the simulation results is smaller than the corresponding data. In the case of the oldest age group of 60 and above, the model follows the data closely up until 2009. Compared with the 2001 level, the actual saving rate increment in 2009 was 7.8 percentage points and the simulated increment, 6.0 percentage points. That is about 77.3% of the actual increment. But the simulated saving rate diverges from the data and starts to fall while saving rates in the data continue to increase even after 2009. The model still explains 36.9% of the increment in actual saving rate from 2001 to 2012. Table 3 provides the detailed results of saving rate changes from 2001 to 2012 in the model and compares them with corresponding real changes.

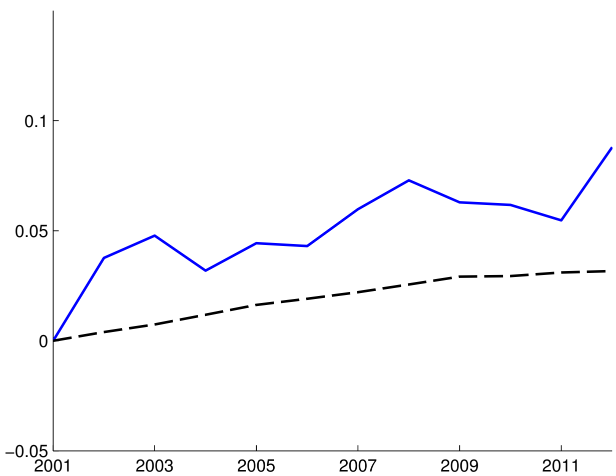
Other factors might have contributed to the divergence between simulations and data for the



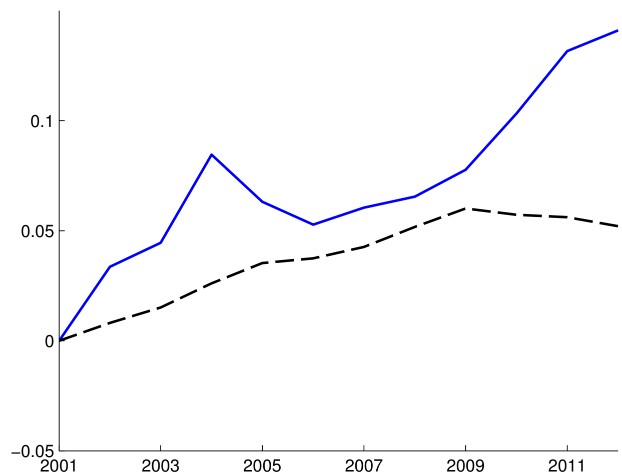
(a) Age 30–39



(b) Age 40–49



(c) Age 50 – 59



(d) Age 60 and above

Figure 8: Changes in Saving Rates by Age Decades

oldest group since 2009. There were some significant changes from 2009 following the global financial crisis in 2008 – 2009. For example, the Bank of Korea lowered its policy rate substantially from 2009.[11] The much lower interest rate might affect the consumption-saving choice of older households. Recent literature such as Wong (2016) and Auclert (2016) discover that monetary policy could affect consumption choice differently by individuals' status including age, asset holdings and portfolios.

[11] Until Oct. 2008, the policy rate of Korea was 5.25% but it was lowered to 2% in Jan. 2009 and stayed at a lower level than before.

Table 3: Changes of Saving Rates from 2001 to 2012

Age	Data	Model	Change in Model / Change in Data
30 – 39	0.032	0.013	0.393
40 – 49	0.032	0.023	0.718
50 – 59	0.088	0.031	0.360
60 and above	0.141	0.052	0.369

4.3 Robustness Check

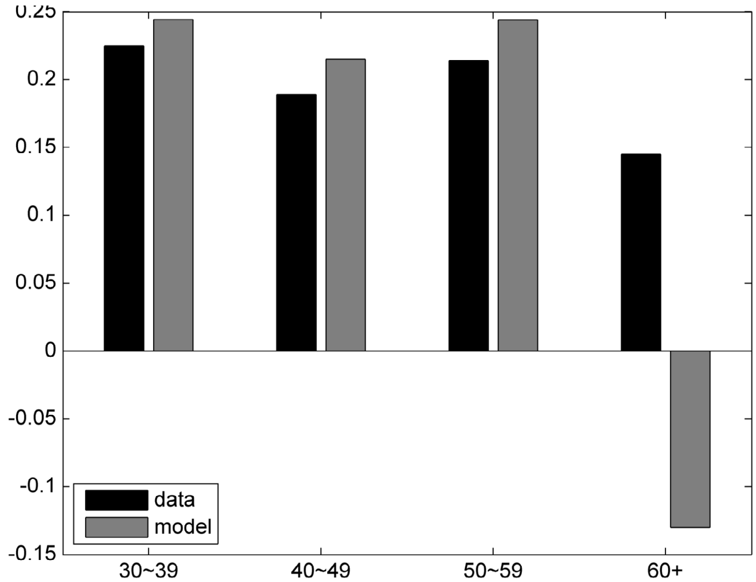
One difference between the simulation results in the initial state and the corresponding data in 2001 is the shape of the age-saving profile. While the model generates a hump-shaped profile, which is a typical result of a life-cycle model, the pattern from the extracted data shows a dip in the middle ages as shown in Figure 6b. As documented in Lee et al. (2000) and Mason and Miller (1998), Taiwan households also exhibit a similar pattern; they argue that a rise in dependency rate relative to household income during those ages contribute to such divergence.

The dip in saving rates in middle ages is worth noting because it may contribute to positive savings at older ages in the data, whereas the model predicts a significant dissaving. Not enough savings due to factors such as an increase in dependency rate in middle ages might result in more saving at older ages. If saving rates are already high at older ages, there may not be as large a saving response to longevity shocks.

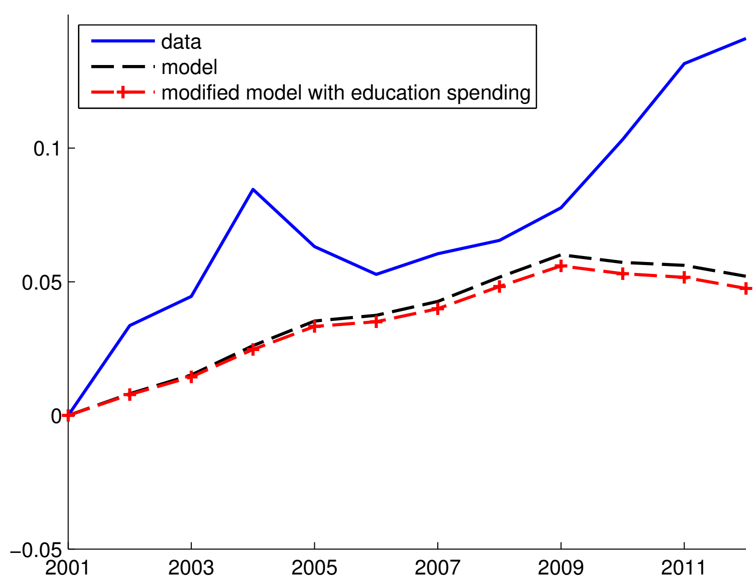
In Korea, the rise in children's education expenses is considered to be an important factor in driving the plunge in savings at middle ages. It is well-known that Koreans put heavy emphasis on education. Recently, Kwon and Oh (2014) find that the average Korean household in their 40s spends about 14% of their disposable income on their children's education while the corresponding American household spends only 2.1% of their income. They also find that if they ignore the education spending from the household consumption expenditure, the profile would return to a typical hump shape.

To address this concern, I simulate the model with a modified budget constraint. The new budget constraint is applied to individuals aged 40 – 59. It is assumed that a constant portion of disposable income must be spent on education similar to the out-of-pocket medical expenses in Scholz et al. (2006). The modified budget constraint is represented by

$$\begin{aligned} c_h + c_h^e + a_{h+1} &\leq a_h(1+r) + wn_h \\ c_h^e &= e(a_h r + wn_h), \end{aligned}$$



(a) Saving Rates by Age Decades in Initial State



(b) Changes in Saving Rates of 60s

Figure 9: Results from a Model with Modified Budget Constraint

where c_h^e represents educational expenses and e is the ratio which determines the portion of education spending out of disposable income. In the simulation, e is calibrated to 0.12 to take into account the difference between the ratio of education spending out of disposable income from Korean households and that from American households as in Kwon and Oh (2014).

With the modified budget constraint in middle ages, the model successfully generates a dip in saving rates. Figure 9a compares the saving rates of the data and the model with the modified budget constraint. Saving rates are higher for individuals aged 30 – 39 than those in 40 – 49 or 50 – 59. Results from the model follows closely the saving rates in the data. A significant dissaving by older individuals still exists in the model, however, although the size is slightly smaller than the result of the simulation with the original budget constraint (from -16.8% to -13.2%).

The dynamic responses of saving rates to longevity shocks remain essentially unchanged despite the change in budget constraint. Figure 9b shows the dynamic responses of saving rates from individuals aged 60 and above. With the modified budget constraint, the increment of saving rate becomes slightly smaller. However, the maximum difference between the two results does not exceed 0.5 percentage points.

5 Conclusion

During the first decade of the 2000s, two interesting phenomena arose in Korea: a rapid reduction in mortality rate at older ages and an increase in aggregate saving ratio, increasing with age of the household head. The life-cycle model in this paper explains the surge in saving rates with unexpected longevity shocks. A sudden drop in mortality rate and the feature of unpredictability generates a sharp adjustment in consumption for older people. The model shows that unexpected longevity shocks can explain at least 35% of the observed increase in saving ratio by age.

In cases like Korea, additional savings at older ages due to longevity shocks imply a stretched financial situation at the personal level. In societies where individuals receive enough public and private pensions, on the other hand, longevity shocks could impose heavy burdens on the government or insurance companies. The results of this paper thus suggest that preparation at all levels of the society is necessary in economies with growing life expectancies at older ages.

Lastly, there are factors besides longevity shocks which could affect consumption-saving decision differently by age. Not only policy variables such as the interest rate, but also cultural attributes such as the fading trend of old age support by children may elicit a hike in saving rates of older people. The effects of these factors on saving rates are possible areas of future research.

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