Life-cycle Consumption in an Aging Economy: The case of Korea

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This paper estimates the changes in the life-cycle profiles of consumption due to changes in age-specific death rates—one of the most important causes of population aging. Household Income and Expenditure Survey data is used for the estimation. The results show that consumers choose lower levels of non-durable consumption as age-specific death rates decrease, suggesting that they substitute current consumption with future consumption in response to increased life expectancy. While these consumption decreases are observed in overall ages, they appear notably large at ages close to retirement, approximately after the age of 50. A historical simulation based on the estimation results and changes in age distribution between 1995 and 2016 suggests that aggregate per capita consumption decreased constantly, by an annual average of 0.9%. Both the changes in individual consumption due to lowered age-specific death rates and the changes in age distribution due to population aging played an important role in these per capita consumption decreases. Prediction results suggest that per capita consumption may decrease further until mid-2030, and that the individual consumption modification will

emerge as the main channel while the changes in age distribution will work in the opposite direction with the past.

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Ⅰ. Introduction

Population aging is one of the most important changes facing Korea in terms of the economy and society. Population aging is inevitable; the country is inching toward becoming a so-called "super-aged society." Therefore, an important challenge is to understand the effects of population aging and to prepare for the upcoming future.

This paper studies on the effect of population aging on consumption, among its broad effects on economy. It is noted that population aging can affect consumption through various channels. On the supply side, the working-age population is decreased and the average labor productivity is lowered as the labor participation of elderly is increased. This shrinkage of the economy's production capacity leads to changes in household income, affecting consumption choice of individuals. On the other hand, population aging can also influence the demand side. For example, rising life expectancy encourages people to increase their savings to prepare for their extended lifespan. This change in intertemporal substitution between current and future consumption can make the individual life-cycle consumption patterns to be changed.

The focus of this paper is on the demand side channels of population aging. The main question is that how individual profiles of life-cycle consumption has changed as life expectancy—one of the most important causes of population—has increased. The change in life expectancy is measured in a rich dimension by using the age-specific death rates. The microdata of the Household Income and Expenditure Survey published by Statistics Korea is used for the estimation. First, the patterns of life-cycle consumption along the changes in age-specific death rates are estimated. Then, using the estimates the historical and predicted effects of population aging channeled through increased life expectancy and age distribution, on the level of aggregate per-capita consumption are estimated.

The results show that the levels of non-durable consumption are decreased as age-specific death rates decrease, suggesting that individuals substitute their current consumption with future consumption in response to increased life expectancy. While these consumption decreases are observed in overall ages, they appear notably large at ages approximately after the age of 50, suggesting that this intertemporal substitution largely happens for individuals at ages close to retirement. Simulation results show that historically both the increased life expectancy and the changes in age distribution worked importantly, while the life expectancy channel is expected to be more important in the future.

The finding that an increase in life expectancy of individuals leads to a decrease in present consumption is a consistent result with theories and other literature.[1] However, this research differs from previous studies in the following ways.

First, this study estimates the effect of the increased life expectancy on the overall life-cycle profiles of consumption, rather than its impact on a single measure of consumption. The estimation results in fact show that the effect is significantly different by age of individuals.

Second, this study estimates the relationship between age-specific death rates and consumption using a non-parametric method. This considers the parametric model uncertainty and potentially non-linear relationship between the death rate and consumption. It also considers the fact that the model needs to be sufficiently flexible to estimate the heterogeneous effects which could vary by ages as mentioned above.

Third, this study focuses on the demand side channel, driven by changes in intertemporal substitution choices due to increased life-expectancy. The effects of cohorts and time is controlled to exclude the effect of income growth and variation. The use of rich age-specific death rates as the measures of life-expectancy gives variations mitigating the potential problems of spurious co-trend relationship between the consumption and life-expectancy.

With these features, the estimation results of this study present a detailed picture of how the rising life expectancy had changed the life-cycle consumption pattern. Simulation results based on these estimates reflect the heterogeneous effects along the life-cycle. The estimates of life-cycle consumption profile in this paper which explicitly considers the changes in life expectancy can gives a quantitative basis for future research.

The content of this study is organized as follows. Section II provides the model specification and data, while Section III presents the model's estimation results. Section IV analyzes the impact of population aging on aggregate per-capita consumption in Korea, based on the estimation results, and outlines future prediction. Section V concludes.

1) In domestic research, Kim Seok-gi and Im Jin (2015) and Hong Jae-hwa, Lee Young-jae, and Kang Tae-su (2016) use an overlapping generation model and find that a decrease in age-specific death rates leads to a decrease in the average propensity to consume and an increase in savings. Meanwhile, Lee Hong-jik and Choi Ji-won (2015) and Jeon Gwang-myeong, Lee Hong-jik, Bang Su-yeon, and Lee Dong-jae (2017) use a linear model to present the finding that rising life expectancy reduces the average propensity to consume.

II. Model Specification and Data

This paper uses pseudo-panel data, which is panelized based on the birth data and gender of household heads, constructed from the Household Income and Expenditure Survey of Statistics Korea. Before explaining the data, it is noted that the following model considers underlying panel data structure.

1. Model specification

A partially linear model is constructed as below.

$$\log(C_{cgt}) = \beta_c\gamma_c + \beta_t\psi_t + \beta_g\eta_g + f(a, \{P(\alpha,g,t)\}_{\alpha=a}^{\overline{a}}) + \epsilon_{cgt} \cdots (1)$$

Here, the $\log(C_{cgt})$ on the left side represents the logarithm of consumption of an agent, born at time c with age a and gender g at time t. On the right side, γ_c, ψ_t, and η_g refer to dummies of birth year, time and gender, respectively. The non-parametric function f reflects the effects of all the current and future death rates P faced by the agent, from the current age a to the expected maximum lifespan $\overline{a}$.[2)]

The model is non-parametrically constructed on a dimension of the age and death rate, which is the main focus of this study, while constructed parametrically for other control variables. This partial structure is for the balance between the flexibility and the inefficiency, by avoiding a huge inefficiency when estimating all the variables in a non-parametric manner.

Dummies of birth year controls the effect of lifetime income or resources. As the economy grows, generations born later are more likely to enjoy higher lifetime income than the preceding generations. These dummies try to capture the effect of variation of lifetime income. The time dummies control for the effect of aggregate business cycle fluctuations.

Explaining the difference in consumption with time of birth and age as in (1) is in line with the Modigliani's life-cycle hypothesis under certainty. This model additionally captures the effects of time and gender and, above all, allows for consumption to differ depending on age-specific death rates as a factor of population aging. It is worth noting that the effects of time of birth, time, and age cannot be separately identified without making additional assumptions.[3)] This study

2) The equation (1) implies that the age-time dependent death rates can be regarded as the parameters of consumers' expected utility. For example, expected utility function that explicitly considers the survival of consumers may be expressed as $\sum_{t=0}^{T}(1-P_t)E_0[\beta^t U(C_t)]$ In such a utility function, the current and future death rates can be viewed as the parameters that affect the optimal consumption choice of consumers.

3) This is attributed to the fact that, since the age equals the current time minus time of birth, all the dummies of time of birth, age, and time are linear dependent. In this model, they are not perfectly linear dependent because a nonparametric term is used for the age, not age dummies, but still a similar problem remains potentially.

identifies them following Deaton (2019).[4]

To reduce the number of dimensional spaces, the expected future and current death rates in (1) are replaced with only the current death rate, as in (2) below. That is, the death rate faced at the current time, $P(a,g,t)$, is used as a summary indicator for all of the expected future death rates.[5] This final equation (2) is used for the estimation.[6]

$$\log(C_{cgt}) = \beta_c \gamma_c + \beta_t \psi_t + \beta_g \eta_g + f(a, P(a,g,t)) + \epsilon_{cgt} \quad \cdots (2)$$

The above multivariate partially linear model is estimated following the two-stage estimation method by Speckman (1988). The Nadaraya-Watson estimator is used for the estimation of the nonparametric term.[7]

2. Data

For consumption data, this paper uses I use quarterly data of the Household Income and Expenditure Survey published by Statistics Korea from 1990 to 2016. As publication for quarterly data was discontinued in 2017 due to statistical standard revision, data are only available up to 2016.

It collects data on household heads by groups with the same time of birth and gender in each quarter and construct pseudo-panel data by averaging their consumption spending in each group. The groups of birth year are divided as five-year groups increments starting from 1915. Groups with fewer than five observations are excluded to reduce errors. In addition, age is restricted from 30 to below 80.

Only non-durable spending, excluding durable spending, is used for the consumption measure. The level of consumption is standardized using an equivalent scale of $\sqrt{N}$, with N being the number of household members.

For the age-specific death rate, the dying probability from the life tables published by Statistics Korea is used. Here, the dying probability refers to the probability that a person of a certain age dies during that certain age. For the prediction in Section Ⅳ, the dying probability from the estimated life table and population projections, both published by Statistics Korea, are used.

4) The identification relies on the assumption that the time effects are orthogonal to a time trend and are average to zero over the sample period. For details, see Deaton (2019).
5) Several potential problems can be pointed out for this model specification. First of all, the death rates may not be a highly relevant parameter for individual's intertemporal consumption choices. Furthermore, the current death rate as a summary indicator may not represent the future death rate properly. Meanwhile, it is noted that the logarithm of age-specific death rates is nearly linear to ages, which means that the death rate increases by ages at a highly stable rate. If age-specific death rates are linear to ages, all the changes in future death rates can be represented by the two parameters of a linear equation. In this case, the number of dimensions that the current death rate should represent for decreases significantly.
6) If gender and death rates are removed from equation (2), it shrinks to the model of Fernandez-Villaverde and Krueger(2007).
7) As for the kernel function, I this paper use the standardized Epanechnikov kernel. The bandwidth matrix for the multivariate kernel is assumed to be a diagonal matrix, and the two parameters of the diagonal matrix are chosen to minimize the out-of-sample prediction errors according to five-fold cross-validation.

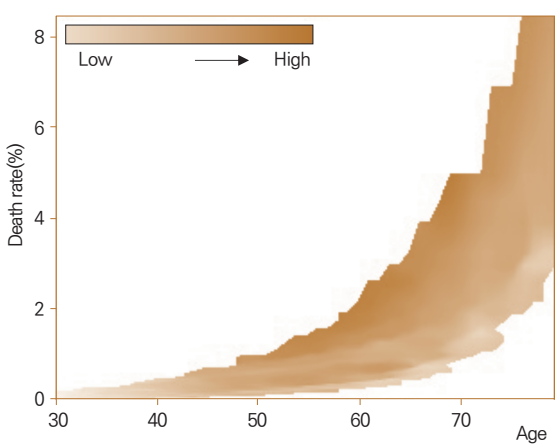
Ⅲ. Estimation Results

The estimated levels of consumption by age and death rate are shown in Figure 1. The figure shows the expected value for log-consumption predicted by the non-parametric term in (2), excluding the fixed effects of time of birth and time. Darker color indicates higher levels of consumption.

To clearly identify change in consumption due to death rate, Figure 2 depicts slices of the 3D graph of Figure 1 along the death rate dimension. Each line in Figure 2 indicates the expected level for log consumption predicted by death rate, conditional on each integer value of age (30…79). To demonstrate a clear pattern, average differences by age are standardized.[8)]

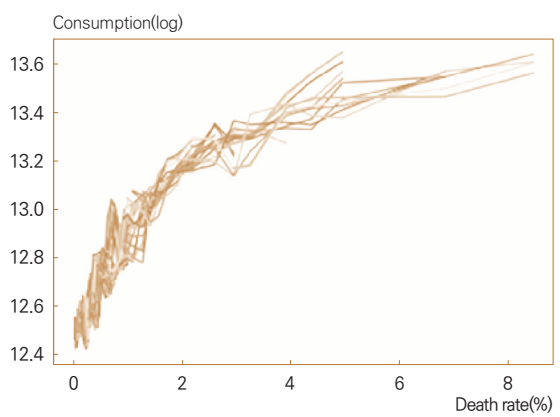
Figure 2 shows a clear pattern in which the level of consumption declines as the death rate decreases. These estimation results suggest that consumers change their choice of consumption, by reducing their current level of consumption when other conditions are fixed, as life expectancy increases.

〈Figure 1〉 Expected consumption level by age and death[1)]



1) Darker color indicates higher levels of consumption

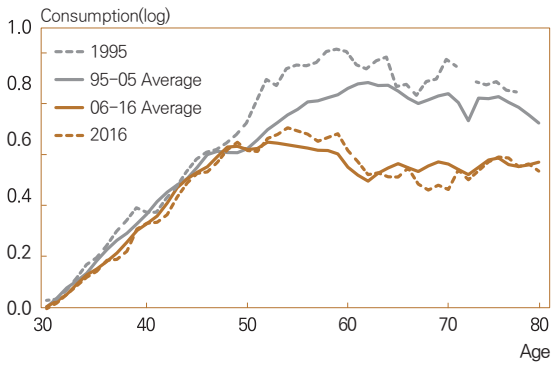
〈Figure 2〉 Consumption and the death rate [1)]



1) Each line indicates the expected consumption level conditional on each integer value of age (30, …, 79). Average differences by age are standardized.

8) For example, the level of consumption at age 31 is adjusted to equal two average levels at age 30 and 31 in the area where the graph for age 30 overlaps with the graph for age 31. In the same way, consumption levels at each age up to the age of 79 are adjusted sequentially.

〈Figure 3〉 Estimated historical changes in life-cycle[1)]



1) The gray and brown lines are the life-cycle consumption estimated based on age-specific death rates in 1995 and 2016, respectively. All the values are demonstrated as a relative value compared with the average in 1995-2016 at the age 30

Figure 3 shows estimated life-cycle patterns of consumption in each period. For instance, the lifecycle consumption for 1995, shown in the gray dotted line, is a cutoff from the contour map of Figure 1 according to age-specific death rates in 1995. Again, this is the prediction from the non-parametric term, controlling the fixed effects of time of birth and time.

The gray line in Figure 3 is the average of life-cycle consumption according to death rates in the 1995-2005 period, while the brown line represents average consumption based on the death rate in the 2006-2016 period. The life-cycle consumptions of economic agents tend to rise gradually after the 30s, reach a peak, and then enter a decline. They are relatively flattened after the 60s. These inverse U shape patterns of life-cycle consumption are consistent with the findings of previous research.

Comparing life-cycle patterns of consumption in the 1995-2005 period and 2006-2016 period, the pattern differs significantly around after the age of 50. Before 50, there is almost no notable gap between the two periods. After 50, however, the life-cycle consumptions of the two periods begin to diverge significantly. This notable changes of the consumption pattern after the age of 50 suggest that changes in intertemporal substitution of consumption due to increasing life expectancy had largely happened for agents that confronted retirement.

Another notable feature in the pattern changes is that the peak of consumption seems to occur at early ages relatively in later period. The peak is in the early 60s in the period 1995- 2005, but it is in the early-50s in the period 2006-2016.

In sum, a pattern of decreasing current consumption along with declining age-specific death rates is observed in the estimation of life-cycle pattern. For 20 years from 1995, life-cycle consumption showed a rapid decline after the 50s, the ages close to retirement, and the age of peak consumption declined from the early 60s to early-50s.

Ⅳ. Simulation

This section analyzes changes in the aggregate level of per-capita consumption, based on the previous estimation on the changes in individual consumption choices and the changes in the age distribution of economy. The amount of changes is calculated based on counter-factual simulations by comparing two predictions with and without the changes in age-specific death rates and/or the age distribution.

The aggregate level of per-capita consumption is defined as a weighted average of age-dependent individual consumption, and the weight comes from the age distribution of economy. Because the changes in consumption are significantly heterogeneous by age, as is shown in previous Section, intertwined effects from between the individual consumption choices and its aggregating age distribution can be highly important for the changes in aggregate consumption. Also, in this situation, there is no guarantee that changes the aggregate consumption exhibited in the past will be continued in the future in a linear fashion. In these regards, the simulations in this section based on the estimated heterogeneous changes in individuals' consumption incorporate the intertwined effects between micro-level individual consumption changes and macro-level population distribution changes[9].

1. Decomposition

Hereunder, total change in per-capita consumption between two time periods is mainly decomposed into two channels: (i) changes in individual consumption due to a decline in age-specific death rates (individual channel) and (ii) changes in population distribution (age distribution channel).[10]

2. Historical Simulation

First, the cumulative changes in per-capita consumption for the 20 years from 1995 to 2016 is calculated, taking 1995 as

9) The effect of population aging in this section refers to both channels from the change in individual consumption choices associated with the falling death rates and the change in age distribution. Since the size of effects are calculated based on the estimation results in Section III, it still captures only the demand-side channel, excluded the fixed effects of time of birth and time. The effect of supply-side channel transmitted through lifetime income or business cycle, originated by changes in total population or labor productivity, needs to be studied separately. Meanwhile, the simulations in this section incorporate the effect of lower fertility on age distributions, not only the effect of the increasing life expectancy, because they are based on actual data of age distribution. There is a possibility that changes in the fertility rate, marriage rate, and other factors have affected, to some degree, life-cycle consumption as well as age distribution. However, the effects of these factors on lifecycle consumption that cannot be explained by the changes in age-specific death rates go beyond the scope of this study.

10) Specifically, change in aggregate per-capita consumption is decomposed into two separate channels, as shown below:

$$\underbrace{\sum_{\text{Cohort}}\left(W_1C_1-W_0C_0\right)}_{\text{Change in per-capita consumption}}=\underbrace{\sum\left\{W_1\left(C_1-C_0\right)\right.}_{\text{Individual channel}}+\underbrace{\left(W_1-W_0\right)C_1}_{\text{Age distribution channel}}+\underbrace{\left.\left(W_0-W_1\right)\left(C_1-C_0\right)\right\}}_{\text{Joint effect}}$$

Here, C_0 and C_1 refer to consumption levels predicted by the death rates at time 0 and time 1. W_0 and W_1 indicate the population weights by cohort at time 0 and time 1, respectively. The individual channel refers to the effect of a change in the individual life-cycle consumption due to a rising life expectancy under a fixed population weight, while the age distribution channel is the effect of change in the population weight assuming fixed life-cycle consumption.

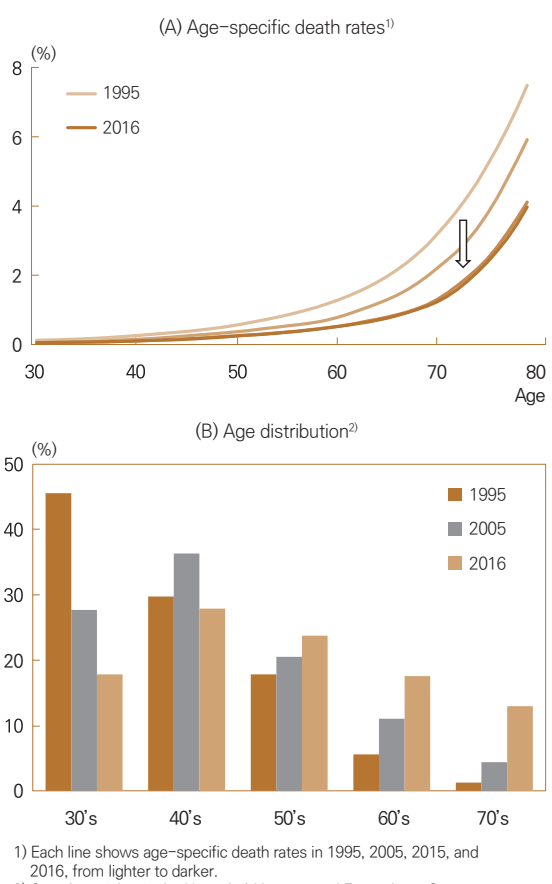
the base year. Note that the age distribution is based on sample weights in the Household Income and Expenditure Survey.

Figure 4 shows the changes in age-specific death rates and age distribution during the analysis period. It can be seen that the death rates decline substantially over the 20-year period. The change in age distribution feature a gradual increase in the elderly population due to increased life expectancy. A shift of the baby boomers, who occupy a large share of the total population, is notable; a large population mass of baby boomers moves from under 30 to 40s and 50s as time flows.

The simulation results are shown in Figure 5. The aggregate per-capita consumption is decreased by an annual average of 0.9% (18% on a cumulative basis) from 1995 to 2016. Both the individual channel and the age distribution channel significantly contribute to the decrease in per-capita consumption, with the age distribution channel affecting the consumption to a greater extent than the individual channel.

Meanwhile, to answer the question of which channel is exerting greater impact at the current time, a 'marginal' concept of effects over a short period would be more appropriate than a cumulative effect This paper now calculates effects of both channel over the past one year, not the cumulative effect since 1995. Figure 6 shows the relative size of effects of two channels for each year. Its trend shows that the age distribution channel has a relatively large effect on consumption until the mid-2000s, however it decreases since then.

〈Figure 4〉 Historical changes in age-specific[1] death rates and age distribution[2]



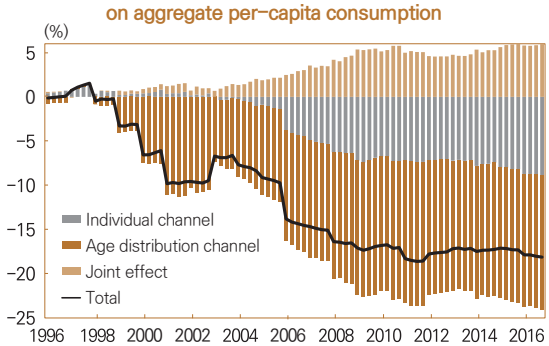
1) Each line shows age-specific death rates in 1995, 2005, 2015, and 2016, from lighter to darker.
2) Sample weights in the Household Income and Expenditure Survey.

On the other hand, the effect of the individual channel grows gradually and seems to become more important after late

2000s.

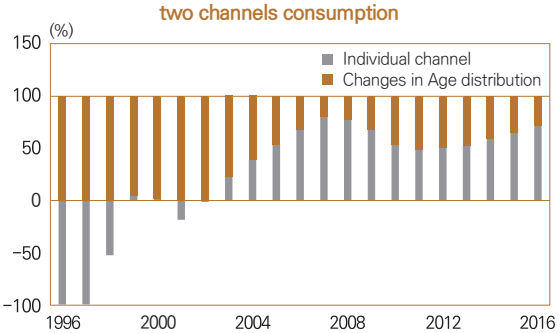
This gradual decline of relative effects of the age distribution channel is connected to the aging of baby boomers. For example, individuals born in 1955, the starting age of baby boomers, turned their 50s in 2005, and the consumption pattern in Figure 3 tells that they approached the ages of their highest level of consumption. As more baby boomers entered their life-cycle peak of consumption, the increase in baby boomers' consumption mitigated more the negative effect of the age distribution channel. Another reason is that the share of youths, whose consumption level is lower, had felled gradually due to low fertility, which also lifted the level of per-capita consumption.

〈Figure 5〉 Cumulative effects of two channels on aggregate per-capita consumption



1) The graph shows the cumulative effects after 1995 in each quarter.

〈Figure 6〉 Relative size of effects of two channels consumption [1)]



1) The relative size of effects of two channels for each year are compared. The cumulative effects of two channels are smoothed with LOWESS to reduce noises from changes in survey sample. For years in which the individual channel increases per-capita consumption, the relative size for the age distribution is set to 100% while the size for the individual channel is demonstrated as negative values.

3. Predictions

In this section, the changes in per-capita consumption due to the two channels of population aging is predicted until 2060. The assumed path on future age distribution and death rates relies on the projections of Statistics Korea. One caveat is that the prediction result is dependent to the estimated past relationship between death rates and consumption. Economic agents may buffer or hedge the risk on life expectancy by using their own savings or financial products such as pensions, and these endogenous preparation affects the future path of aggregated consumption.

The assumed path on future age distribution and death rates is shown in Figure 7. The death rates are projected to decline until 2060 but stabilize gradually, and the age distribution is predicted to show a continuing increase in the share of people

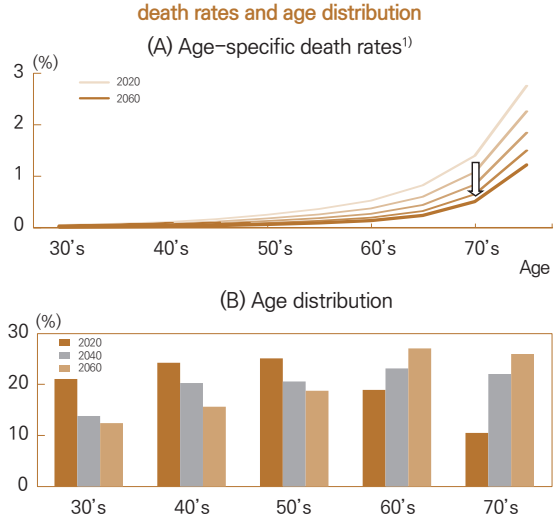
11) This is attributed to a rapid decline in the share of young people, who have a low level of life-cycle consumption, driven by low fertility.

aged 60 or older.

Prediction results show that the per-capita consumption is expected to decrease at an annual average rate of 0.7% from 2020 to 2035 (see Figure 8). After the mid-2030s, the net effect from two channels is almost neutral, that no further decline in consumption is expected until 2060.

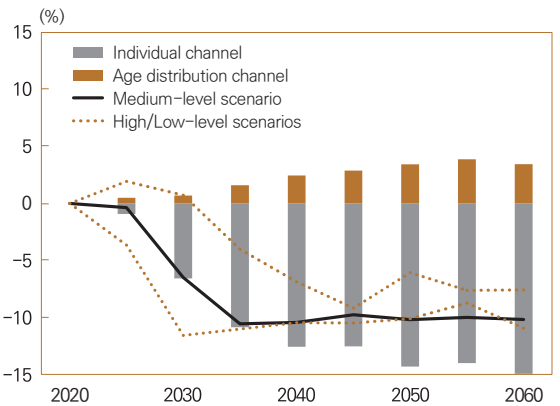
Interestingly, the effects of two channels, the individual and age distribution channels, are expected to move in opposition directions. Whereas the individual channel continues causing consumption to decline, the age distribution channel is expected to raise consumption, as opposite to the past.[11] Since the effect of the individual channel is found to be greater than the effect of the age distribution channel, the total effect reduces per-capita consumption.

〈Figure 7〉 Predicted changes in age-specific death rates and age distribution



1) Each line shows age-specific death rates in each 10 years from 2020 to 2060.

〈Figure 8〉 Predicted effects of two channels on future per-capita



1) The figure shows the cumulative effects after 2020 in each 5 years. The solid line indicates the result based on the medium-level scenario for age distribution projected by Statistics Korea. The dotted lines correspond to high/low-level scenarios.

V. Conclusion

Korea is currently facing the retirement of baby boomers, which caused the working-age population to begin to decline in 2019. The proportion of people aged 65 or older is likely to exceed 20% in 2025, Korea is expected to become a super-aged society. This is much faster pace relative to other advanced countries, even when compared to Japan. Given this circumstance, an analysis of the effects of population aging is deemed to be a core task to prepare for the upcoming future.

The simulation results show that population aging had shrunk per-capita consumption by an annual rate of 0.9% from 1995 to 2016. Furthermore, the result predict that per-capita consumption can be further shrunk by an annual rate of 0.7% from 2020

to 2035, based on historical relationship. Therefore, in a policy perspective, caution is necessary to smooth the future consumption path, and to prevent further tightening of restrictions on consumption, associated with other risks in addition to increasing life expectancy.

While this study focuses on the demand-side channel associated with the rising life expectancy, the supply-side channel, such as related to decreasing working-age population and declining labor productivity, is also expected to have important impacts on consumption. To help the government and central bank minimize the negative effects of population aging and make policies capable of coping with it, extensive researches in various dimensions need to continue going forward.

〈 References 〉

Abel, A. B. (2001). Will bequests attenuate the predicted meltdown in stock prices when baby boomers retire?. Review of Economics and Statistics, 83(4), 589-595.

Andrews, D. W., and Bonnar, S. (2018). Population aging, implications for asset values, and impact for pensions plans: An international study. Phase 2 Final Report.

Attanasio, O. P., Banks, J., Meghir, C., and Weber, G. (1999). Humps and bumps in lifetime consumption. Journal of Business & Economic Statistics, 17(1), 22-35.

Attanasio, O. P., and Weber, G. (2010). Consumption and saving: models of intertemporal allocation and their implications for public policy. Journal of Economic literature, 48(3), 693-751.

Bang, S., Chun, K., Lee, D., and Lee, H. (2017). Population aging-impacts and policy imperatives, Ch 6. Population aging and consumption, Bank of Korea, 270-295.

Bloom, D. E., Canning, D., and Graham, B. (2003). Longevity and life cycle savings. Scandinavian Journal of Economics, 105(3), 319-338.

Blundell, R., and Powell, J. L. (2001). Endogeneity in nonparametric and semiparametric regression models.

Brooks, R. (2006). Demographic change and asset prices. In Demography and financial markets (pp. 23-25). Reserve Bank of Australia.

Carroll, C. D., Hall, R. E., and Zeldes, S. P. (1992). The buffer-stock theory of saving: Some macroeconomic evidence. Brookings papers on economic activity, 1992(2), 61-156.

Carvalho, C., Ferrero, A., and Nechio, F. (2016). Demographics and real interest rates: Inspecting the mechanism. European Economic Review, 88, 208-226.

Choi, J., Lee, H. (2015). Analysis of background behind the sluggishness of household consumption since the global financial crisis. Monthly Bulletin, Bank of Korea, 69(8).

Deaton, A., and Paxson, C. (2000). Growth and saving among individuals and households. Review of Economics and Statistics, 82(2), 212-225.

Deaton, A. (2019). The analysis of household surveys: a microeconometric approach to development policy. World Bank Publications.

Fernández-Villaverde, J., and Krueger, D. (2007). Consumption over the life cycle: Facts from consumer expenditure survey data. The Review of Economics and Statistics, 89(3), 552-565.

Florens, J. P., Johannes, J., and Van Bellegem, S. (2012). Instrumental regression in partially linear models. The Econometrics Journal, 15(2), 304-324.

Gourinchas, P. O., and Parker, J. A. (2002). Consumption over the life cycle. Econometrica, 70(1), 47-89.

Härdle, W., Liang, H., and Gao, J. (2000). Partially linear models. Springer Science and Business Media.

Härdle, W., and Müller, M. (1997). Multivariate and semiparametric kernel regression (No. 1997, 26). SFB 373 Discussion Paper.

Hong, J., Kang, T., and Lee, Y. (2016). Population aging and extension of retirement age(Quantiative analysis using overlapping generation model. Working Paper, Bank of Korea, 22(2).

Kim, S., and Lim, J. (2015). The effects of increases in life expectancy on age-specific propensity to consume: focusing on old ages. KIF Research Paper, 2015(4), 1-81.

Mankiw, N. G., and Weil, D. N. (1989). The baby boom, the baby bust, and the housing market. Regional science and urban economics, 19(2), 235-258.

Modigliani, F., and Brumberg, R. (1954). Utility analysis and the consumption function: An interpretation of cross-section data. Franco Modigliani, 1(1), 388-436.

Nishimura, K. G. (2011). Population ageing, macroeconomic crisis and policy challenges. In Panel on The General Theory and the Policy Reponses to Macroeconomic Crisis at the 75th Anniversary Conference of Keynes' General Theory, University of Cambridge.

Papetti, A. (2021). Demographics and the natural real interest rate: historical and projected paths for the euro area. Journal of Economic Dynamics and Control, 132, 104209.

Speckman, P. (1988). Kernel smoothing in partial linear models. Journal of the Royal Statistical Society: Series B (Methodological), 50(3), 413-436.

Takáts, E. (2012). Aging and house prices. Journal of housing economics, 21(2), 131-141.