

Explaining Why Retirees Do Not Choose Annuities in Korea: A Probability of Consumption Shortfall Approach

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Abstract Many assume that for retirees, purchasing an annuity is a better option than self-annuitization in the decumulation period. In Korea, retirees have shown a strong preference for properties (real estate), and a decision to annuitize has been extremely rare. Using a genetic algorithm, we show that self-annuitization can be recommended as an optimal choice for retirees in Korea if they consider properties as one of the investment options. We set three scenarios that a worker can choose at retirement: self-annuitization, purchasing a whole life annuity, and mixed strategy. We then calculate an optimal asset allocation for each scenario capable of minimizing probability of consumption shortfall (PCS). An important observation is achieved: the optimal asset allocation for minimizing PCS vary by the income quintiles, and PCS rises significantly as the preference for purchasing a whole-life annuity increases. In case of a large reduction in consumption after retirement, however, annuitization may be a better option for retirees in the lowest income quintile.

Keywords: annuity puzzle, self-annuitization, annuitization, probability of consumption shortfall, optimal asset allocation

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1. Introduction

In recent decades, the “annuity puzzle” has been one of the most interesting research subjects in the field of pension finance and actuarial science. Post-retirement life of retirees has been clearly extended as the life expectancy gradually grows. Longevity risk, a risk of outliving accumulated savings in retirement, then has become one of the most important factors that significantly influences the financial decisions of retirees. A classical study [1], employing intertemporally separable utility function with neither bequest motive nor uncertainty other than death existing, showed that it is optimal for retirees to annuitize their wealth, provided that they are able to purchase a whole life annuity with an actuarially fair annuity premium. Most retirees, however, still prefer receiving a lump-sum payment to receiving an annuity. This is apparently a “puzzle,” given the fact that a regular payment not only protects their income security after their retirement, but also minimizes their longevity risk before they die.

So far, there has been an enormous amount of related literature regarding the annuity puzzle. Following Yaari’s seminal paper, numerous studies have reported a variety of reasons for why individuals choose to receive lump-sum payments rather than annuities. Four factors have been mainly discussed as determinants that play a

significant role in reducing the demand for annuities: preannuitized wealth levels, actuarially unfair prices of the annuity products, bequest motives, and uncertain health expenses.

First, [2] have suggested that existing preannuitized wealth levels, such as those of social securities or defined benefit (DB) pensions, may drop the demand for annuity purchases. This is also supported by [3], who has shown that the preannuitized wealth is the most quantitatively important factor that affects the retiree’s decision. To alleviate this impact of accumulated wealth at retirement, [4] provides a solution for dropping the lump-sum payout decisions by imposing restrictions on liquidating options. He has proved that annuitization rates differ considerably by plan types, calling for an appropriate default design for a pension scheme.

Second, [5,6] have established that the annuity puzzle might be attributable to actuarially unfair prices of the annuity products due to adverse selection. In the annuity market, insurance premiums should be set high because an individual who voluntarily purchases the annuity products would probably be healthier and live longer than average. [7] has argued that the adverse selection raises annuity price by 7-10 percent. The actuarially unfair prices of annuity products make them less attractive, crowding out the demand for them. [8] have estimated the elasticity of annuity demand to prices, which implies the need for enhancing financial literacy, particularly for less-educated individuals.

Third, bequest motives would lower demand for annuities, as [9] have suggested that bequests would serve as effective annuity products with less default risk for retirees if they live longer than their average lifespan. In other words, retirees choose to bequeath because they expect to support themselves by relying on their heirs until they die. As so, bequest motives may reduce the uninsured risk for retirees. [10,11] also have found coherent results about bequest motives. Furthermore, [12,13] has argued that the bequest motives would affect demand for the annuity products negatively by reducing the opportunity cost of precautionary saving.

Fourth, [14,15] have demonstrated that the retirees would face borrowing constraints, since the annuity products are not able to be sold or borrowed. Therefore, if they encounter any health problem that requires a large amount of money, they will have difficulties with this liquidity problem. [16] also have suggested that medical expenditure risk might lower the demand for annuities, and [17] has found empirical evidence on this health expenditure risk. By employing a life-cycle model, [18] has attempted to illustrate optimal portfolio choice under health risk. However, [19] have argued that despite the existence of medical expenditure risk, it is still optimal to fully annuitize their wealth.

Other factors also have been suggested to explain the annuity puzzle. [20,21] have found that incompleteness of the annuity market would make retirees become reluctant to purchase them, since the annuity products do not hedge inflation risk as they provide the payouts in nominal value. If nominal annuities are available only in the annuity market, retirees cannot maintain their stable consumption patterns as the real value of the payouts would gradually decrease. Besides, such incomplete annuity products would incur welfare costs to retirees.

[22] has extensively examined household decisions about annuitization using dynamic programming techniques. Mortality risk, marital status, risk aversion, and presence of preexisting annuities affect the value of the retirees' annuities. Married retirees tend to prefer annuities more than single retirees do because of the pooling effect of their mortality risks. This result is in concordance with [23], who have demonstrated the effect of risk pooling and risk sharing among family members. Brown also has shown that retirees with poor health are significantly less likely to annuitize. Bequest motives, however, did not seem to have significant effects on retirees according to Brown's paper. [24,25] also has demonstrated that bequest motives cannot clearly explain the annuity puzzle. These findings are in direct opposition to the studies mentioned above.

Meanwhile, [26] have attempted to figure out the annuity puzzle through a behavioral explanation. They adopted the concepts of "mental accounting" and "loss aversion," which make retirees not consider the annuity products with their total retirement lifespan. Instead, they have claimed that retirees recognize the annuity products as risky gambles rather than as insurance instruments, where loss aversion affects them so that they expect larger potential losses than potential gains, resulting in the unpopularity of annuities.

Recently, a psychological explanation was proposed by [27]. They have employed a psychological theory,

"mortality salience," which ascribes the avoidance of annuities to death-related thoughts occurring while making annuity decisions. Their study implies the significance of keeping retirees away from thinking about their death while purchasing annuity products.

In Korea, we can easily find the annuity puzzle in the retirement market. According to the "Retirement Pension Status Report" in the third quarter of 2016 by the Financial Supervisory Service, only 1.6 percent of retirees chose to receive their retirement benefits as annuities, while 98.4 percent chose to receive a lump-sum amount. Then, one might ask that in which asset the retirees invest their money to achieve a successful self-annuitization after their retirement in Korea. We find that there exists an uncommon number in the composition of household wealth in Korea (see Table 1). Unlike other countries, properties (real estate) account for the largest part (74.0 percent) of the total household net wealth. This is an exceptionally higher number compared to United States (34.94 percent), United Kingdom (55.26 percent), Japan (43.72 percent), and Canada (56.74 percent).¹ Furthermore, it is even higher if we limit the scope of the household to age 60 and above (82.0 percent). This means that Korean retirees in particular tend to prefer holding their assets as properties to using other investment options such as stocks, bonds, or deposits.

Table 1. Household Wealth by Head of Household's Age (Unit: ten thousand KRW, %)

Asset Category	Assets	Financial Assets			
		% of Assets	Savings	Deposit for Lease & Rent	
Total	36,187	9,400	26.0	6,942	2,458
Under 30	8,750	5,478	62.6	2,091	3,386
30-39	25,730	9,634	37.4	5,050	4,583
40-49	36,564	11,146	30.5	7,778	3,368
50-59	44,302	11,351	25.6	9,389	1,962
60 or above	36,648	6,582	18.0	5,608	975
Asset Category	Non-Financial Assets				
Age		% of Assets	Properties		
			Residence	Others	
Total	26,788	74.0	25,029	14,244	1,759
Under 30	3,273	37.4	2,663	2,094	610
30-39	16,097	62.6	14,530	10,147	1,567
40-49	25,418	69.5	23,245	14,249	2,173
50-59	32,951	74.4	30,552	16,009	2,399
60 or above	30,066	82.0	28,976	15,787	1,090

*Source: Survey of Household Finances and Living Conditions (2016), Statistics Korea.

This unusual predisposition in properties might be explained by the property bubbles that appeared in the early 2000s in Korea. After bailout from the International Monetary Fund (IMF) in 1998, the Korean government reduced the regulatory burdens for properties in order to boost the economy, including providing tax relief and loosening restrictions on transactions. As a result, the property prices increased significantly in the early 2000s,

¹ [28]

especially in Seoul and the regions around Seoul. The real estate price from 2000 to 2005 in Korea increased 37.9 percent; for Seoul and the regions around Seoul, it was 59.1 percent and 54.8 percent, respectively, for the same period. Presumably, this higher growth rate of prices in the real estate market in Korea might have led to a high propensity for properties among Koreans. In 2006, [29] was conducted by the Korea Research Institute for Human Settlements. There were two questions about the preference for properties: 1) Do you agree with investing in properties to increase wealth? 2) What is your priority among investment options if you have extra money? The results are presented in Figure 1.

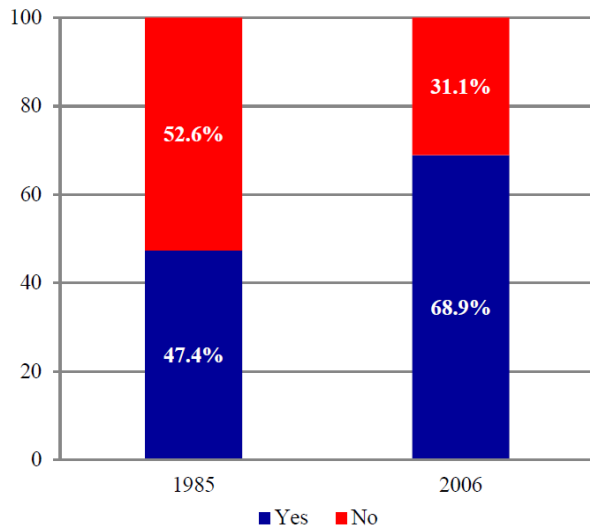


Figure 1. Do you agree with investing in properties to increase wealth?

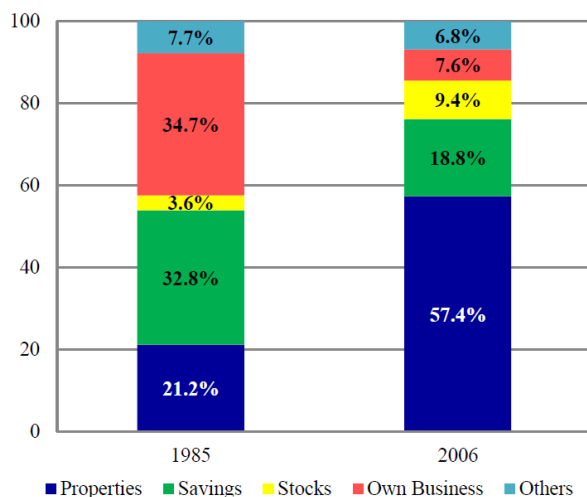


Figure 2. Preference Changes as an Investment Option Between 1985-2006

For the first question, 68.9 percent of respondents said yes. This indicates that people in Korea became less reluctant about investing in properties, compared to 1985. Furthermore, the results in the second question clearly shows that more than half of the respondents chose properties as their favorable investment option, whereas only 21.2 percent regarded it as an effective investment in 1985. Thus, it is obvious that Korean people have started to consider properties as their investment option rather than other investment methods.

In this paper, we examine “probability of consumption shortfall” (hereinafter referred to as PCS) when a worker invests in several asset categories during his or her lifetime, particularly focusing on the role of properties. The aging problem in Korea is the fastest among developed countries, which might aggravate the longevity risk and the PCS of the retirees. Thus, it is of great importance for retirees to identify a rational financial decision-making that helps their retirement wealth not to be depleted during the decumulation period. With the strong propensity for properties among Koreans, we expect to find evidence for why Korean workers are not willing to purchase whole life annuities. We set three scenarios that retirees would take as their asset allocation strategies at retirement. We then compare the PCS of each scenario to identify the optimal asset allocation.

In the remaining part of the paper, Section 2 introduces the assumptions and research methodology used in the simulation. Section 3 explains the results of the simulation. Finally, Section 4 concludes with a brief summary, a critique of the findings, and future developments.

2. Assumptions and Research Methodology

2.1. Assumptions for Analysis

This paper attempts to figure out Korean workers' inclination to invest primarily in properties by examining the PCS of a person with specific asset allocation strategies during his or her lifetime. The assumptions for analysis are set as follows.

Table 2. Average Rate of Return and Standard Deviation of Financial Assets, Properties, and Pension Assets (Unit: %)

Year	Financial Assets		Properties	Pension Assets ¹⁾
	Domestic Stocks	Deposits		
2001	37.47	6.21	9.87	-
2002	-9.54	6.26	16.43	-
2003	29.19	4.76	5.74	5.92
2004	10.51	4.35	-2.07	5.47
2005	53.96	4.52	4.01	3.96
2006	3.99	4.96	11.60	4.65
2007	32.25	5.28	3.14	8.81
2008	-40.73	5.36	3.11	4.15
2009	49.65	4.64	1.46	5.67
2010	21.88	4.31	1.89	5.75
2011	-10.98	3.90	6.86	3.16
2012	9.38	3.24	-0.03	4.35
2013	0.72	3.00	0.37	2.53
2014	-4.76	2.83	2.10	3.57
2015	2.39	1.97	4.42	2.65
2016	3.32	1.53	1.35	-
Average	11.79	4.20	3.75	4.67
Standard Deviation	23.78	1.33	4.64	1.63

1) We use the rate of return of Investment Pool for Public Funds for the pension assets. However, the data is not available in 2001, 2002, and 2016.

* Source: Bank of Korea, KB Financial Group, Investment Pool for Public Funds.

Assumption 1: Asset accumulation of a worker starts at age 30 and net income is invested annually in three asset categories: financial assets, properties, and pension assets. Financial assets consist of domestic stocks and deposits (see Table 2).² As the Employee Retirement Benefit Security Act in Korea restricts the benefit withdrawal during the working period (i.e. before retirement), a worker can spend his money only from his financial assets during the accumulation phase. Thus, we separate the pension assets from the financial assets and they are managed separately.

Assumption 2: Workers are categorized by income quintiles; see Table 3 for the average income for each quintile. Income increases annually by the average wage growth rate based on the average growth rate of negotiated wages from 2007 to 2015 in Korea (see Table 4). Here, we do not distinguish between income and wage. In other words, there is no additional income for all workers other than wage.

Table 3. Households Income for Each Quintile (Unit: thousand KRW)

Quintiles	1 st quintile	2 nd quintile	3 rd quintile	4 th quintile	5 th quintile
Income	1,416.9	2,904.0	4,025.5	5,330.9	8,545.3

*Source: Household Survey Data in 3rd quarter of 2016, Statistics Korea.

Table 4. Wage Growth Rate from 2007 to 2015¹⁾ (Unit: %)

Year	2007	2008	2009	2010	2011
Growth Rate	6.26	5.54	1.15	2.97	3.47
Year	2012	2013	2014	2015	Average
Growth Rate	5.33	3.13	2.80	2.82	3.72

*Source: Household Survey Data in 3rd quarter of 2016, Statistics Korea.

Assumption 3: The consumption level of each worker is provided as the average expenditure for each quintile (see Table 5) and increases annually by the inflation rate, based on the average inflation rate from 2001 to 2016 in Korea (see Table 6). In addition, considering the fact that retirees tend to spend less money after retirement, we set three consumption rates (π) for the consumption level (100 percent, 70 percent, and 50 percent). For example, a 70 percent consumption rate means that a retiree at age 60 will spend 70 percent of the consumption amount he spent at age 59.

Assumption 4: Workers participate in a defined contribution (DC) plan, making yearly contributions at the beginning of each year during their continuous years of service. The contribution amount is determined as one-twelfth of the yearly income.³

Assumption 5: Workers are supposed to retire at age 60, at which point they make financial decisions as in the following scenarios. Workers will receive the pension amount annually by assumed interest rate if they choose to

purchase whole life annuities, while workers who decide to self-annuitize will receive annual returns by the asset allocation strategies they choose. There are three scenarios of financial decisions, given in Table 7.

Table 5. Households Expenditure for Each Quintile (Unit: thousand KRW)

Quintiles	1 st quintile	2 nd quintile	3 rd quintile	4 th quintile	5 th quintile
Expenditure	1,277.6	2,010.0	2,479.5	3,005.0	4,123.3

*Source: Household Survey Data in 3rd quarter of 2016, Statistics Korea.

Table 6. Inflation Rate from 2001 to 2016 (Unit: %)

Year	2001	2002	2003	2004	2005	2006
Inflation Rate	4.1	2.8	3.5	3.6	2.8	2.2
Year	2007	2008	2009	2010	2011	2012
Inflation Rate	2.5	4.7	2.8	2.9	4.0	2.2
Year	2013	2014	2015	2016	Average	
Inflation Rate	1.3	1.3	0.7	1.0	2.46	

* Source: Statistics Korea (<http://www.index.go.kr>).

Table 7. Financial Decision Scenarios of Workers at Retirement

Asset Category	Pension Assets	Financial Assets	Properties
Scenario 1	Self-annuitization		
Scenario 2	Whole-life annuity	Self-annuitization	
Scenario 3	Whole-life annuity		

Assumption 6: Workers have two principles regarding their asset allocation strategies as follows. First, they choose the asset allocation strategy that maximizes the Sharpe ratio while in the accumulation period. After retirement, however, they choose an asset allocation strategy that minimizes the PCS.

2.2. Research Methodology

2.2.1. Accumulation Period: Portfolio that Maximizes the Sharpe Ratio

In the accumulation period, workers take the asset allocation strategy that maximizes risk-adjusted return by using a mean-variance model. The optimal portfolio can be drawn by the mean-variance model that incorporates the expected return of an asset and its correlation with others, called “efficient frontier.” Further, if we are able to borrow a risk-free asset with no limits, we can achieve a higher return by investing in a risk-free asset and perfectly diversified risk assets. The “Sharpe ratio” is a measure for risk-adjusted return, calculated by subtracting the return of the risk-free asset from the return of a risky asset, then dividing it by the standard deviation of the risky asset.

Assume that a portfolio is composed of n risky assets and the weight of each asset is $\{w_1, w_2, \dots, w_n\}$. Let $E[r_p(t)]$ represent the expected return of a portfolio; $\sigma[r_p(t)]$ the standard deviation of a portfolio; $\sigma[r_i(t)]$ the standard deviation of an asset i ; and $r_f(t)$ the return of a risk-free asset. Then the Sharpe ratio is calculated as follows:

$$SR = \frac{E[r_p(t)] - r_f(t)}{\sigma[r_p(t)]} \tag{1}$$

² We do not include bonds in financial assets. According to the Survey of Household Finance and Living Conditions (2016), 91.6 percent of households in Korea prefer deposits as a way of financial asset management and 4.0 percent choose stocks; no respondents choose bonds.

³ In Korea, the Employee Retirement Benefit Security Act requires employers of a DC plan to make yearly contributions for their employees of at least one-twelfth of each employee’s wage.

where $\sum_i w_i = 1$ and $w_i \geq 0$.

2.1.2. Decumulation Period: Portfolio that Minimizes the Probability of Consumption Shortfall (PCS)

If a worker chooses to self-annuitize, the value of the worker’s assets might be declined to zero until his death. This risk can be defined as “ruin risk.” [30] first suggested PCS, which reflects the ruin risk combined with the survival probability of each age. Let T_x represent the remaining lifetime of a retiree aged x at time $t=0$; τ_R the earliest point at which the exhaustion of the retiree’s wealth occurs. Then PCS is defined as follows:

$$PCS = P(T_x > \tau_R), \tag{2}$$

where $\sum_i w_i = 1$ and $w_i \geq 0$.

Let ${}_tP_x$ represent the probability of a retiree aged x who survives until time $(x + t)$ ⁴ and let ω denote the lifespan. Provided that T_x and τ_R are stochastically independent, the PCS also can be defined as follows:

$$PCS = \sum_{t=0}^{\omega-x} {}_tP_x \cdot P(\tau_R = t). \tag{3}$$

Here, τ_R must be determined by a simulation method because it is related to various paths of asset value fluctuations that require numerical analysis. Let $W(t)$ represent the asset value of a retiree from the initial wealth at retirement, where the consumption amount R is made annually. Also let i_t denote the rate of return at time t ; then we can define the growth model of the asset value as follows:

$$W_1(t) = \begin{cases} (W_0(t) - R)(1 + i_t) & \text{if } W_0(t) > R \\ 0 & \text{if } W_0(t) \leq 0 \end{cases} \tag{4}$$

where $W_0(t) = W_1(t - 1)$

The point when ruin occurs depends on the consumption amount (R) and the rate of return (i_t). In the case of self-annuitization, asset categories are set as domestic stocks, deposits, and properties as mentioned earlier. The rate of return (i_t) is determined by the “geometric Brownian motion” (GBM). Let $S_i(t)$ represent the price of asset i at time t ; μ_i the average rate of return of asset i ; σ_i the standard deviation of asset i ; and ϵ_i the Wiener process of asset i ; then GBM is defined as follows:

$$\frac{S_i(t + \Delta t)}{S_i(t)} = \exp \left[\left(\mu_i - \frac{1}{2} \sigma_i^2 \right) \Delta t + \sigma_i \epsilon_i \sqrt{\Delta t} \right], \epsilon_i \sim N(0, 1) \tag{5}$$

Therefore, i_t is presumed by a stochastic model. In this paper, we run simulations for each scenario 10,000 times by employing a stochastic model that incorporates the correlations between investment assets. We use the Cholesky decomposition method to reflect the correlations.

⁴ We employ the seventh experience life table (2012-2015) in Korea for the survival rates.

⁵ Here is a proof of the equation.

$$\begin{aligned} P(T_x > \tau_R) &= P(T_x - \tau_R > 0) \\ &= \sum_{t=0}^{\infty} P(T_x - t > 0 | \tau_R = t) \cdot P(\tau_R = t) \\ &= \sum_{t=0}^{\infty} P(T_x > t) \cdot P(\tau_R = t) \\ &= \sum_{t=0}^{\infty} {}_tP_x \cdot P(\tau_R = t) \\ &= \sum_{t=0}^{\omega-x} {}_tP_x \cdot P(\tau_R = t). \end{aligned}$$

For a complete derivation of the equation, including the structural and technical assumptions, see Appendix in Albrecht and Maurer (2002).

When calculating PCS, it is not easy to clearly determine the mathematical logic of τ_R since it is a random variable that is affected by the uncertain value of several assets. Thus, we employ a genetic algorithm. The genetic algorithm is a stochastic search algorithm that replicates the evolution mechanisms of nature, first introduced by John Holland in the 1970s. It aims to find exact or approximate solutions to optimization and search problems ([31]).

To find the optimal ratio of the three assets that minimizes the PCS, a scalar-valued objective function $f: S \rightarrow \mathbb{R}$ can be structured as a problem of finding the set

$$\Theta^* = \operatorname{argmin}_{\theta \in \Theta} f(\theta) = \left\{ \theta^* \in \Theta : f(\theta^*) \leq f(\theta), \forall \theta \in \Theta \right\}, \tag{6}$$

where $\Theta \subseteq S$ and the set $S \subseteq \mathbb{R}^3$ denote the search space. The variables $\theta = (\theta_1, \theta_2, \theta_3)$ are determined between 0 and 1 under constraint of $\sum \theta_i = 1$, and the set Θ represents the available search space. The solution set Θ^* may include a specific single solution or countable solutions, or may have unlimited number of solutions. According to [32], Genetic algorithms can be used to solve the optimization problem in both continuous and discrete models. Hence, we examine the optimal portfolio using the genetic algorithms.

2.3. Calculating Annuity Payment

An “immediate life annuity” is an annuity contract that a retiree can purchase with a single lump-sum payment and receive a regular payment until it terminates upon the death of the retiree. Thus, an immediate life annuity can be a great means of stabilizing the decumulation period for retirees who are making their living only through their savings accounts without any additional income. In this paper, we set an immediate life annuity as a mean of whole-life annuity, which has no delay period of payments. Let P_0 represent the single premium of the annuity; α the rate of acquisition costs; β the rate of renewal commission; λ the rate of management expenses per year; r^* the interest rate on a product; ω the maximum lifespan; and ${}_tP_x$ the survival rate of a retiree aged x at time $(x + t)$. Then, the payout amount for an immediate life annuity (A_0) can be calculated as follows:

$$A_0 = \left[\frac{P_0 \times (1 - \alpha - \beta)}{\sum_{t=0}^{\omega-x} (1 + r^*)^{-t} \times {}_tP_x} \right] \div (1 + \lambda) \tag{7}$$

We use the data of the three biggest life insurance companies in Korea. The rate of acquisition costs, the rate of renewal commission, the interest rate on product, and the rate of management expenses per year for each annuity product are presented in Table 8. The sum of α and β is 7 percent for all products, however, the interest rate on product and the rate of management expenses per year are different by companies.

In this article, we set the total rate of acquisition costs and renewal commission as 7.00 percent; the interest rate on a product as 2.50 percent; and the rate of management expenses per year as 0.83 percent based on the average rates of the three annuity products. The payout amount for an immediate life annuity is varied by the interest rate on

the product, however, we assumed that it is fixed for the whole period.

The overall structure of our paper is illustrated in Figure 2, drawing on the assumptions and the research methodology described so far.

Table 8. Total Operating Cost and Interest Rate on Immediate Life Annuity Products

Annuity product	Rate of acquisition costs	Rate of renewal commission
A	5.00% of premium	2.00% of premium
B	4.50% of premium	2.50% of premium
C	4.60% of premium	2.40% of premium
Average	7.00% of premium	
Annuity product	Interest rate on product	Rate of management expenses per year
A	2.48%	1.20%
B	2.50%	0.60%
C	2.52%	0.70%
Average	2.50%	0.83%

* Source: Policy manuals for each annuity product (Dec. 2016).

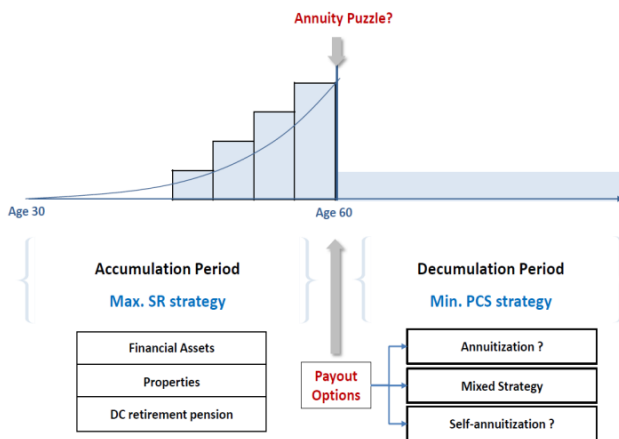


Figure 3. Overall Structure of the Simulation

3. Results

To identify the annuity puzzle in Korea, we analyze optimal asset allocation for each income quintile. Each worker’s life is divided into the two periods on the basis of the retirement point: the accumulation period and the decumulation period. We particularly focus on minimizing the PCS in the second period.

3.1. Accumulation Period

We assumed that a worker receives a regular income from ages 30 to 60, and this period is defined as the “accumulation period.” A worker’s income and consumption are generated annually at the beginning of each year. Net income, income subtracted by consumption, is invested into the financial assets and properties by optimal asset allocation that maximizes the Sharpe ratio. However, there is no asset rebalancing during the accumulation period. Table 9 displays the result of the asset allocation that maximizes the Sharpe ratio.

In Table 9, properties play a key role in the optimal asset allocation. This accounts for 72.82 percent of the total asset allocation, much higher than the other asset

categories. Despite the fact that the risk-return profile of the properties is inferior to that of deposits, the properties still remain significant since they provide some hedge against the investment risk of stocks.⁶ This explains why the properties have been a great means of investment alternatives in Korea. Thus, the strong propensity for properties among Koreans has been a rational financial decision. Table 10 shows the amount of accumulated assets for each quintile at the retirement age managed by the asset allocation of Table 9.

Table 9. Optimal Asset Allocation in the Accumulation Period (Unit: %)

Financial Assets		Properties	Pension Assets	Total
Domestic Stocks	Deposits			
14.00	4.85	72.82	8.33	100.00

* Source: Authors’ calculations.

Table 10. Accumulated Assets at Retirement Age (Unit: thousand KRW)

	1st quintile	2nd quintile	3rd quintile
Retirement Pension	140,359	287,672	398,769
Domestic Stocks	88,404	506,122	859,719
Deposits	19,783	87,999	145,509
Properties	177,211	778,130	1,284,539
	4th quintile		5th quintile
Retirement Pension	528,083		846,503
Domestic Stocks	1,216,493		2,412,796
Deposits	212,625		396,333
Properties	1,876,228		3,492,142

* All numbers were rounded off to the nearest integer.

** Source: Authors’ calculations.

3.2. Decumulation Period

“Decumulation period” refers to the time from retirement until a worker’s death. Only consumption is generated at the beginning of every year during this period. Therefore, it is highly important for retirees to manage ruin risk since they use the amount of accumulated assets without any income. Thus, we examine the optimal asset allocation of the retirees by identifying asset allocations that minimize the PCS. The optimal asset allocation varies by income quintile because the PCS directly depends on the accumulated assets and the consumption level of retirees. With this approach, we are able to examine the annuity puzzle in more detail with different income levels of retirees.

3.2.1. Scenario 1

Table 11 shows the asset allocation and PCS when workers self-annuitize all of their assets. It is clear that PCS is closely related to the income quintile and the consumption rate.

Provided that the consumption rate is constant, retirees in the lowest income quintile should invest primarily in risky assets, whereas those in the higher income quintile are able to invest in a wide selection of assets. For instance, retirees in the 1st quintile should put 90.78 percent of their money in domestic stocks, while those in 2nd quintile invest 96.74 percent in deposits if they

⁶ Correlation between domestic stocks and properties is -0.11.

maintain the same consumption level as before. The asset allocation for deposits declines as the level of assets at retirement increases, and it is distributed into other assets. It means that the low-income workers should take a certain level of risk to earn a higher rate of return on their assets and sustain their consumption; however, higher income workers do not need to pursue a high yield to make their living, and are able to support their consumption during the decumulation period through a relatively low-risk, low-return investment strategy.

Table 10. Asset Allocation and PCS of Scenario 1 (Unit: %)

π	Asset	Income quintile				
		1st	2nd	3rd	4th	5th
100%	Domestic Stocks	90.78	3.21	7.21	13.04	22.74
	Deposits	9.04	96.74	91.67	67.11	44.01
	Properties	0.18	0.05	1.12	19.86	33.25
	PCS	41.07	0.00	0.00	0.00	0.00
70%	Domestic Stocks	85.80	9.59	19.00	27.63	27.31
	Deposits	13.83	81.16	42.33	41.40	26.61
	Properties	0.37	9.25	38.67	30.97	46.08
	PCS	21.88	0.00	0.00	0.00	0.00
50%	Domestic Stocks	11.23	21.51	29.96	30.43	31.54
	Deposits	87.42	43.45	25.63	23.04	31.84
	Properties	1.35	35.04	44.41	46.53	36.62
	PCS	2.88	0.00	0.00	0.00	0.00

* Sum of asset allocation percentages equals 100%.

** Source: Authors' calculations.

In addition, it appears that there exists a threshold for diverse asset allocation among the income quintiles. For example, we find that the asset allocation ratio of 1st, 2nd, and 3rd quintiles in each consumption rate (50 percent, 70 percent, and 100 percent) is quite similar. Their portfolio mainly consists of deposits, which indicates that retirees in these quintiles should manage their assets safely or otherwise the ruin risk would increase. On the right side of the threshold, the asset allocation is rather diversified, meaning that retirees are able to take profit-seeking strategies with their ruin risk not increasing. In particular, the asset allocation for properties increases significantly. This indicates that it might be a rational financial decision for those retirees to invest highly in properties with the view of minimizing PCS. Thus, retirees should set different asset allocation strategies in the decumulation period, considering both the amount of their assets and their consumption level.

3.2.2. Scenario 2

Table 12 provides the asset allocation and PCS when a worker annuitizes pension assets and self-manages financial assets and properties. Compared to scenario 1, the asset allocation ratio of deposits is relatively low in scenario 2, except for the 1st quintile. This can be interpreted as the role of deposits providing a stable cash flow substituted with the whole life annuity.

With respect to PCS, it is higher in scenario 2.⁷ Particularly, we can compare a worker in the 1st income quintile with the consumption rate of 100 percent. The

⁷ We are not able to compare the PCS of the 2nd, 3rd, 4th, and 5th income quintiles since no ruin occurs in scenarios 1 and 2. Looking at the 1st income quintile, the PCS is lower in the case of self-annuitization.

PCS is 41.07 percent in scenario 1; however, it rises to 52.31 percent if a worker buys a whole-life annuity through pension assets. This indicates that the cash flow from a whole life annuity hardly overwhelms that of self-annuitization. Therefore, self-annuitization seems more effective than annuitization in alleviating the PCS.

Table 11. Asset Allocation and PCS of Scenario 2 (Units: %)

π	Asset	Income quintile				
		1st	2nd	3rd	4th	5th
100%	Domestic Stocks	90.78	3.34	9.60	17.23	26.02
	Deposits	9.06	96.47	77.29	57.52	35.25
	Properties	0.16	0.19	13.11	25.25	38.73
	PCS	52.31	0.00	0.00	0.00	0.00
70%	Domestic Stocks	84.07	14.90	22.36	28.98	33.20
	Deposits	15.61	64.03	34.19	28.75	27.47
	Properties	0.32	21.07	43.45	42.27	39.33
	PCS	25.84	0.00	0.00	0.00	0.00
50%	Domestic Stocks	10.98	26.33	31.70	33.95	30.95
	Deposits	88.87	25.35	26.34	29.09	29.05
	Properties	0.15	48.32	41.96	36.96	40.00
	PCS	6.55	0.00	0.00	0.00	0.00

* Sum of asset allocation percentages equals 100%.

** Source: Authors' calculations.

3.2.3. Scenario 3

Table 13 presents the PCS when a worker annuitizes all of his assets at retirement. Since the payout from a whole life annuity is regularly generated every period, ruin does not actually occur in scenario 3. Retirees, however, would not be able to sustain their living with just a small amount of annuities. Thus, we redefine the ruin risk as a probability that the payout of the annuity does not exceed the amount of consumption. As a result, ruin does not occur in the 2nd, 3rd, 4th, and 5th income quintile for all consumption rates. Hence, buying a whole life annuity can be an effective way of hedging the ruin risk for retirees in those quintiles. Retirees in the lowest quintile, on the other hand, will almost always experience ruin (99.36 percent, 96.25 percent), even if they curtail their consumption at 70 percent as before.

Table 13. PCS of Scenario 3 (Units: %)

π	Income quintile				
	1st	2nd	3rd	4th	5th
100%	99.36	0.00	0.00	0.00	0.00
70%	96.25	0.00	0.00	0.00	0.00
50%	0.53	0.00	0.00	0.00	0.00

* Source: Authors' calculations.

The overall analysis of the results shows that, regarding PCS, self-annuitization has the advantage over purchasing a whole life annuity. Table 14 shows the PCS of each scenario and consumption level. The PCS of the 1st income quintile shoots up as the amount of whole-life annuity increases. One interesting thing here, is that the PCS is lower⁴ in scenario 3 if the consumption rate drops by 50 percent. This is because ruin never occurs until the age of 98, and it occurs for sure at age 99 in this case. Therefore, it is better for retirees to annuitize all of their wealth if they spend significantly less than before, and they will be able to avoid ruin risk as well if risk-sharing is available through their families.

However, we cannot exactly examine the superiority between two strategies for retirees in the 2nd, 3rd, 4th, and 5th quintile because the PCS is zero regardless of all scenarios. Nevertheless, self-annuitization is generally thought to be superior to annuitization, considering certain advantages such as liquidity of assets or bequest availability.

Table 12. PCS of All Scenarios for Each Consumption Rate (Units: %)

π	Scenario	Income quintile				
		1st	2nd	3rd	4th	5th
100%	Scenario 1	41.07	0.00	0.00	0.00	0.00
	Scenario 2	52.31	0.00	0.00	0.00	0.00
	Scenario 3	99.36	0.00	0.00	0.00	0.00
70%	Scenario 1	21.88	0.00	0.00	0.00	0.00
	Scenario 2	25.84	0.00	0.00	0.00	0.00
	Scenario 3	96.25	0.00	0.00	0.00	0.00
50%	Scenario 1	2.88	0.00	0.00	0.00	0.00
	Scenario 2	6.55	0.00	0.00	0.00	0.00
	Scenario 3	0.53	0.00	0.00	0.00	0.00

* Source: Authors' calculations.

4. Conclusions

In Korea, financial planning for retirees has been focused only on maximizing the retirement assets. Investment performance can be a good measure of evaluating investments during the accumulation period at which the cash flow is continuously generated by income amount. However, a different approach should be adopted after retirement since the most important issue in the decumulation period is how to transfer the accumulated assets safely to a continuous, stable flow of consumption. Notwithstanding, there have so far seldom been concrete discussions about how to achieve this crucial point. Furthermore, it is obvious that the longevity risk of retirees in Korea has been exacerbated by the rapid drift of population ageing.⁸ Therefore, it is of great significance to manage accumulated assets not to be exhausted, so that retirees are able to make their living without ruin after retirement.

In this paper, we analyze the annuity puzzle in Korea: that most workers choose to self-annuitize their retirement assets. We set the asset allocation portfolio with domestic stocks, deposits, and properties in the accumulation period. In the decumulation period, we compare asset allocations of three scenarios with the view of minimizing PCS: self-annuitization, annuitization and mixed strategy. In most cases, PCS depends on the consumption amount, asset allocation and expected lifespan. To be more specific, PCS is negatively affected by the higher consumption amount, lower rate of return on investment, and longer expected lifespan. The main findings from the simulations are described as follows.

Firstly, the weight of properties in the asset allocation is significantly high in the accumulation period. It seems that properties can give some hedge against the risk of domestic stocks in the portfolio. Secondly, the asset

allocations for minimizing PCS vary by the income quintiles. This is because the returns on investment to meet the amount of consumption that retirees need are different in the income quintiles. Thirdly, the PCS increases significantly as the preference for a whole-life annuity increases. It is probably due to the fact that payout amount of a whole life annuity hardly beats the consumption amount of retirees. In case of consumption reduction, however, annuitization may be a better option for a retiree in the lowest income quintile.

These findings have important implications for designing financial planning for retirees. One of the issues emerging from these findings is that we should consider an individual's financial status from various angles when making financial decisions, rather than relying solely on the same standard for all workers. Minimizing the PCS would be particularly more significant for retirees in low income quintiles whose income levels are under the minimum cost of living. Furthermore, the evidence from this study suggests that self-annuitization might be more efficient for low income quintile retirees with the view of PCS, which gives a plausible explanation for the annuity puzzle in Korea.

Nevertheless, it does not mean that their self-annuitized assets are enough for retirees to make their livings in the decumulation period. In this regard, a reverse mortgage loan may be a great means of supporting their consumption, considering the fact that most of the Korean retirees' assets consist of real estate. One advantage of the reverse mortgage is that homeowners are able to generate monthly payments without selling it (i.e. homeowners are able to dwell in the collateralized house). In reality, the demand for the reverse mortgage has rapidly increased among Korean retirees since its implementation in 2007, yet the coverage rate among elderly households is still remain at 0.81 percent.⁹ From a worldwide perspective, not many countries are actively introducing the reverse mortgage for retirees.¹⁰ Given the fact that reverse mortgage could provide an alternative solution for stabilizing the retirement income security without a huge government expenses, the reverse mortgage may be a complementary solution for the annuity puzzle and would be effective in enhancing the elderly poverty for countries experiencing a population aging problem. Future studies are therefore encouraged to identify the potential effects of the reverse mortgage.

This study has the following limitations. First, we do not consider other income sources such as those from national and basic pension benefits or part-time jobs. Also, we ignore the fact that workers in the low income quintile are generally not willing to keep their DC assets until retirement, because they usually withdraw their money whenever they change jobs. The current study is not specifically designed to consider these factors since the primary aim of this paper is to compare superiority among the annuitization strategies by income quintiles. However,

⁹ The annual increase rate of the reverse mortgage contract is 140.24 percent (2007-2015).

¹⁰ A government-guaranteed reverse mortgage program is being implemented in U.S., Hong Kong, Japan, and Korea. In U.K. and Australia, there exists equity release products from financial companies. However, most of the countries' reverse mortgage products are not popularized and the market sizes are limited.

⁸ According to OECD Income Distribution Database, the elderly poverty rate (over 65) is 45.7 percent in Korea, which is the highest among 37 countries (2015).

these factors will affect the PCS of retirees positively or negatively, so they should be taken into account to reflect the financial status of Korean workers more precisely. Therefore, it would be interesting to assess the effects of other variables regarding the PCS of retirees.

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