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Annuity Puzzle is a Reasonable Choice: Evidence from Korean Annuity Market

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Abstract

Although many existing papers have studied optimal retirement plans for retirees in the US and UK, there is little attention in Asian countries. However, there are several limitations in applying those implications to retirees in Asian countries due to the differences in cultural backgrounds, expected life spans, financial market conditions, and characteristics of annuity products. This study attempts to explain an annuity puzzle found in Korea by estimating retirees' ruin probabilities by gender, age, guaranteed periods, portfolio structures, and market perspectives. The results indicate that the annuity puzzle in Korea is the product of rational decision making. Under the current market conditions, people can easily benchmark an annuitization strategy by themselves. Especially, females can more easily conduct self-annuitization due to the lower IRR. In addition, annuity options such as guaranteed period do not seem to give considerable benefits to annuitants. Nevertheless, an appropriate investment strategy must be considered to conduct a successful self-annuitization strategy.

Key Words: Annuitization, Self-annuitization, Annuity Puzzle, Probability of Ruin

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1. Introduction

As a systematic risk, longevity risk is defined as uncertainty that people might live longer than they expected. To hedge longevity risk, several strategies and techniques have been introduced. Annuities are known as one of the greatest financial tools in managing longevity risk (Gupta and Li, 2007). Since Yaari(1965)'s initial introduction, benefits of annuitization have been supported by other studies (e.g., Chen and Milevsky (2003), Davidoff, Brown, and Diamond (2005)).

From the perspective of economic theory, annuity products should be valued by risk-averse retirees (Milevsky and Young, 2007). Regardless of its benefits, the current annuity market is not as big as many experts expected. Retirees prefer to receive their retirement benefits in a form of a lump-sum instead of an annuitization option (Sondergeld (1997), MacPherson and Plotnick (2002), Warner and Pleeter (2001), Drinkwater and Sondergeld (2004)). Moreover, people do not purchase annuity products. King and Leape (1987) note that single premium annuities are just about 0.4% of entire wealth of American consumers. Brugiavini (1993) also presents that the average ratio of annuity premiums to total earnings is approximately 0.8% in their samples in the survey of personal incomes in the UK. Thus, the theory is inconsistent with empirical evidence. This is why researchers call this phenomenon an annuity puzzle.

The annuity puzzle phenomenon is also frequently found in Korea. Samsung Life Insurance Retirement Research Center (2011) reports that only 0.2% of people who are eligible for being annuitants choose the annuitization option. Kim (2004) shows that only 0.3% of retirees respond that they have annuity policies. Furthermore, 97.0% of retired people select a lump-sum instead of annuitization during the last quarter in 2013 (Financial Supervision Service, 2014).

The annuity puzzle catches considerable attention of researchers because it is against an economic based assumption that individuals are rational. In order to explain reasons of the annuity puzzle, various possible factors have been discussed by prior literature (see Section 2 for more details). In general, these studies have focused on the cases in the US or UK. However, there are several limitations in applying those implications to retirees in Asian countries due to the differences in cultural backgrounds, expected life spans, financial market conditions, and characteristics of annuity products. This study intends to explain the annuity puzzle found in Korea by measuring the probabilities of ruin. Overall, results show that the annuity puzzle in Korea is based on reasonable decision making instead of an irrational way of thinking. Under the current market conditions, an annuitization strategy does not give substantial incentives compared to a self-annuitization strategy. In addition, it is relatively easier to benchmark an annuitization strategy. Nevertheless, an appropriate investment strategy should be prepared to conduct a successful self-annuitization

strategy.

This paper is organized as follows: In Section 2, possible reasons of the annuity puzzle are described. Section 3 explains research design and data for implementing analyses. Furthermore, research results are suggested in Section 4. The last section summarizes and explains limitations of the study. In addition, it also proposes research questions for further studies.

2. Possible reasons of Annuity Puzzle

The evidence for the annuity puzzle poses several questions to researchers such as why so few consumers understand the benefit of longevity insurance and why they do not utilize the implied mortality credit. Since Yaari (1965) evokes the benefits in annuity products, researchers have focused on clarifying the reasons for annuity puzzle in terms of annuity products, consumer behavior, contracts, social structure, financial market, and other relevant factors. Among the various possible factors, their main interests are bequest motive, available payout options, liquidity risk (healthcare expenditure), pre-existing annuity sources, incomplete market, and fee and administrative cost.

Above all, the bequest motive is regarded as an important factor to make people hesitate to purchase annuities.[2] Friedman and Warshawsky (1990), Lockwood (2012), and Yogo (2011) insist that the bequest motive is a crucial factor blocking the annuitization. Bernheim (1991) points out that more than half of the elderly anticipate leaving bequest worth more than $10,000.

How to design payment options also may determine the degree of annuity selection because people select a certain type of payout among available options. Banerjee (2013) proves that available options can affect the decision to annuitize retirement assets. He insists that 98.8% of retirees choose the annuity option when a lump-sum option is limited and only 27.3% select the option otherwise. Those findings imply that the annuity puzzle can be considerably solved by an appropriate default designs.

On the other hand, if people have other annuitized financial source, they tend to avoid buying annuity products since they regard that the regular cash flow from other annuitized sources will protect them from longevity

[2] The bequest motive is related with the number of children. Gale and Scholz (1994) find that households with children have more incentive to leave bequest than households without children. In addition, HRS survey shows a similar result that more family with children (67%) agree with the importance of bequest than family without children (55%). However, some other studies contradict these assertions concluding that the bequest motive has a marginal impact on annuity purchases (Hurd 1987; Hurd 1989). Vidal-Melia and Lejarraga-Garcia (2006) and Brown and Poterba (2000) concur with previous assertions that the bequest motive is not a significant factor in consumers' decisions to forego annuitization using models that separate married couples and unmarried consumers.

risk. Purcal and Piggott (2008) explain that the low annuity demand is explained by pre-existing annuitization. Yogo (2011) also proves that other annuity sources such as public pension or social security can be a possible reason of the annuity puzzle. His findings are consistent with conclusions of Bernheim (1985) and Dushi and Webb (2004).

Another possible reason of the annuity puzzle is liquidity risk. This is a critical problem of annuitization. Once people convert their assets to annuity products, they may not hold enough cash equivalent assets. Therefore, it causes a liquidity problem when unexpected events such as health problems happen (Sinclair and Smetters (2004), Peijnenburg, Nijman, and Werker (2010). Yogo (2011) also supports that the concern of health shocks is a main reason of the annuity puzzle. Furthermore, family networks can be a source of funding in case of dire circumstances for health emergencies or outliving income. In other word, people regard family network as a kind of self-insurance. Brown and Poterba (2000) find that the married tend to purchase less annuity products than the unmarried since each function as a mini-annuity market.

Brown (2007) regards lack of knowledge as another barrier. He says that lack of understanding of how annuities work and how annuities are worthy makes people underestimate their longevity risk. In addition, people cannot easily obtain and interpret relevant information such as credit ratings, premium structures, and underwriting requirements. For these reasons, he suggests financial education to public policy toward annuitization and new product as a solution to alleviate the annuity puzzle.

However, there are some controversial views about an incomplete market which makes annuity prices unfair and increases fee and administrative cost. Although unfair prices might be the reason for the annuity puzzle, many existing researches prove that the annuity pricing process is fair in the US and UK. Cannon and Tonks (2010) examine the compulsory market (1994-2009) and voluntary market (1957-2009). They suggest that the price is fair even when they consider the loading factor in annuity products compared with other financial and insurance products. Murthi, Orszag, and Orszag (1999) and Mitchell et al. (1999) provide same results. One interesting thing is the recent money's worth (MW) trend examined by Cannon and Tonks (2010). MW is defined as a ratio of the expected present value of the cash flow made by annuity to the money paid for annuity purchase. Cannon and Tonks (2010) find that MW has been decreasing because of changes in regulation, industrial concentration, insurance cycle, and pricing of mortality risk. It implies that the annuity puzzle is caused not by unfair pricing, but by decreasing MW trend. For consumers, the perception of overly high premiums dampens demands of annuities regardless of what the truth is. This perception leads consumers to seek other products for two reasons: they cannot afford the cost of annuities (Lopes, 2003) or they think they can get a better return elsewhere on their investment (Milevsky, 1998).

According to Finkelstein and Poterba (2004), fees and administrative costs do not significantly affect the decision of annuitization. They show that the benefits came from the annuitization are still substantial even they consider administrative loads. However, Mitchell et al. (1999) estimate that the expected present value of annuity cash flows is merely 84% of the annuity cost. Milevsky and Young (2005) also argue that high mortality risk fee charged by the annuity providers can be the most important factors to understand the annuity puzzle. They point out that the average annual charge on variable annuity (2.08%) is higher than the average mutual fund charges (1.38%).

The most prior literature has examined the annuity markets in the US and UK. In spite of that, it is doubtful whether these factors can be directly applied to the Korean annuity market due to the differences in cultural backgrounds, expected life spans, financial market conditions, and characteristics of annuity products. Therefore, this study aims at explaining the annuity puzzle in Korea with Korean empirical data. It is expected to give more direct and meaningful implications to develop the Korean annuity market.

3. Research Design

3.1. Methodology

To explain the annuity puzzle found in Korea, this study adopts the concept of probability of ruin suggested by Milevsky and Robinson (2005)[3]. Milevsky and Robinson (2005) define ruin as an event that the self-annuitants cannot sustain their strategy due to the lack of enough wealth. Similarly, in this study, the probability of ruin is defined as a risk that self-annuitants' remaining wealth becomes less than the benchmarked monthly benefits of annuitants as shown Equation (1).

$$\text{Prob(Ruin)} = \text{Prob(Remaining Wealth} < \text{Benchmarked Monthly Benefit)} \quad (1)$$

To estimate the probability of ruin at time t, the remaining wealth status and benchmarked monthly benefits at time t should be estimated. Then, the remaining wealth status (W) of self-annuitant j at time t is also determined by previous year's wealth status, withdrawal amount (B), investment return (R), and saving level (S). In addition, the wealth status formula of individual j at time t can be denoted as following Equation (2).

$$W_{jt} = (W_{jt-1} - B_{jt-1}) \times (1 + R_{jt-1}) + S_{jt-1} \quad (2)$$

where W_{jt}: remaining wealth of the individual j at time t,

[3] Self-annuitization is a strategy used by those people who do not want to annuitize their wealth. Milevsky and Robinson (2000) define self-annuitization as a process of consuming a fixed amount from wealth and replicating a life annuity.

$B_{j,t}$: benchmarked benefit of the individual j at time t,

$R_{j,t}$: investment return of the individual j at time t. and

$S_{j,t}$: saving amount of the individual j at time t

As a benchmarked benefit, withdrawal amount (B) is determined by gender (G), guaranteed period (P), and policyholder's age (A). This study considers both males and females G∈[male, female], three types of guaranteed years P∈[10 years, 20 years, 30 years], and three age groups A∈[55, 60, 65].[4] All benchmarked benefits are determined before implementing a strategy, and the amounts are fixed as the monthly benefits of annuitants are fixed. One thing to note is that the actual withdrawal amount of self-annuitants must be larger than benchmarked benefit B, due to the tax and managerial fee.[5] Then, adjusted benchmarked benefit (B') which should be withdrawn is shown in Equation (3).

$$B_{j,t}^{'}(1-tax-fee)=B_{j,t} \Leftrightarrow B_{j,t}^{'}=\frac{B_{j,t}}{(1-tax-fee)} \quad (3)$$

where, $B_{j,t}^{'}$: adjusted benchmarked benefit of individual j at time t.

Moreover, when retirees decide their retirement strategies, a financial market perspective (M) is very important.[6] This study considers three types of financial market conditions, M∈[Scenario □, Scenario □, Scenario □]. Here, Scenario I assume that the market conditions are similar to those in the last 15 years. Scenario □ and □ assume market conditions of the last 10 years and the last 5 years respectively. In addition, the market returns can be affected by the portfolio structures (I). Even under the same market scenario, the expected returns might be different depending on asset allocations So, it includes three static investment portfolios, I(stock : bond) ∈ {(2:8), (5:5), (8:2)}. In addition, it assumes that the rate of return (R) follows normal distribution based on its average and standard deviation by each scenario and portfolio structure, $R \sim N(\mu_{M,I}, \sigma_{M,I}^2)$.

The wealth status at time t, $W_{j,t}$, can be affected by the saving amount at time t-1. However, savings, S,

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[4] The Korean annuity market has an interesting feature: there is none of pure life annuities. Although some products are titled as life annuities, all those annuities include guaranteed benefit options. These options make monthly benefits smaller than benefits of pure life annuity products.

[5] This study assumes that all assets are invested in financial assets. To make these assets to cash, self-annuitants have to sell the part of investment portfolio. In this process, tax and managerial fee can be charged.

[6] If the financial market conditions are good to earn high rates of return, the self-annuitization strategy is a better choice than the annuitization strategy.

are not considered as a critical factor in Korea since the pension replacement rate, which shows the ratio of retirement income relative to pre-retirement income is merely 38.3% for males and 41.1% for females respectively (Shin, Son, and Lee, 2014). These figures imply that most of retirees spend all of their cash flow generated from the self-annuitant strategy without saving. Therefore, it does not bias the result when eliminating savings in Equation (1). Then, model for estimating self-annuitants' remaining wealth at time t in Equation (2) can be revised as follows.

$$W_{it} = (W_{it-1} - B_{it-1}) \times (1 + R_{it-1}) \tag{4}$$

Now, based on the model in equation (4), it projects the remaining wealth of self-annuitants for the time t with Monte-Carlo simulation (n=2000) and compare each figure with retiree's adjusted benchmarked benefit. Then, it could count the frequency of the event that ruin occurs, and then the ruin probability at time t can be calculated based on the following formula (5).

$$\Pr(W_t < B) = \frac{1}{2000} * \sum_{i=1}^{2000} k_i \tag{5}$$

where, k=1 if ruin happens at time t. and 0 otherwise.

For this analysis, it includes more assumptions as follows: First, all retirees own ₩100,000,000 at the beginning of the retirement plan choice. Second, the monthly benefits of annuitants are only determined by gender, age, assumed interest rate, initial wealth, fee, and internal option in annuity products such as guaranteed period. Third, the remaining assets are reinvested for his lifetime with fixed portion: stock and bond portions are 2:8, 5:5, and 8:2 respectively. Fourth, each retiree's terminal age is 110. Last, the trading fee and tax for investment are the same for all investment periods. Then, totally, 54 cases will be examined by gender, guaranteed periods, portfolio structures, and market perspectives.

3.2 Data

To estimate the probability of ruin, benchmarked benefits and investment returns should be projected. Then, the data of annuitant's benefits are obtained from individual insurance firms and blogs of individual general agents (GAs).[7] In general, age, gender, guaranteed period, and assumed interest are included in statement of annuity price quotes. Totally 338 samples of annuity products are gathered and the summary is shown in Table 1.

[7] Although there is an official web site (www.pub.insure.or.kr) for comparing the annuity products, available information is limited and the given information is not standardized. So, it is limited to access the annuity prices by gender, age, and options.

Table 1. Data Summary

Variable	Obs	Mean	Std. Dev.	Min	Max
Age	338	57.38	4.51	45	66
Gender	338	0.68	0.47	0	1
Initial Wealth (₩1,000)	338	170,414.20	65,462.11	100,000.00	500,000.00
Guaranteed Period	338	24.49	12.28	10	55
Assumed Interest	338	0.036	0.005	0.025	0.043
Monthly benefit	338	654.1647	260.0615	255	1953.04

Note) Gender equals 0 if females and 1 otherwise. Initial wealth is the annuity price. Guaranteed period provision guarantees annuitants' benefit for the period regardless of the policyholder's survivorship. Interest rate is a discount factor.

To calculate the monthly benefit level by age, gender, initial wealth, guaranteed period, and assumed interest rate, this study sets a regression model whose independent variables are normally included in the statement of price quote as shown in Equation (6).[8]

$$Monthly\ benefit = B_0 + B_1 Age + B_2 Gender + B_3 Initial wealth + B_5 Guaranteed\ Period + B_5 Assumed\ \ interest \quad (6)$$

Based on the above regression model (6) and assumptions described in Section 3.1, annuitants' monthly benefits are estimated by gender, age, and guaranteed periods in annuity policies. Table 2 presents the monthly benefit levels when initial wealth (the price of annuity) equals to ₩100,000,000. Moreover, the interest is assumed as 4.0%, an average rate in samples. However, insurance firms charge 0.05% of annuitants' monthly benefits as a management fee. Although the management fee is not substantial, it slightly reduces the net value of the monthly benefits. Actual monthly benefits that annuitants finally receive are measured as shown in Table 3.

Table 2. Monthly Benefits (B) of Annuitants without Management Fee

Guaranteed Period	Male			Female		
	Age 55	Age 60	Age 65	Age 55	Age 60	Age 65
10	417.53	443.00	468.48	362.67	388.15	413.62
20	406.87	432.34	457.82	352.01	377.49	402.96
30	396.20	421.68	447.16	341.35	366.83	392.30

[8] All variables in the regression model are statistically significant at the 1% of level. Moreover, R-square is 97.98%. Therefore, the factors in the regression model explains annuity pricing structure very well. The benefits are positively related with age, assumed interest rate, and initial wealth. In addition, males receive more benefits than those of females. However, the guaranteed period has negatively related to the amount of monthly benefits (See Appendix 1 for more details).

Table 3. Monthly Benefits (B') of Annuitants with the Management Fee (0.05%)

Guaranteed Period	Male			Female		
	Age 55	Age 60	Age 65	Age 55	Age 60	Age 65
10	415.44	440.79	466.14	360.86	386.21	411.56
20	404.83	430.18	455.53	350.25	375.60	400.95
30	394.22	419.57	444.92	339.65	364.99	390.34

Next, it calculates how much self-annuitants must withdraw to match the net cash flow of annuitants of the same age. In Korea, there are two types of transaction cost for investment: one is the transaction fee (0.05%) and the other one is tax (0.30%). Table 4 represents the amount of selling assets (B') to match the benchmarked benefit and those are somewhat larger than net cash values.

Table 4. Monthly Withdrawals of Self-annuitants: Fee and Tax (0.05% and 0.30%)

Guaranteed Period	Male			Female		
	Age 55	Age 60	Age 65	Age 55	Age 60	Age 65
10	416.90	442.34	467.77	362.13	387.56	413.00
20	406.25	431.69	457.13	351.48	376.92	402.36
30	395.61	421.05	446.48	340.84	366.28	391.71

Note) The strategy self-annuitants use to generate the monthly income equivalent to the net cash flow of annuitants is shown in Table 3. However, self-annuitants must sell their portfolios over the value of net monthly benefits of annuitants to match the amount due in the management fee (0.05%) and tax (0.30%).

Data on the returns and standard deviations of stock and bond for 15 years (scenario I), 10 years (scenario II), and 5 years (scenario III) are obtained from Korea Composite Stock Price Index 200 (KOSPI 200) and Korea Investors Index (KIS). KOSPI 200 index consists of the largest 200 companies traded in Korean stock market and KIS shows the movement of the bond market over 9000 bonds whose duration, credit rate, and leverage are different. As can be seen in Table 5, the expected monthly returns (standard deviation) of stock and bond investment are 1.03% (6.52%) and 0.39% (0.11%) for recent 15 years. However, the expected monthly outcomes become 0.83% (5.72%) and 0.35% (0.08%) for recent 10 years and 0.36% (4.04%) and 0.28% (0.04%) for the last 5 years. Those figures obviously show that the expected market returns and volatility become smaller. Based on market data, it projects returns of portfolios depending on asset allocations with three scenarios: stock and bonds consist of 2:8, 5:5, and 8:2. Since the returns of stock and bond are correlated, it considers this effect when returns are projected.

Table 5. Monthly Rate of Return on Asset Allocations

	KOSPI 200 (Stock)	KIS (Bond)	Stock vs Bond Allocations		
			S:B=2:8	S:B=5:5	S:B=8:2
Scenario I (2001-2014)	1.03% (6.52%)	0.39% (0.11%)	0.52% (1.31%)	0.71% (3.26%)	0.90% (5.22%)
Scenario II (2005-2014)	0.83% (5.72%)	0.35% (0.08%)	0.45% (1.14%)	0.59% (2.86%)	0.74% (4.58%)
Scenario III (2010-2014)	0.36% (4.04%)	0.28% (0.04%)	0.30% (0.81%)	0.32% (2.02%)	0.34% (3.24%)

Data) Korea Composite Stock Price Index 200 (KOSPI 200) and Korea Investors Index (KIS)

4. Results

In order to clarify the reason of the annuity puzzle in Korea, this study estimates the probability of ruin by gender, age, guaranteed period, and market perspective. By calculating probabilities of ruin, self-annuitants' risk can be measured when they withdraw cash equivalent to the benefits of annuitants. More specifically, it examines three following aspects: 1) when the ruin might be initially found, 2) what degree of ruin probability occurs at the end of each guaranteed period, and 3) how the pattern of ruin probability is developed until the terminal age (age 110). It describes the results of male first, and compare them with females'.

First of all, it examines the age that ruin might be initially found. Overall, the results illustrate that the initial timing is earlier if the guaranteed year is shorter, the portfolios are riskier, and the market returns are lower. As shown in Table 6, the first ruin event may happen later if the financial market conditions are more favorable (scenario I). For example, the first ruin event of male group at age 55 with 10-year guaranteed option and 50% of risky portfolio is found at age 71. In addition, the timing can be delayed by choosing a longer guaranteed period option. If the above group selects a 30-year guaranteed option instead of the 10 year, the initial ruin is found at age 72. Moreover, the relatively conservative investment is effective to delay the initial timing of ruin occurrence as well. By reducing the portion of risky asset investment from 50% to 20%, the first potential ruin age increases from 71 to 84. Under the conditions of scenario I, people do not have an incentive to buy annuity products because they could manage their wealth keeping the liquidity from the self-annuitization strategy. On the other hand, when the market conditions become unfavorable and similar to latest 10 years (scenario □) and 5 years (scenario □), it may give more incentive to buy annuity products because lowered expected market returns make the initial timing of ruin earlier. However, such an incentive seems to be limited, especially for retirees with high risky investment portfolio.

Table 6. Ages Ruin is Initially Found (Males) (unit: age)

Age	Guaranteed Period	Scenario I			Scenario II			Scenario III		
		S:B =2:8	S:B =5:5	S:B =8:2	S:B =2:8	S:B =5:5	S:B =8:2	S:B =2:8	S:B =5:5	S:B =8:2
Age 55	10	84	71	65	80	67	66	78	71	66
	20	85	72	66	81	68	66	79	71	66
	30	87	72	66	82	68	66	80	72	67
Age 60	10	83	73	69	83	73	70	80	73	71
	20	84	73	69	84	74	70	80	74	71
	30	85	73	70	85	74	70	81	74	72
Age 65	10	87	81	73	87	79	74	85	77	75
	20	88	81	73	87	79	74	85	78	75
	30	89	81	74	88	79	74	86	78	75

Second, it estimates probabilities of ruin at the end of guaranteed period. The probability of ruin within guaranteed period can be an important standard when people decide their retirement plans between the annuitization and self-annuitization. If retirees cannot tolerate imposed ruin risk at the end of guaranteed period, they are willing to annuitize their disposal wealth instead of choosing a self-annuitization strategy. Table 7 shows that the probabilities of ruin are almost zero when the financial market is favorable (scenario I). In scenario I, the probabilities of ruin are less than 10% even with 80% of risky asset allocation. On the other hand, in scenario □ where the market conditions are similar to latest 5 years, the probabilities of ruin increase. However, the significant increase in ruin probability is applied to only retirees who benchmark benefits of annuity products with 30-year guaranteed period and/or portfolio of high risk asset allocations. If retirees benchmark benefits with 10-year or 20-year guaranteed annuity product, risk of ruin is not still large. One more interesting thing in Table 7 is that the ruin probabilities are almost close to zero within 10 years regardless of age, asset allocation, and market conditions. In other words, retirees can manage their wealth without ruin at least for 10 years. Therefore, it gives an important implication that under the current market conditions, the 10-year guaranteed option does not give considerable incentives to annuitize retirees' wealth.

Third, it examines aspects of how the probability of ruin develops until the terminal age (110). Table 8 shows that the probability of ruin is adversely related to the degree of market optimism. As expected, the overall ruin probabilities are the smallest in scenario I and the largest in scenario □. Under the market perspective of scenario I, the ruin probability of male group aged at 65 with a 20% risky portfolio, is just about 12.9% at the age 110. In addition, its ruin probability becomes 40.6% in scenario □. However, the male's ruin risk drastically soars to almost 100% in scenario □ if portfolio includes 20% stocks and 80% bonds.

The trend of the change in the probability of ruin depending on market perspectives gives important implications. Until the end of guaranteed period, the ruin risk can be easily managed by benchmarking the benefits with relatively shorter guaranteed period or by selecting the portfolio with less risky assets. However, to maintain low risk of ruin until the terminal age, more aggressive portfolio allocation may be needed especially if the market is similar to the last 5 years (scenario □).

Table 7. Probabilities of Ruin at the end of Guaranteed Periods (Males) (unit: %)

Age	Guaranteed Period	Scenario I			Scenario II			Scenario III		
		S:B =2:8	S:B =5:5	S:B =8:2	S:B =2:8	S:B =5:5	S:B =8:2	S:B =2:8	S:B =5:5	S:B =8:2
Age 55	10	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
	20	0.00	0.50	3.75	0.00	0.40	4.75	0.00	2.75	14.15
	30	0.00	2.70	7.20	0.20	3.35	10.20	6.85	29.95	39.75
Age 60	10	0.00	0.00	0.30	0.00	0.00	0.20	0.00	0.00	0.00
	20	0.00	0.70	4.25	0.00	1.20	5.90	0.00	6.80	19.45
	30	0.35	2.75	8.60	0.25	6.80	12.20	1.95	37.90	47.20
Age 65	10	0.00	0.00	0.15	0.00	0.00	0.15	0.00	0.00	0.05
	20	0.00	1.20	4.45	0.00	2.10	7.95	0.05	11.40	26.20
	30	0.70	5.55	9.05	2.60	9.00	15.05	55.95	51.25	55.40

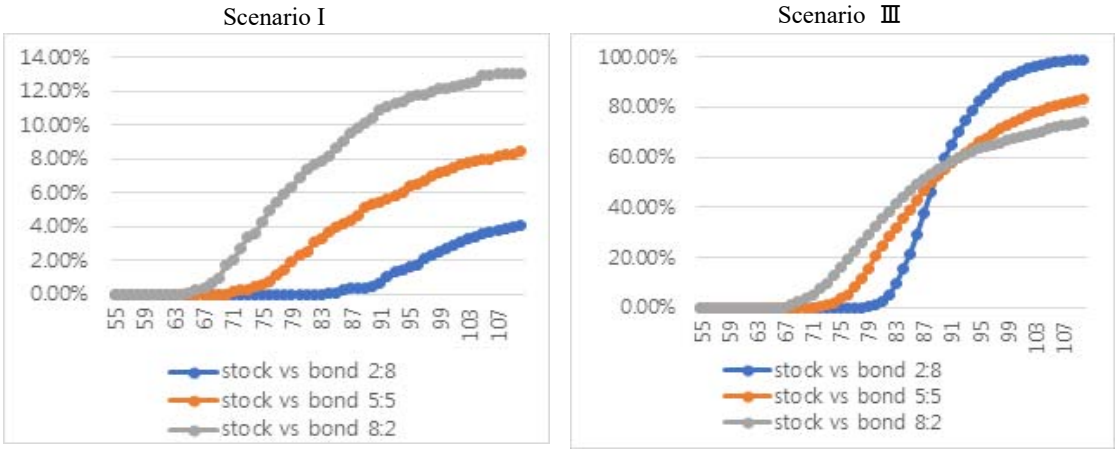
Table 8. Probabilities of Ruin at the Terminal Age (Males)

Age	Guaranteed Period	Scenario I			Scenario II			Scenario III		
		S:B =2:8	S:B =5:5	S:B =8:2	S:B =2:8	S:B =5:5	S:B =8:2	S:B =2:8	S:B =5:5	S:B =8:2
Age 55	10	4.10	8.45	13.05	19.65	15.30	19.25	98.80	83.00	74.25
	20	3.05	7.35	12.35	14.75	13.55	18.25	97.70	79.65	71.90
	30	2.05	5.95	11.30	10.70	11.50	16.85	94.90	75.70	69.10
Age 60	10	9.00	9.30	14.40	30.45	21.40	21.40	99.30	84.25	77.65
	20	6.15	7.60	13.20	24.20	18.70	19.65	98.90	81.10	75.20
	30	4.30	6.55	12.15	17.20	16.25	18.10	97.90	78.70	72.75
Age 65	10	12.85	11.35	14.65	40.60	23.30	25.35	99.75	87.25	79.05
	20	9.95	10.35	13.70	33.80	20.85	23.45	99.30	85.25	77.20
	30	7.50	9.20	12.60	26.85	18.50	21.75	98.85	81.70	75.50

Figure 1 shows the accumulated probability of ruin by market perspective and asset allocation. When the financial market is favorable, retirees maintain the low ruin risk with low portion of risky asset for all periods. It implies that the self-annuitants can successfully benchmark the annuitization strategy even with low risky portfolio if the market conditions are optimistic. However, the above relationship is not sustained when the

expected investment returns follow scenario □. Although the low portion of risky portfolio is still superior to the high risky investment portfolio at the early stage, the probability of ruin significantly soars and becomes larger since at the certain age. For example, 20% of stock investment is the safest portfolio that minimizes the ruin probability before age 90. However, this portfolio is dominated by 50% and 80% of risky portfolios after age 90. The implication is that more aggressive investment strategies are required for low ruin risk when the financial market conditions are not favorable to retirees. Hence, the optimal investment portfolio to minimize the ruin probability should be considered depending on market conditions. Without considering an optimal investment allocation, the self-annuitization strategy might fail.

Figure 1. Probability of Ruin: Male, age 55 with 10 Year Guarantee in Scenario I and Ⅲ



Note) X-axis is an age of policyholders and Y-axis is an accumulated ruin probability of policyholders.

Last, it compares the results of males with females'. Although most figures provide similar implications with males, interestingly, the probabilities of ruin for females are considerably smaller than males in all cases when other given conditions such as age, guaranteed period, and portfolio structure are the same. Table 9 shows that the ruin probability of ruin of the female group at age 55 with the 10-year guaranteed option and 20% of risky portfolio is initially observed at age 95. It means that this female group's initial ruin is found 10 years later than the male group with same conditions.

Table 9. Timing that Ruin is Initially Found (Females)

Age	Guaranteed Period	Scenario I			Scenario II			Scenario III		
		S:B =2:8	S:B =5:5	S:B =8:2	S:B =2:8	S:B =5:5	S:B =8:2	S:B =2:8	S:B =5:5	S:B =8:2
Age 55	10	95	75	67	86	69	67	83	74	67
	20	100	76	67	88	70	68	84	74	68
	30	106	77	68	90	70	68	86	75	68
Age 60	10	89	76	71	89	76	71	83	75	72
	20	91	77	71	91	76	71	84	76	73
	30	94	77	71	93	77	72	85	76	73
Age 65	10	92	81	75	91	81	75	89	79	76
	20	94	82	75	92	81	75	90	80	76
	30	95	83	76	94	81	75	91	80	76

Then, how can it be explained? Is it due to the unfair pricing applied to males? There is not enough evidence on the discriminative pricing between males and females. In prior literature, several studies prove that the prices are actuarially fair in terms of value of MWs (see Mitchell et al., 1999; Brown, 2007; and Gong and Webb, 2010). Lee (2013) also proves that the MWs in Korea are similar to the US (Mitchel et al., 1999) and Singapore (Fong et al., 2010). Even those values are larger than Australia (Ganegoda and Bateman, 2008). In addition, the initial cost and managerial fee are the same for both males and females in Korea. These costs might reduce the advantages of annuity products. However, this does not mean those costs make the annuity prices actuarially unfair.

Another possible reason can be induced from the different required internal rate of returns (IRR) by gender. Since the longevity risk of the females is higher, annuity firms design to provide less monthly benefits to females when other conditions are the same. Thus, females' required internal rates of return (IRR) to benchmark the annuitization strategy are relatively and significantly lower than those of males (see Table 10). For example, the minimal monthly IRR of males to generate monthly benchmarked benefits without ruin risk varies from 0.36% to 0.41% per month. On the other hand, females just need 0.29% to 0.34%. Based on the financial market returns as shown in Table 5, those required IRRs are not a big problem for females. Therefore, females could conduct the self-annuitization strategy more easily with lower ruin risk. As a result, the annuity puzzle is expected to be prominent to females.

Table 10. Monthly IRR of Self-annuitants to Match Net Cash Flow of Annuitants

Age	Guaranteed Period	Male	Female
Age 55	10	0.39%	0.32%
	20	0.38%	0.31%
	30	0.36%	0.29%
Age 60	10	0.41%	0.34%
	20	0.39%	0.33%
	30	0.38%	0.31%
Age 65	10	0.42%	0.36%
	20	0.41%	0.34%
	30	0.40%	0.33%

These advantages of low IRR are also shown in females' probability of ruin at the end of the guaranteed periods and at the terminal age. Table 11 shows that the largest ruin probability of female aged 65 is 4.7% at the end of the guaranteed period scenario I. In addition, the maximum risk becomes 9.3% at the terminal age with the same scenario I (see Table 12). However, if other conditions are same, the ruin risk for males at the end of the guaranteed period and at the terminal age are 9.1% and 12.6% respectively (see Table 7 and Table 8). Furthermore, the ruin development patterns of females illustrated in Figure 2 are consistent with those of males. Nevertheless, the ruin risk is relatively and considerably lower than males. The above results imply that females can more successfully benchmark the annuitization strategy than males in all scenarios, maintaining low probability of ruin. As a result, females are more likely to choose the self-annuitization rather than males.

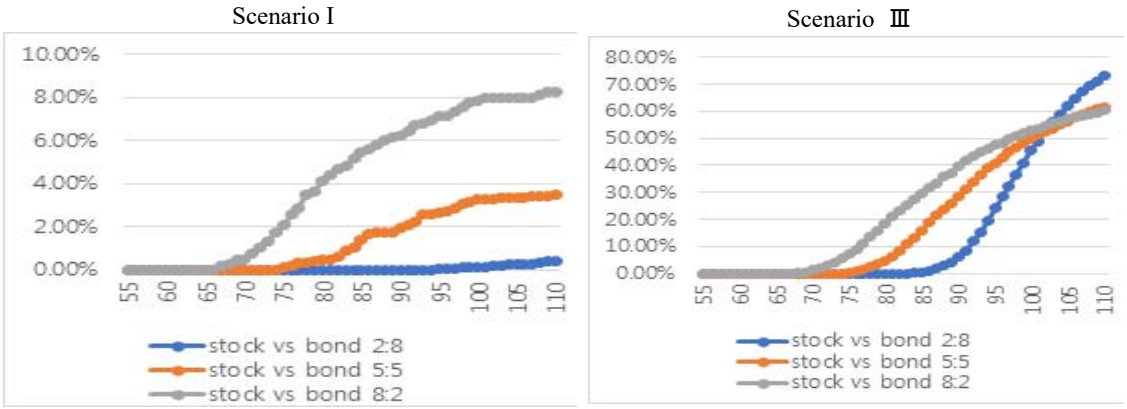
Table 11. Probabilities of Ruin at the end of Guaranteed Periods (Females) (%)

Age	Guaranteed Period	Scenario I			Scenario II			Scenario III		
		S:B =2:8	S:B =5:5	S:B =8:2	S:B =2:8	S:B =5:5	S:B =8:2	S:B =2:8	S:B =5:5	S:B =8:2
Age 55	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	20	0.00	0.00	1.75	0.00	0.10	2.10	0.00	0.15	6.30
	30	0.00	0.55	4.20	0.00	0.85	5.75	0.00	9.35	23.70
Age 60	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	20	0.00	0.30	2.15	0.00	0.30	2.50	0.00	1.20	8.85
	30	0.00	0.85	4.95	0.00	2.30	7.40	0.95	16.15	31.65
Age 65	10	0.00	0.00	0.10	0.00	0.00	0.05	0.00	0.00	0.00
	20	0.00	0.20	2.15	0.00	0.40	4.40	0.00	2.95	13.05
	30	0.05	2.15	4.65	0.15	3.50	9.35	6.70	26.85	39.45

Table 12. Probabilities of Ruin at the Terminal Age (Females) (%)

Age	Guaranteed Period	Scenario I			Scenario II			Scenario III		
		S:B =2:8	S:B =5:5	S:B =8:2	S:B =2:8	S:B =5:5	S:B =8:2	S:B =2:8	S:B =5:5	S:B =8:2
Age 55	10	0.40	3.50	8.25	2.50`	6.25	13.00	73.15	61.55	60.45
	20	0.25	3.15	7.60	1.65	4.90	12.05	62.35	56.60	57.20
	30	0.05	2.50	6.50	0.70	3.95	11.00	49.90	51.15	53.95
Age 60	10	0.95	3.45	9.15	4.25	10.45	14.70	85.50	65.10	63.80
	20	0.50	2.90	8.45	2.60	9.15	13.30	76.80	60.85	60.70
	30	0.45	2.30	7.75	1.15	7.40	12.05	65.75	55.25	58.10
Age 65	10	1.50	6.15	9.25	9.60	12.10	16.45	92.20	70.10	67.50
	20	1.00	5.30	8.10	6.15	9.75	14.75	87.10	65.45	65.05
	30	0.60	4.50	7.25	3.75	8.30	13.55	78.15	60.50	62.15

Figure 2. Probability of Ruin: Female, age 55 with 10 Year Guarantee in Scenario I and Ⅲ



Note) X-axis is an age of policyholders and Y-axis is an accumulated ruin probability of policyholders.

5. Conclusion

Although many of existing studies have examined optimal retirement plans for retirees in the US and UK, there is little attention to retirees in Asian countries due to the lack of interest and data. However, there are several limitations in applying those implications since the expected life spans, annuity products, cultural backgrounds, and financial market conditions are totally different. This paper attempts to examine the annuity market in Korea where the aging pace is the fastest among OECD countries, and there is a mature life insurance market.

To explain the annuity puzzle found in Korean, it estimates the probabilities of ruin depending on age, gender, guaranteed period options, and portfolio structures with three types of market perspectives using empirical data in Korea. Overall the results suggest that the annuity puzzle is not a byproduct of unreasonable decisions.

Under the current market conditions, retirees can benchmark the benefits of the annuitization strategy through the self-annuitization strategy. In addition, the current annuity product options such as guaranteed options do not seem to attract retirees' interests. Furthermore, the annuity puzzle is expected to be prominent to females since females have lower required IRRs than males to benchmark the annuitization strategy. However, an appropriate asset allocation should be considered for conducting the successful self-annuitization strategy. Although the portfolio with less risky assets can delay the ruin, there might be remarkable increase in ruin risk at a certain time.

This study has following limitations. First, it only uses the level of ruin probability as a standard for choosing retirement plans. However, it will be more helpful to include level of risk tolerance of retirees and utilities to decide more reasonably. Second, it does not provide an optimal investment strategy by age, gender, or other annuity option features. Therefore, it is important to continue researching this topic in the future.

Appendix 1. Regression Analysis of Benefit and Relevant Factors

	Coefficient	Robust Std. Error	t	P>ltl
Age	5.095	0.441	11.56	0.000
Gender	54.853	4.210	13.03	0.000
Assume Interest	9144.503	540.340	16.92	0.000
Initial Wealth	0.004	0.000	74.69	0.000
Guaranteed Period	-1.066	0.070	-15.18	0.000
Constant	-619.058	34.268	-18.06	0.000

Note) N=338, F=1301.97, R-square=0.9798, Ajd R-square=0.9789, Root MSE=37.74

Note) The regression model is shown in the equation (6); All variables in the regression model are statistically significant at the 1% of level and R-square and adjusted R-square are 97.98% and 97.89% respectively. The benefits are positively related with age, assumed interest rate, and initial wealth. In addition, males receive more benefits than those of females. However, the guaranteed period is negatively related to the amount of monthly benefits.

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