Portfolio Choice with Puts: Evidence from Variable Annuities

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Abstract

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We investigate the asset allocation behavior of individuals who select an out-of-the-money long-dated "longevity put" option on their investment funds. We compare their allocations against those who do not choose this type of protection. Using a unique database we find that these investors take-on 5% to 30% more risky/equity exposure when they are protected. Yet, when this longevity put option is not purchased we confirm the classical life-cycle age phased reduction in equity. We offer a rudimentary model of utility-maximizing behavior that justifies the increased allocation to risk, provided the investor is willing, able and understands to exercise the longevity put option if-and-when it matures in the money.

KEYWORDS: Retirement, Pensions, Lifecycle Investing, Longevity Risk

JEL Codes: D91, G11

1 INTRODUCTION AND MOTIVATION

Motivated by the increasing need and interest in examining consumer/investor behavior on the household level, in this paper, we investigate the actual portfolio choice and asset allocation behavior of individuals who acquire portfolio insurance in the form of an out-of-the-money long-dated longevity put option on their investment funds. We compare and contrast the sub-account allocations against those investors who do not elect to pay for this type of protection. The evidence comes from variable annuity (VA) policies, and using a unique database of nearly a million policyholders contributed by seven different insurance companies, we find that investor's have 5% to 30% additional risky/equity exposure when a longevity put option is selected. And, their exposure to risky/equity is relatively constant across all ages. Yet, when this longevity put option is not purchased, so the investment portfolio resembles a conventional mutual fund, we confirm an age-phased reduction in risky/equity exposure over the human lifecycle.

The paper then offers a rudimentary model of utility-maximizing behavior in the presence of this longevity put option that indeed justifies the increased allocation to risky/equity, provided the investor is willing, able and understands to exercise the annuity option if-and-when it matures in the money. This, of course, is debatable given the long standing body of evidence – first documented by Modigliani (1986) – that individuals intensely dislike annuitization despite its welfare enhancing properties. We obviously can't opine on the level of understanding or comprehension exhibited by individuals who acquire these rather complicated puts. Although we will present some evidence that the distribution channel – i.e. the intermediary that sells and presumably explains the product features to the buyer – does have an impact on the risk exposure.

Regardless of the perceived rationality of this behavior, we believe our paper is the first to examine actual asset allocations within variable annuity policies. This is currently (early 2008) a $1.5 trillion dollar market in the U.S. and is expected to grow as aging baby boomers take control of their own retirement assets and generate their own pensions. Our results – which essentially document a type of moral hazard behavior – have both policy and risk management implications which we emphasize and discuss later in the paper.

1.1 What exactly is a variable annuity?

At first glance, Variable Annuities (VAs) are close cousins of mutual funds – which bundle individual securities, such as stocks and bonds, into diversified units or trusts – but they are formally classified as an insurance policy in addition to being registered as a security. Traditionally they have provided tax sheltered growth and they embed a variety of financially engineered derivatives that provide guarantees on the account value.

As of late 2007 there is more than $1.5 trillion USD invested in VAs, with gross annual sales in the hundred billion dollar range according to the consulting firm LIMRA International. This is not a trivial market. Like all insurance policies, and in contrast to standard exchange traded options, insurance companies charge for this downside protection by deducting an ongoing fraction of assets as opposed to an up-front fee. For example, the extra premiums for these policies are on the order of 50 to 80 basis points of extra management fees in addition to the basic management fees one pays on any mutual fund or ETF. These unique pricing features differentiate the analysis of these derivative securities from the standard Black-Scholes approach where the option premiums are paid up-front and in advance. This will be important later when we examine optimal allocations and is worth noting from a behavioral point as well. Another characteristic of these guarantees that make their pricing a challenging task is that they have really long (up to several decades) maturity period. As demonstrated by Bakshi, Cao, and Chen (2000), the pricing and valuation of long dated options is much more complicated compared to conventional short term options. This paper is definitely not about pricing and valuing these options, but rather on the observed behavior of individuals in the presence – and absence – of these options.

The latest (i.e. after the year 2000) generation of variable annuity contracts – and the specific focus on this paper – have been financially engineered to provide an assortment of lifetime income guarantees that are meant to protect the policyholder against what the industry has coined the "sequence of returns risk" and "longevity risk". This refers to the chance that a retirement portfolio from which cash is being withdrawn, suffers early losses and the retiree lives longer than average. The common denominator of all these insurance riders is that they contain an implicit put option on financial markets plus some form of longevity insurance, akin to a pure life annuity. Of course, using the concept of the put-call parity, they can also be viewed as call options to annuitize at some variable strike price.

The (anecdotal) sales "pitch" for these products revolve around the idea that these guarantees should induce investors to take-on more financial risk than they normally would; if they didn't have these guarantees. This is precisely the issue at the core of this paper. Using a unique database of policyholder behavior supplied by LIMRA International, we document that VA policyholders are indeed adopting more aggressive allocations (i.e. higher equity exposures) when these riders are actually selected. We also examine the theoretical merits of this advice by deriving the optimal asset allocation - under a stylized model of these products - in the presence of these optional riders.

Without getting swamped by excessive insurance-industry jargon, we focus specifically on a type of rider that is called a Guaranteed Minimum Income Benefit in the industry and we label the longevity put. While the exact mechanics of this option are explained analytically in the section entitled *Investing with a Longevity Put*, the essence of a longevity put is a derivative that allows the holder of the account to annuitize the funds at a guaranteed rate - which then provides a guaranteed level of lifetime income. The longevity put is closely related to another popular insurance rider called the Guaranteed Minimum Withdrawal Benefit (GMWB) - which is not the focus of this analysis - but which is yet another form of put option contained and selected within many variable annuities. See the book by Milevsky (2006), and the actuarial references therein, for a more analytic discussion of the GMWB and some of the risk management, pricing and arbitrage issues.

The longevity-put can be selected (or not) when the variable annuity policy is initially purchased. This rider gives the holder the ability to annuitize some minimally guaranteed amount at some contractually guaranteed rate. Thus, for example, if a \$10,000 premium is placed into a variable annuity, the insurance company might guarantee that at least \$15,000 can be annuitized in ten years. The purchase price (or annuity factor) would be specified within the contract; for example \$20 per dollar of lifetime income. So, essentially, this contract would guarantee a life annuity of at least \$15,000 / \$20 = \$750 per year in the worst case scenario. And, if the market value of the (sub accounts within the) variable annuity is worth more than guaranteed \$15,000 in ten years time, the policyholder can annuitize the (greater) market value at market annuity rates.

We obviously don't want to get lost within the minutia of these insurance policies since we believe that our research sits squarely within the portfolio choice literature. We are investigating actual retail asset allocations of individual investors, but in the presence of performance and investment guarantees. Our main empirical conclusion is that the presence of investment guarantees do in fact result in greater risk exposure – which is a type of moral hazard – even at advanced ages. Yet, we also echo a warning note that in some cases where the options are "out of the money", this extra amount of risky asset exposure might not be justified. In the extreme, this could be akin to buying traditional homeowners insurance that only protects against wind-related damage, but not being aware that flood damage is excluded. In the context of many of these variable annuity riders, the investor truly has to annuitize in order to capitalize on the value of the guarantee. We emphasize this in light of the long standing body of academic literature and empirical evidence that retirees disdain and avoid anuitization. According to the same LIMRA International group, during the 1980s and 1990s, less than 5% of Variable Annuities were ever annuitized. Of course, it remains to be seen whether the variable annuities designed for the 21st century will exhibit the same minuscule rate of annuitization.

1.2 Agenda for the paper

The remainder of this paper is organized as follows. In the next section #2 we review some of the relevant literature on the topic of portfolio choice over the human lifecycle. Recent papers in the finance literature have extended the basic portfolio choice model to include items such as labour income, housing, mortgages and insurance. We try to review them all and tie into our paper. Then in section #3 we describe our unique data and provide summary results on the actual choices of individuals. The subsequent section #4 provides a very basic analytic model of portfolio choice in the presence of these guarantees and the final section #5 concludes with some additional observations. Note that in this paper we do not develop a complete model of optimal portfolio choice in the presence of these guarantees, and under general investment preferences; rather, we leave that for future research.

2 REVIEW OF RELEVANT LITERATURE:

A number of recent papers have extended the set of decisions included in the portfolio choice problem to highlight the interaction and the risks faced by the household, broadly defined. This literature has recently gained traction after the AFA keynote address by Campbell (2006). For example, Goetzmann (1993), Yao and Zhang (2005) as well as Cocco (2005) focus on the role of the housing portfolio; Campbell and Cocco (2003) focus on optimal mortgage choices; Cairns, Blake and Dowd (2005) examine portfolio choice in defined contribution pension plans, Sundaresan and Zapatero (1997) examine the role of defined benefit pensions, while Dybvig and Liu (2004), Bodie, Detemple, Ortuba and Walter (2004) model the impact of flexible retirement dates; Jagannathan and Kocherlakota (1996) and Viceira (2001) stress the impact of aging; Faig and Shum (2002) are motivated by the demand for illiquid assets; Koo (1998) as well as Davis and Willen (2000) model the role of labor income; Dammon, Spatt and Zhang (2001) focus their attention on capital gains and income taxes; Heaton and Lucas (2000a) focus on the role of background risk. Chen, Ibbotson, Milevsky and Zhu (2006) examine the role of insurance over the lifecycle within a portfolio choice context. Others go back to basics and extend portfolio choice models to include more sophisticated (and realistic) processes for investment returns, such as Chacko and Viceira (2005) or time-varying and mean-reverting risk premiums, such as Kim and Omberg (1996) or Detemple, Garcia, Rindisbacher (2003).

The common denominator in the above papers - and a frequently debated question – is how portfolio allocations to risky assets (stocks) should evolve with investors' age. Finance practitioners consistently recommend lowering the stocks content of one's portfolio with increasing age. Much of this is at the heart of recent lifecycle and/or lifestyle funds promoted by fund companies. A popular rule of thumb is to have the share of equities equal to 100 minus investor's age. Academic financial economists turned to this issue mostly in the last decade. Several models of portfolio choice that include human capital (e.g. Bodie, Merton, and Samuelson (1992), Jagannathan and Kocherlakota (1996), Cocco, Gomes, and Maenhout (2005), Gomes and Michaelides (2005)) by and large support the recommendation to decrease equity share in the portfolio with increasing age, although the generated profiles are not necessarily monotonic. Recall the classical result by Merton (1969, 1973) that age should not matter in the absence of human capital considerations.

A number of these papers have established some stylized empirical facts. Several studies investigate the determinants of the stocks share in investors' portfolios, in particular the age effect. Relevant to this paper, most of these studies document a declining age-equity share profile, for example Bodie and Crane (1997), VanDerhei, Galer, Quick, and Rea (1999), Agnew, Balduzzi, and Sunden (2003), and Curcuru, Heaton, Lucas, and Moore (2004). Others document a hump-shaped pattern, with a declining part starting at the ages of 50-60. Examples of these would include Yoo (1994), Bertaut and Starr-McCluer (2001), and Faig and Shum (2006).

It is important to remind the reader – especially within the context of our later results – that Ameriks and Zeldes (2004) show that the age to equity share profile is sensitive to the model specification. In fact, any regression explaining portfolio choice with age can include only two of the possible three variables: age, time, and cohort. While Ameriks and Zeldes (2004) find a hump-shaped relationship in a regression with age and time effects, they report an increasing allocation to stocks/equity with age in a regression with age and cohort effects. The overwhelming majority of researchers, however, consider a cohort effect the least significant among the three and make the assumption that it is equal to zero.

To preview some of our results, we also find a declining (equity, stock) risk allocation within the account as policyholders age, but the age effect is substantially weakened once the insurance rider – i.e. the longevity put – is selected. Our estimation results are displayed in Table #3 and Table #4, and will be explained later.

The common assumption of most of the aforementioned utility-based models is that investors act rationally. However, a growing body of literature documents that this is not always the case. Benartzi (2001) provides evidence that individuals allocate about one-third of their 401(k) pension accounts in their company stock, the share far too large than would be justified by any asset allocation model. Benartzi and Thaler (2001) report that often individual investors use simple 1/n rule to allocate their assets among available choices regardless of the nature of those choices, which demonstrates that most individual investors do not understand such basic investment principle as diversification. Moreover, Benartzi and Thaler (2002) argue that based on their experimental results, investors do not even have well-defined investment preferences. This evidence gives us some doubt whether annuitants really understand the benefits of the longevity put when they buy a VA contract.

VAs with longevity puts represent some type of portfolio insurance. Some studies on this subject dismissed simple portfolio insurance as suboptimal for a utility-maximizing behavior as argued, e.g., by Brennan and Solanki (1981) and Benninga and Blume (1985). Other researchers, however, sought to rationalize the widespread use of portfolio insurance in the financial industry. Leland (1980) argued that portfolio insurance can be beneficial for at least some individuals, while Brennan and Schwartz (1988) confirmed optimality of time-invariant investment strategies.

3 DESCRIPTION OF THE DATA

The data that we employ in our empirical analysis was provided by LIMRA International. LIMRA collected contract and product information from 10 member companies that sold variable annuity policies within the period of January 2000 to June 2004; the policies had to be in force as of June 2004 and had to offer at least one type of longevity put at the time of purchase. As a result, LIMRA's dataset contains information on 812,367 individual variable annuity contracts.

LIMRA's dataset has several advantages compared to most other sources of financial micro level data. The two most popular data sources employed in household portfolio choice literature are Survey of Consumer Finances (SCF) and Panel Study of Income Dynamics (PSID). First, LIMRA's dataset has a definite size advantage. It provides data on more than 812,000 annuity contracts. In comparison, PSID contains panel data on about 8,000 families while SCF has information on 4,000+ households in each of its triennial surveys. Second, LIMRA's data come directly from insurance company's original contracts and therefore are much more accurate than self-reported information from the surveys. Third, LIMRA's data provide much higher level of detail with respect to asset allocation choices (e.g., amounts invested in small-cap, medium-cap, large-cap, or international stock funds, investment grade or high-yield bond funds, balanced funds, etc.) Finally and most importantly, LIMRA's dataset is unique in terms of providing information for asset allocation within variable annuities with and without longevity puts.

However, as was rightfully argued in Campbell (2006) there simply is no perfect source of household financial data. We have to mention some caveats of LIMRA's dataset, such as insufficient information about investors' personal characteristics and lack of data on their other investment accounts.

LIMRA's dataset contains 60 variables providing information about investors and contract characteristics, such as: investors' age, gender, state of residence, distribution intermediary channel; account value and its breakdown into amounts invested in several types of funds; whether one of the three different sub categories of longevity put was selected as well as the features of each type of guarantee

We had to eliminate records with missing age information and those records for which the values of different sub-accounts do not add up to the account value; this reduced our sample from 812,367 to 679,579 observations. We further limit our sample to those investors who (i) either selected no optional guarantee or (ii) selected the Guaranteed Minimum Income Benefit (longevity-put) only. We do this for two reasons. First, compared with other types of optional guarantees, such as so-called Guaranteed Minimum Withdrawal Benefit (GMWB) or Guaranteed Minimum Accumulation Benefit (GMAB), the longevity-put is the closest equivalent to a life annuity with longevity insurance. Second, it is by far the most popular guarantee selected by individuals in our dataset. Of all the contacts with at least one guarantee selected, the contracts where only longevity-put was selected represents 95 percent of the data. As the result, we have a "clean" dataset of 660,336 observations with either a longevity-put or no optional guarantees selected. This serves as the core date of our subsequent analysis.

3.1 Analysis of the Results

We now present the relationship between asset allocation and age for investors who selected the longevity put vs. those who did not select any guarantees. More specifically, we consider the percentage of VA account invested in high and medium risk (HMR) assets (a.k.a risky assets) as a function of investor's age. According to our definition, we regard the following funds as high or medium risk: large-cap, mid-cap, and small-cap stock funds, high-yield bond funds, balanced funds, specialty/sector funds, and international equity funds. On the other hand, we view investments in investment-grade bond funds, money-market funds, and fixed funds, as low risk (LR). Table #1 presents the percentage invested in HMR for seven companies (out of original number of ten) for ten age groups in five year buckets. We excluded three companies with very low number of policies with a longevity-put selected. The excluded companies represent a mere 0.3 percent of all VAs with a longevity-put. We focus our analysis on the two companies with the highest number of annuity policies in our sample. These two companies (anonymously referred to as company 1 and company 2) combined represent 52 percent of VAs with a selected longevity-put. Figure #1a presents the percentage allocation to risky assets for company 1 while Figure #2a – for company 2. In both cases, two age vs. HMR lines are presented: one for investors who selected a longevity-put and another for those who did not select any additional guarantees.

[Table #1 placed here] [Figure #1 placed here] [Figure #2 placed here]

As can be observed from company 1 results, for investors who did not select any optional guarantee, the percentage invested in HMR assets declines with age from 63 percent in the below-age-40 group to 46 percent in the above-age-80 group. This is very different from the age-HMR profile for those who selected a longevity-put. Among those investors, the percentage invested in HMR assets practically does not change with age being between 67 and 68 percent. Overall, their exposure to HMR assets is significantly higher. We conclude that additional HMR (risk) exposure in the group of longevity-put selectors is between 5 and 18 percent of their VA account value.

The results for another company demonstrate a similar trend. The allocation to risky assets for investors who selected a longevity-put is substantially higher (the difference is between 10 and 31 percent) and declines with age much slower than for investors who did not select any optional guarantee. Interestingly, the share of assets invested in HMR assets, is significantly lower in company 1 than in company 2 for any age group. Furthermore, in company 1, for investors who selected longevity-put, this share is very stable regardless of age. These differences should be attributed to the different investment choices available in each company, as well as to different asset allocation restrictions applied when a longevity-put rider is selected.

Finally, Figures #1b and #2b illustrate the impact of the distribution channel on the selection of HMR versus LR. What we mean by distribution channel is the type of intermediary that sold the variable annuity to the customer in question. We find stark differences in the amount allocated to the HMR assets – both with and without the selection of the longevity-put - depending on whether the VA was purchased through a bank, independent financial advisor, wirehouse broker, etc. Of course, this is not to say that any of the channels necessary influence or cause the allocation, this could obviously be a clientele effect. People who are more "conservative" and hence likely to hold less HMR assets might be more likely to purchase the VA through a bank, and vice versa.

3.2 Multivariate Statistical Analysis

In the next step we check whether the relationship between age and percentage invested in HMR assets observed in Table #1 holds in the presence of other variables that could explain

HMR holdings. To do this, we employ a set of linear models with percentage invested in HMR assets as the dependent variable (Y_i). Model 1 is run for the whole sample, consisting of VA policies without any optional guarantees selected and those with a longevity-put selected:

$$Y_i = \beta_0 + \beta_{LP} X_{LPi} + \beta_{AGE} X_{AGEi} + \beta_{AGE2} X^2_{AGEi} + \beta_M X_{Mi} + \beta_{ACC} X_{ACCi} + \beta_{IRA} X_{IRAi} + \sum_{j=1}^{4} \beta^d_j X^d_{ji} + \sum_{k=1}^{7} \beta^c_k X^c_{ki} + \varepsilon_i \quad (1)$$

where i = the ith VA policy and the explanatory variables are as follows:

1. Longevity-put (X_{LP}). Dummy variable, equals one when longevity put is selected and zero otherwise.

2. Age (X_{AGE}).

3. Age squared (X^2_{AGE}). Captures possible non-linearity on the age to HMR relationship.

4. Gender - (X_M). Dummy variable, equals one when the annuity policy holder is a male and zero otherwise. A number of previous studies document and argue that males are generally considered to be more overconfident compared to females (e.g. Barber and Odean (2001)), which is why they may have a tendency to invest proportionally more in risky assets. Whether or not this is the case/reason, we included this dummy variable to test the presence of a gender-based effect.

5. Log of account value (X_{ACC}). Can be viewed as a proxy for investors' wealth, although we are fully cognizant of the fact that we do not know the investors' other holdings, which could be substantial. Other studies often find that wealthier investors have more aggressive asset allocations, which is why we include it as well.

6. Inside or Outside an IRA (X_{IRA}). We use this dummy variable to capture the tax status of the underlying account. The variable is equal to 1 if the variable annuity is classified as an IRA, a.k.a personal pension plan and zero otherwise. Since investments inside IRAs are tax-sheltered, we may expect to see a higher share of fixed income assets in those accounts; the interest income of which is taxed at a higher rate than dividends or capital gains on stocks. Remember, that variable annuities are tax-sheltered investments already, so theoretically it should not make a difference in terms of the tax implications.

7. Distribution channel(X_j^d). Intermediary by which the variable annuity contract was purchased. We employ four dummy variables, $X_1^d - X_4^d$, which represent the following distribution channels: insurance agent, stockbroker, financial planner, and bank employee, correspondingly. The omitted category is independent agent. This variable controls for the possible impact and influence of the intermediary on the percentage of risky assets selected. Indeed, it could be the same intermediaries are better than others at explaining the value (or lack thereof) of the longevity put, which would then influence the asset allocation.

8. Company (X_k^c). As the share invested in risky assets can be company-specific, we control for this by using seven dummy variables $X_1^c - X_7^c$ for each of the seven companies (out of original ten) that sold VA policies with longevity-put riders. The omitted category is the three companies with the lowest number of VA contracts with a longevity-put.

Two sub-samples are used for our second model – Model 2. One sub-sample contains the data on variable annuity contracts for which no optional guarantee was selected, while the second regression only includes the contracts where variable annuity holders selected the longevity put which is the focus of our analysis. Model 2 differs from Model 1 by excluding the longevity-put dummy variable:

$$Y_i = \beta_0 + \beta_{AGE} X_{AGEi} + \beta_{AGE2} X_{AGEi}^2 + \beta_M X_{Mi} + \beta_{ACC} X_{ACCi} + \beta_{IRA} X_{IRAi} + \sum_{j=1}^{4} \beta_j^d X_{ji}^d + \sum_{k=1}^{7} \beta_k^c X_{ki}^c + \varepsilon_i \quad (2)$$

The results of both models are presented in Table #2. The sole purpose of running Model 1 is to estimate the effect of the longevity-put on the percentage invested in HMR assets. As can be judged by the positive and strongly significant coefficient of LP variable, VA policyholders who selected the longevity-put invested almost 14 percent more in HMR assets than those who did not select the LP. To assess whether regression coefficients overall are different for longevity-put selectors vs. non-selectors, we perform the Chow test. F-statistics from this test proves that the differences are highly significant.

[**Table #2, placed here**]

Next, we analyze the results of Model 2. As judged by the negative coefficient on AGE, the share invested in risky assets declines with age in both sub-samples. However, it declines much faster for those investors who did not select any optional guarantee, as the AGE coefficient in Model 1 is three times higher in absolute value than in Model 2 and their difference is highly significant based on the t-test. Moreover, AGE2 coefficient is negative in Model 1 but positive in Model 2. This suggests that the share invested in risky assets is a concave function of age that declines faster for older ages for investors who did not select any optional guarantee. For those who selected the longevity-put, however, the decline with age is much slower and there is even a reversal for older ages.

Besides age, several other variables prove to be significant in explaining the percentage of an account invested in HMR assets in both models. As suspected, men invest more aggressively than women. Variable annuities that are part of a tax-sheltered (IRA) personal pension plan have a lower share of risky assets and a higher proportion of low-risk bonds. This would be an intuitively pleasing result - i.e. bonds are more likely to be placed in tax shelters - where it not for the (perhaps not) widely known fact that variable annuities are already tax sheltered. Another puzzling result, however, is that the account size (wealth level) is negatively associated with an allocation to HMR (risky) assets.

The coefficients on the distribution channels dummy variables lead one to the conclusion that for investors who did not select an optional guarantee, financial planners induce (recommend?) higher allocation to risky assets than other distribution channels. For those who selected the longevity-put, however, relatively riskier asset allocation is induced (recommended?) by stock brokers. As for the company dummies, all of them are statistically significant. However, since the companies are anonymous in our study, we will not delve in to the longevity-put contract details (some more lucrative than others) which might drive this particular result. Instead, we repeat our regression analysis for all seven companies selected for the age-HMR distributions. The results of these regressions are presented in Table #3.

[Table #3, placed here]

As before, we focus our analysis on company 1 and company 2. In terms of AGE to HMR (risky equity) relationship, these results are similar to those presented in Table #2. The share of risky assets declines with AGE much faster for investors who have not selected a Guaranteed Living Benefit. Again, one can see some increase of HMR share in older ages for investors who selected longevity-put. Male investors generally allocate more to risky assets. In terms of account market value, however, the results are different depending on the company. In company 1, the market value of the account is positively related to the share of risky assets, whereas in company 2, the relationship is negative (similar to the result for the whole sample). Interestingly - and in contrast to the pooled results – in both companies the share invested in HMR is higher when the variable annuity is within tax-deferred account, but only when the longevity-put is not selected. But, when the longevity-put is selected the IRA status is associated with "more bonds" and less HMR asset classes.

4 INVESTING WITH A LONGEVITY PUT

In this section we construct a (simple) stylized model of portfolio choice in the presence of the longevity-put (a.k.a. Guaranteed Minimum Income Benefit) option. Our objective is to derive a measure for the amount of extra risk an investor is willing to take when granted a longevity-put option that protects his/her downside risk.

We start by postulating a generic investor with initial wealth W_0 that is currently optimally allocated α^* percent to risky assets, and $(1 - \alpha^*)$ percent to safe assets. These allocations take place within a variable annuity, but without any extra riders. The risky and safe assets correspond to the high & medium risk (HMR) and low-risk (LR) funds described in the earlier section.

Note that by selecting this particular allocation - which we assume is optimal – the investor has revealed his explicit risk preferences. And, under the classic Merton (1969, 1970) model that assumes constant relative risk aversion (CRRA) and lognormal asset returns, the implied coefficient of relative risk-aversion γ will be equal to $\gamma = (\mu - r)/(\alpha^*\sigma^2)$ where μ is the expected return, σ is the volatility and r is the risk-free rate of return. For example, an investor with a pre-existing allocation of $\alpha^* = 0.50$ to HMR and $(1 - \alpha^*)$ to LR reveals a risk-aversion of exactly $\gamma = 4$, when the expected return from the HMR investment is $\mu = 0.09$, the volatility is $\sigma = 0.15$ and the risk-free (LR) rate is $r = 0.045$. We now take this so-called rational investor and compute (solve for) how he might change his allocation to the HMR asset class if he were to hypothetically be granted the longevity-put.

More specifically, let α^{**} denote the new (presumably) optimal allocation to the HMR asset class when the longevity-put is wrapped around the investment account. Recall the α^* is the original (optimal) allocation in the absence of this put option guarantee. The difference between α^{**} and α^* is the incremental allocation that is theoretically justifiable, based on the presence of the longevity-put.

Our agenda in this section is to investigate the behavior of $(\alpha^{**} - \alpha^*)$ as a function of the various underlying contractual parameters, such as the strike price of the embedded longevity-put option, the pre-existing asset allocation α^*, the investor's age as well as the other exogenous capital market parameter assumptions μ, σ, and r.

Recall the longevity-put guarantees the ability to convert or annuitize (in the worst case scenario) the guaranteed amount $W_0 e^{\eta T}$ at a pre-specified rate denote by g_x, where η is a guaranteed investment return and T is the contract horizon. Alternatively, of course, the investor can annuitize the account value $\widetilde{W}_T$ at the then-market rate denoted by $\overline{a}_x$. The quantity $\widetilde{W}_T$ is obviously unknown in advance and depends on both the selected allocations of the investor as well as the random performance of underlying market sub-accounts.

The subscript x on both annuity factors denotes the age at which the life annuity is priced or issued, for example age 70 or 75. We refer the interested reader to Milevsky (2006) for a detailed explanation of the actuarial pricing underlying the annuity. Typical market values of $\overline{a}_x$ under the current interest rate environment might be \$10.2 at the age of $x = 70$, 8.44 at the age of $x = 75$ and 6.72 at the age of $x = 80$. This is the cost of \$1 of annual lifetime income, at the various purchase ages.

One can also think of g_x as the strike price of the longevity-put option, although it is not a marketable put option that can be sold in the conventional sense, but more of an exchange rate between a guaranteed amount and lifetime income. Either way the longevity-put option pays-off, or promises lifetime income in the amount:

$$\widetilde{I}_x = \max\left[\frac{W_0 e^{\eta T}}{g_x}, \frac{\widetilde{W}_T}{\overline{a}_x}\right] \tag{3}$$

The justification for (3) is as follows. If the underlying market and sub-accounts perform poorly (i.e. earns less than η per annum during the T-year waiting period), the investor is guaranteed the ability to annuitize at the guaranteed annuity factor rate of g_x. On the other hand, if the market value of the account at time T, is greater than the guaranteed amount $W_0 e^{\eta T}$, the investor can simply annuitize the (higher) account value, at the then-market annuity rates $\overline{a}_x$. In fact, he does not have to purchase this life annuity from the company that issued the longevity-put. He can take his money anywhere and annuitize in the open market. Of course, all of this assumes the investor actually (understands and) wants to annuitize, which is a big unexplored assumption at this stage.

Note once again that $\widetilde{W}_T$ is partially under the control of the investor and depends on the asset allocation vector α, which is to be determined. We have now reached the control and optimal portfolio choice aspect of the problem. To do this we multiply the guaranteed lifetime income denoted by $\widetilde{I}_x$ and defined by equation (3), by the then-market annuity factor $\overline{a}_x$ to convert this flow into a lump-sum value at the horizon time T. The objective is to locate an asset allocation vector α^{**} that maximizes expected utility of wealth.

$$\max_{\alpha} E[U(\widetilde{I}_x\,\overline{a}_x)] \tag{4}$$

The intuition, once again, is as follows. Imagine there is a liquid secondary market for a lifetime income annuity. In theory the annuitant could de-annuitize the income $\widetilde{I}_x$ and obtain a lump-sum in the amount of $\widetilde{I}_x\,\overline{a}_x$. Thus, the true expected utility of wealth is as displayed in equation (4). Indeed, if the option expires out-of-the-money and the market value of the lifetime income $\widetilde{W}_T$ is greater than the guaranteed amount of lifetime income $\overline{a}_x(W_0 e^{\eta T}/g_x)$ the mark-to-market value is simply itself. On the other hand, if the option expires in-the-money the guaranteed lifetime income will kick-in. The objective then is to locate an asset allocation that maximizes the expected utility of this uniquely defined wealth. We abstract from the optimal timing of annuitization under this option as the utility of annuitization, per se.

Under the (new) optimal allocation, the expected return from the investment account will be $\alpha^{**}\mu + (1-\alpha^{**})r - f$, where μ denotes the expected return from the HMR funds, r denotes the LR rate and the new symbol f denotes the extra fee (a.k.a. insurance charge) for the longevity-put. Remember that this put is paid-for in periodic installments through deductions from the return in the account.

We located the optimal allocation and the incremental justifiable risk allocations by simulation, since an analytic approach is impossible and the numerical implementation is equally cumbersome. More specifically, we focused our computational attention on simulations for which the longevity-put annuity factors g_x are within the vicinity of market annuity factors $\overline{a}_x$, which can be viewed as a fair longevity-put case. We also generated a few scenarios in which the longevity-put annuity factors were set-back relative to market based annuity rates, so that $g_x > \overline{a}_{x.}$ Also, for the majority of our simulations we assumed that the guaranteed return η embedded within the longevity-put was 6% per annum. Finally, we started with a 55 year-old investor who purchases a longevity-put with a 15 year horizon. At the age of 70 he plans with 100% certainty to annuitize the account, either under the guarantee (if the HMR asset earns less than 6% over the next 15 years) or under the market rates, generating lifetime income of $\widetilde{I}_g$.

Our results for the allocation that maximizes CRRA utility, relative to the original allocations are displayed in Table #4. We selected a CRRA utility function specification, fully cognizant of the established fact that agents with constant relative risk aversion preferences are not likely to purchase any form of portfolio insurance or investment protection. A rather classical result by now, is that CRRA utility maximizer (in continuous time) hold portfolios that are constantly rebalanced between the available risky assets. Once again we are not deriving a complete model of "who" exactly decides to buy and pay for longevity puts. Rather we are backing-up (the somewhat obvious argument) that "even" a CRRA investor will take on more risk when given the protection.

[Table #4, Placed Here]

A few things are worth noting from the table and our extensive simulations. The "positivity" of the variable - in other words, the justification for additional risk exposure - is dependent on the strike price of the option. The strike price within a longevity-put is not immediately obvious and unrelated to the contract's guaranteed investment return, which we labeled by η, and was in the vicinity of 6% for most of our examples. (Note that sometimes this is expressed with simple compounding, in which case the value must be converted to the true annualized return.)

Our point here is more than just "the devil is in the details," although that certainly is an important take-away. Rather, there can be remarkable heterogeneity between various longevity-put contract provisions that all seem to offer a 6% guaranteed return. In the course of our extensive simulations - to locate the optimal allocation – we observed a number of interesting results. First, in many cases the optimal allocations are labeled "corner solutions". Basically, if the longevity-put annuity factor is favorable to the policyholder, he takes on as much risk as possibly allowed by the contract. In a sense the policyholder has purchased a put option and he maximizes the personal value of this option by taking-on as much risk as possible. This, however, assumes a 100% annuitization rate. On the other hand, if the contractual provisions are less favorable, which in our cases is denoted by a higher parameter value of g_x, the optimal allocations in the presence of the longevity-put are no longer corner solutions. In some cases the optimal share of risky assets with LP is only 5%–10% higher than the one without LP.

We conclude this section be cautioning the reader that our very simple model of optimal asset allocation within a longevity-put structure only scratches the surface of more accurate representations of the dynamic control problem. To name just a few improvements, one would have to incorporate the American-style optionality of when to annuitize, as well as the stochasticity of interest rates and perhaps even the credit risk of the insurer, in the event market do (really) fall.

Our objective in this section is not to provide a complete theory of longevity-put option pricing and utilization, yet we doubt any of the above improvements will change the main result that more risk is acceptable provided the strike price is sufficiently near the money (and the policyholder wants to annuitize.)

5 CONCLUSION AND FINAL THOUGHTS:

The topic of optimal asset allocation over the lifecycle is growing in both scholarly and practical interest, especially after the recent passage of the pension protection act (PPA) in August of 2006. The PPA, amongst other provisions, provides 401k plan sponsors with a safe harbor if they select an appropriate life-cycle fund as the default option for their employees.

Hence there is an ongoing debate around "what" products are suitable and appropriate, including the role of variable annuities with lifetime income guarantees. Indeed, we continue to see an increasing number of normative and prescriptive models on how individuals should invest lifecycle wealth as a function of their risk aversion, their age and the many other assets on their personal balance sheet. See the recent monograph by Ibbotson, Milevsky, Chen and Zhu (2007) as an example of how portfolio choice interacts with insurance and annuity decisions. Within the empirical literature there seems to be conclusive evidence that younger investors hold more aggressive equity (risky) allocations, which tends to decline over time as people approach retirement. Whether this is optimal in the absence of human capital considerations, continues to be the subject of debate.

In this paper we confirm the by-now stylized fact about asset allocation, but look at things from a very different perspective. We examine how actual allocations to risky assets change when individuals are given insurance/market protection in the form of longevity puts, a.k.a. options to annuitize. More specifically, we analyze asset allocations inside variable annuity (VA) policies – a type of tax sheltered mutual fund – in which optional insurance riders are available that give investors the right but not the obligation to annuitize at a contractual rate. We have close to a million policyholder account-opening data spanning in age from 40 to 80 in which we can observe (a) their initial asset allocation, and (b) whether or not a longevity put option was purchased. We document over 600,000 policyholders who have chosen to purchase portfolio insurance on their investment, for which they pay an additional fee of 50 to 80 basis points of assets, per annum.

Our main quotable result is that individuals who acquire and pay for longevity put options on their investment portfolio have 5% to 30% greater equity exposure compared to those who have not selected the longevity put. Alas, to anyone trained in the valuation and pricing of American-style derivative securities, this insight is virtually axiomatic. It is comforting to see this confirmed on Main Street versus Wall Street. Yet, from the insurance company's risk management perspective we provide evidence that one can not make static assumptions about asset allocation and utilization. Moral hazard (or anti-selection) is evident across all ages, which is likely one of the reasons some companies have imposed asset allocation restrictions, or do not allow more than 80% to 90% total equity exposure. An additional contribution of this paper is to illustrate that observed numbers are consistent with the predictions of a simple model of portfolio choice in the presence of such guarantees. On a related note, compliance officers and securities regulators who are concerned about inappropriate levels of investment risk for (elderly) investors, might be interested to know that our model provides justification for the position that an insurance rider should impact investment allocations. This view stands in contrast to a *buffet menu* approach to investment suitability, in which one's choice of stocks versus bonds – i.e. the main course – should be independent of whether a guarantee is elected for "desert", just prior to checking-out.

As a corollary to our main results, we also confirm that gender is a statistically significant determinant of asset allocation and that males tend to have greater equity exposure, consistent with work by Barber and Odean (2001). Then again, we find that in those accounts for which the longevity put is selected, women tend to behave more like men and older investors behave as if they were younger. We also document a unique distribution channel effects, namely that the intermediary – whether a stock broker, insurance agent of financial planner – selling the policy is a determinant of the amount of equity exposure as well as the likelihood of the longevity put being selected. This is something that has not (yet) achieved much attention in the finance literature, but which we hope will spur greater research. Indeed, investor behavior is rarely classified or analyzed based on the intermediary "selling" the product.

In addition we document that variable annuity policies that are purchased within IRA tax shelters tend to have a greater allocation to bonds. This result would be consistent with normative tax-based models, such as the work by Dammon, Spatt and Zhang (2001) were it not for the fact that variable annuities are *already* tax sheltered. In a sense this is somewhat of a puzzle. Why does a variable annuity that is inside a tax shelter have more bonds compared to a variable annuity sitting outside a tax shelter?

On a final note, it is worth emphasizing yet again that longevity put options are not really cash-back guarantees, but rather they provide protection which is contingent on annuitization. In other words, the only way to exercise this longevity put is to irreversibly annuitize the guaranteed amount K, in exchange for lifetime income. In the language of option markets, if the underlying security ends-up at a value of $S < K$, where the strike price is K, the option's payoff is $K - S$. However, this will be paid (by the insurance company) to the holder of the put, *only* if the entire account value K is annuitized. It is therefore conceivable that (some) investors might forgo the in-the-money value $K - S$, if their disutility from annuitization is large enough. And, while Yaari (1965) would no doubt exercise this longevity put option were it in the money by ε, it remains to be seen whether the masses will do the same.

We conclude by noting that Franco Modigliani (1986) dedicated a substantial part of his Nobel prize address to the so-called annuity puzzle, namely that most people shun voluntary annuitization despite its welfare enhancing properties. Might it be that as a last resort it is palatable? If so, then at the very least our paper might be classified as a contribution to the behavioral literature by documenting that individuals accept greater stock/equity market risk when they are *led to* believe they have downside protection.

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Table #1: Age Specific Asset Allocations across Seven Insurance Companies Offering Variable Annuities with a Longevity Put

AGE	C1: % in HMR		C2: % in HMR		C3: % in HMR		C7: % in HMR		C8: % in HMR		C9: % in HMR		C10: % in HMR	
	Without LP	With LP	Without LP	With LP	Without LP	With LP	Without LP	With LP	Without LP	With LP	Without LP	With LP	Without LP	With LP
<=40	63%	68%	76%	87%	88%	92%	77%	88%	47%	74%	85%	76%	86%	95%
41-45	62%	68%	73%	85%	87%	92%	75%	87%	46%	75%	83%	75%	83%	95%
46-50	62%	68%	71%	85%	88%	92%	73%	85%	41%	73%	84%	78%	81%	94%
51-55	60%	68%	67%	84%	88%	92%	71%	85%	38%	71%	82%	76%	75%	93%
56-60	55%	68%	62%	82%	88%	91%	68%	82%	33%	70%	79%	74%	70%	92%
61-65	51%	67%	59%	82%	86%	90%	65%	81%	29%	66%	78%	73%	66%	92%
66-70	50%	67%	58%	82%	86%	89%	64%	80%	27%	64%	76%	73%	64%	91%
71-75	49%	67%	59%	82%	83%	88%	66%	78%	26%	70%	75%	68%	63%	90%
76-80	51%	68%	62%	80%	83%	85%	64%	78%	27%	N/A	73%	N/A	60%	88%
>80	N/A	N/A	47%	78%	80%	87%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

This table presents the percentage invested in high and medium risk (HMR) assets for all seven companies for ten age groups in five year buckets. Funds regarded as high or medium risk (HMR) are: large-cap, mid-cap, and small-cap stock funds, high yield bond funds, balanced funds, specialty/sector funds, international equity funds. The rest of available fund classes -- investment-grade bond funds, money-market funds, and fixed funds -- are considered as low risk assets. The first column for each company represents percentage allocation to HMR for investors who did not select any optional guarantee; the second column represents allocation to HMR for those who selected the longevity-put.

Table #2: Linear Regression - Pooled Sample of All Companies

VARIABLE	Whole sample		Without GLB		With GMIB	
	ESTIMATE	T-VALUE	ESTIMATE	T-VALUE	ESTIMATE	T-VALUE
Intercept	0.8705*	188.97	0.9921*	131.92	0.9132*	59.22
Select Longevity Put	0.1364*	159.76				
Age	-0.0031*	-95.87	-0.0041*	-76.1	-0.0015*	-43.09
Age2	1.9E-07	0.72	-3.5E-06*	-8.02	1.8E-06*	5.57
Male	0.0185*	24.82	0.0256*	18.24	0.0123*	16.45
Log of Account Value	-0.0095*	-30.65	-0.0178*	-30.42	-0.0018*	-5.66
IRA/Tax Shelter	-0.0061*	-7.67	-0.0098*	-6.37	-0.0044*	-5.59
Dist: Career Agent	0.0280*	9.92	0.0757*	18.82	-0.0388*	-8.8
Dist: Stock Broker	0.0362*	12.94	0.0296*	7.27	0.0112*	2.6
Dist: Financial Planner	0.0598*	20.48	0.1474*	31.75	0.0025	0.57
Dist: Bank Employee[A]	-0.0970*	-33.65	-0.1433*	-34.42	-0.0576*	-13.02
Company: C1	-0.0963*	-33.86	-0.0928*	-23.29	-0.1331*	-9.26
Company: C2	0.0671*	24.37	0.0808*	21.68	0.0383*	2.67
Company: C3	0.1382*	45.94	0.2013*	38.11	0.0883*	6.14
Company: C7	0.1009*	36.36	0.1654*	44.29	0.0285*	1.98
Company: C8	-0.0988*	-29.89	-0.0450*	-9.91	-0.0489*	-3.33
Company: C9	0.1061*	31.7	0.2315*	48.5	-0.0733*	-5.03
Company: C10[B]	0.1603*	54.02	0.2058*	47.94	0.1063*	7.38
Adjusted R^2	0.198		0.159		0.154	
Number of Observations	640,570		272,564		368,005	

The above table presents the results of the least squares regressions with the percentage invested in the high and medium risk assets as the dependent variable. The first regression is based on the whole sample. The second regression is based on the sub-sample of variable annuity policies where no optional guarantee was selected. The third regression is based on the sub-sample where the longevity-put was selected.

* Significant at 1% level

A The omitted category is Independent Agent

B The omitted category are companies 4, 5, and 6

Table #3: Company Specific Regression Results

COMPANY	C1		C2		C3		C7		C8		C9		C10	
VARIABLE	Without LP	With LP	Without LP	With LP	Without LP	With LP	Without LP	With LP	Without LP	With LP	Without LP	With LP	Without LP	With LP
Intercept	0.5129*	0.6388*	0.9852*	0.9483*	0.8868*	0.9733*	1.0206*	0.9506*	0.9887*	0.8874*	1.0763*	0.8618*	1.2426*	0.9284*
Age	-0.0026*	-0.0007*	-0.0045*	-0.0018*	-0.0014*	0.0014*	-0.0036*	-0.0024*	-0.0059*	-0.0034*	0.0029*	0.0016*	0.0066*	-0.0013*
Age2	-9.1E-06*	1.7E-06*	-9.3E-06*	3.8E-06*	4.2E-07	1.7E-07	5.2E-06*	5.0E-06*	-1.7E-06	1.4E-05*	3.1E-06*	3.2E-06	-1.5E-05*	-1.9E-06*
Male	0.0037	0.0036*	0.0364*	0.0203*	0.0227*	0.0075*	0.0251*	0.0187*	0.0262*	0.0297*	0.0336*	0.0222*	0.0283*	0.0067*
Log of Account Value	0.0052*	0.0030*	-0.0219*	-0.0067*	0.0023	0.0003	-0.0238*	-0.0060*	0.0244*	-0.0046	0.0115*	-0.0018	-0.0111*	0.0007
IRA/Tax Shelter	0.0079*	-0.0045*	0.0135*	-0.0051*	-0.0071	-0.0013	-0.0504*	-0.0035	0.0275*	0.0096	-0.0175*	-0.0241*	-0.0333*	-0.0025
Dist: Career Agent	0.1780*	-0.0022	0.2169*	0.0268*			0.1674*	0.0519*						
Dist: Stock Broker	-0.0587*	0.0778*	0.2386*	0.0689*	0.0316*	0.0118*	0.1643*	0.0827*					0.1085*	0.0795*
Dist: Financial Planner	0.2359*	0.0512*	0.3102*	0.0693*	0.0305*	0.0040								
Dist: Independent							0.2346*	0.0650*						
Adjusted R^2	0.1213	0.0174	0.1179	0.0184	0.0056	0.0051	0.0684	0.0264	0.0392	0.015	0.0291	0.0071	0.0678	0.0128
Number of Observations	36,165	89,947	65,855	103,348	10,915	57,627	75,490	41,730	25,112	6,219	16,234	9,534	27,152	59,346

The above table presents the results of the least squares regressions with the percentage invested in the high and medium risk assets as the dependent variable. The first column of each regression is based on the sub-sample of company *i* variable annuity policies where no optional guarantee was selected. The second regression is based on the sub-sample from the same company where the longevity-put was selected.

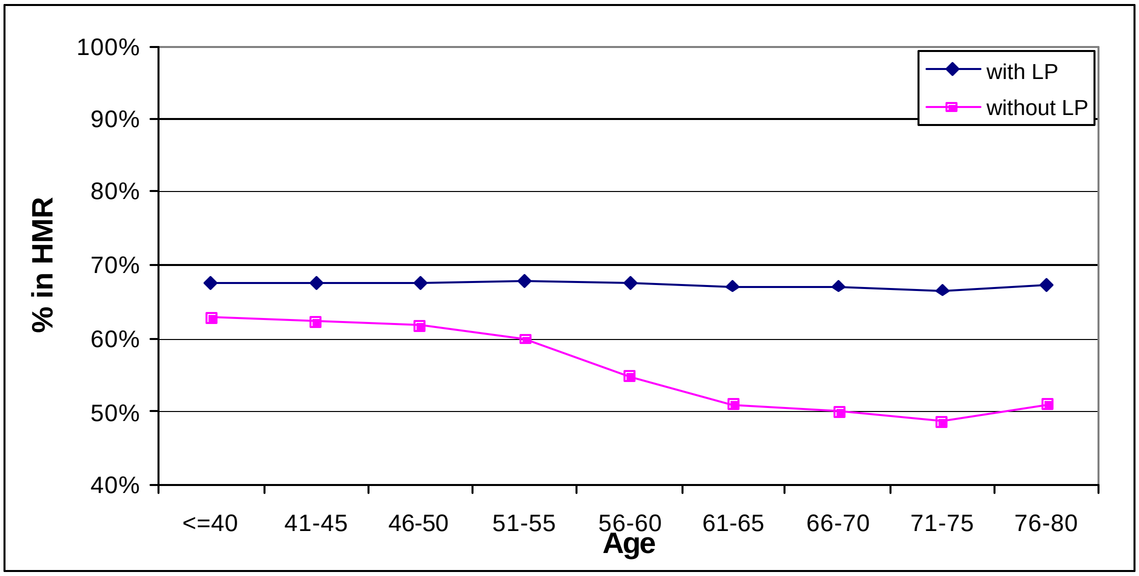
* Significant at 1% level

Table #4: Results of the Theoretical Allocation Model

Age when purchased VA policy	% in HMR (a^*)	Implied g	C.E. without LP	% in HMR (a^{**})	C.E. with LP
55	g_{70}=15				
	30%	6.67	$1.42	100%	$2.28
	40%	5	$1.80	100%	$2.46
	50%	4	$2.14	100%	$2.65
	g_{70}=20				
	30%	6.67	$2.02	40%-50%	$2.03
	40%	5	$1.88	90%	$2.19
	50%	4	$2.13	100%	$2.40
	g_{70}=25				
	30%	6.67	$2.02	30%-40%	$2.02
	40%	5	$2.12	50%-60%	$2.13
	50%	4	$2.18	80-90%	$2.29
60	g_{70}=15				
	30%	6.67	$1.20	90-100%	$1.67
	40%	5	$1.47	100%	$1.78
	50%	4	$1.65	100%	$1.88
	g_{70}=20				
	30%	6.67	$1.60	30-40%	$1.60
	40%	5	$1.65	60%	$1.65
	50%	4	$1.65	80-100%	$1.75
	g_{70}=25				
	30%	6.67	$1.60	30%-40%	$1.60
	40%	5	$1.66	50%	$1.66
	50%	4	$1.71	70%	$1.71
65	g_{70}=15				
	30%	6.67	$1.26	30%-40%	$1.26
	40%	5	$1.24	80-100%	$1.30
	50%	4	$1.28	100%	$1.34
	g_{70}=20				
	30%	6.67	$1.26	30%	$1.26
	40%	5	$1.29	50%	$1.29
	50%	4	$1.31	70%	$1.31
	g_{70}=25				
	30%	6.67	$1.26	30%-40%	$1.26
	40%	5	$1.28	50%	$1.28
	50%	4	$1.31	60-70%	$1.31

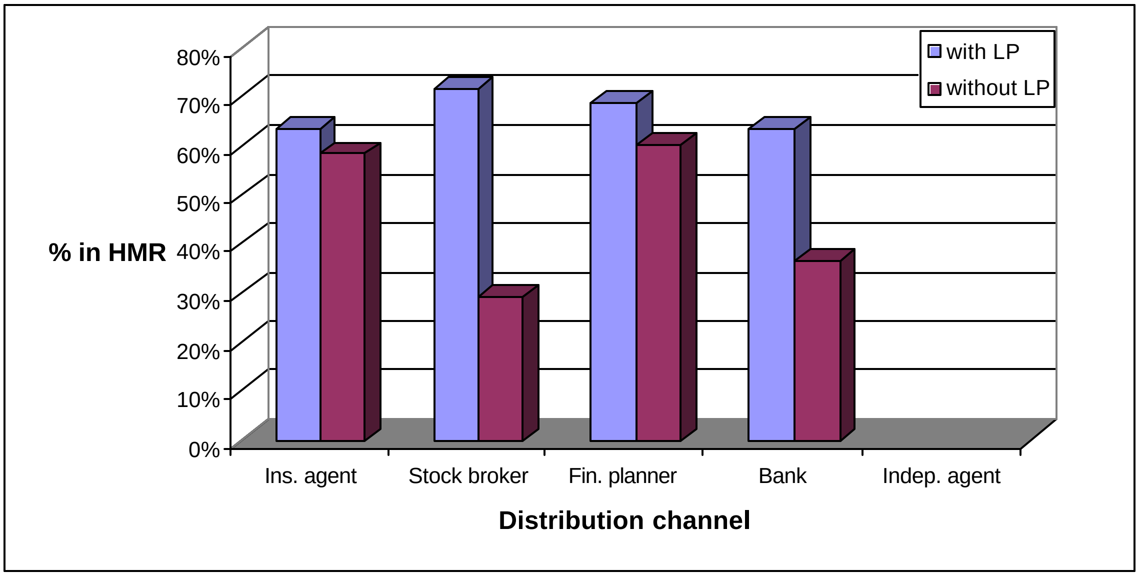
This table presents the optimal percentages allocated to the risky assets when the longevity-put (LP) is selected (a^{**}), generated by the theoretical model. These allocations are based on the initial allocations to the risky assets when no optional guarantees are selected (a^*). Certainty equivalent (CE) wealth is calculated based on $1 of initial investment.

Figure #1a: Company 1: Allocation to Risky Assets as a Function of Age



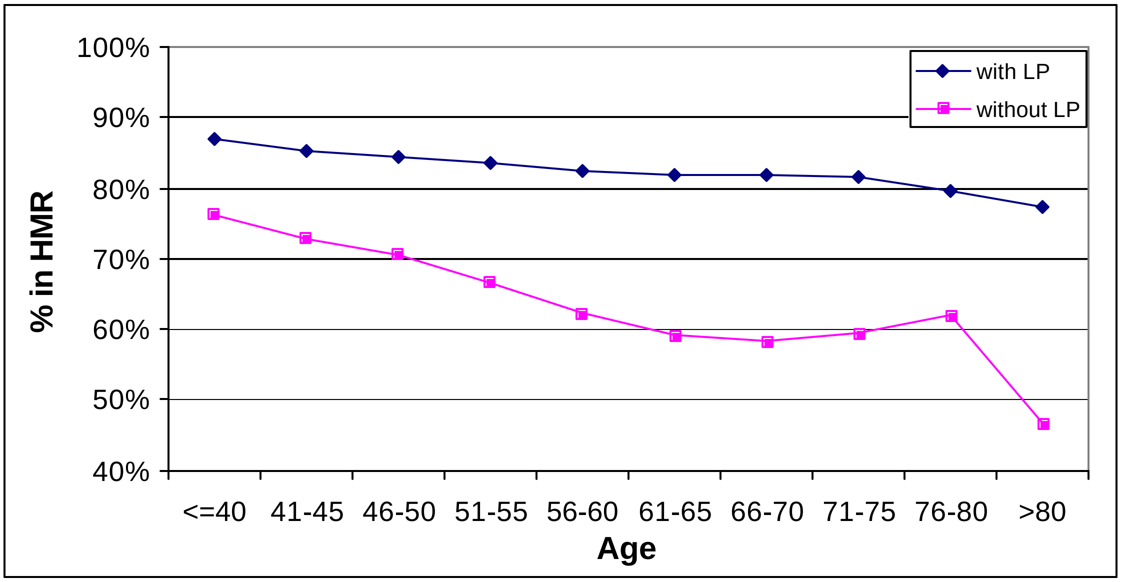
The above figure displays the percentage of the variable annuity sub-account within the policy sold by Company 1, that is allocated to high and medium risk (HMR) asset classes, when the longevity-put is selected and when no optional guarantee is selected. Funds regarded as high or mediumrisk are as follows: large-cap, mid-cap, and small-cap stock funds, high yield bond funds, balanced funds, specialty/sector funds, international equity funds. The rest of the available fund classes - investment-grade bond funds, money-market funds, and fixed funds - are considered as low risk assets.

Figure #1b: Company 1: Allocation to Risky Assets as a Function of the Distribution Channel



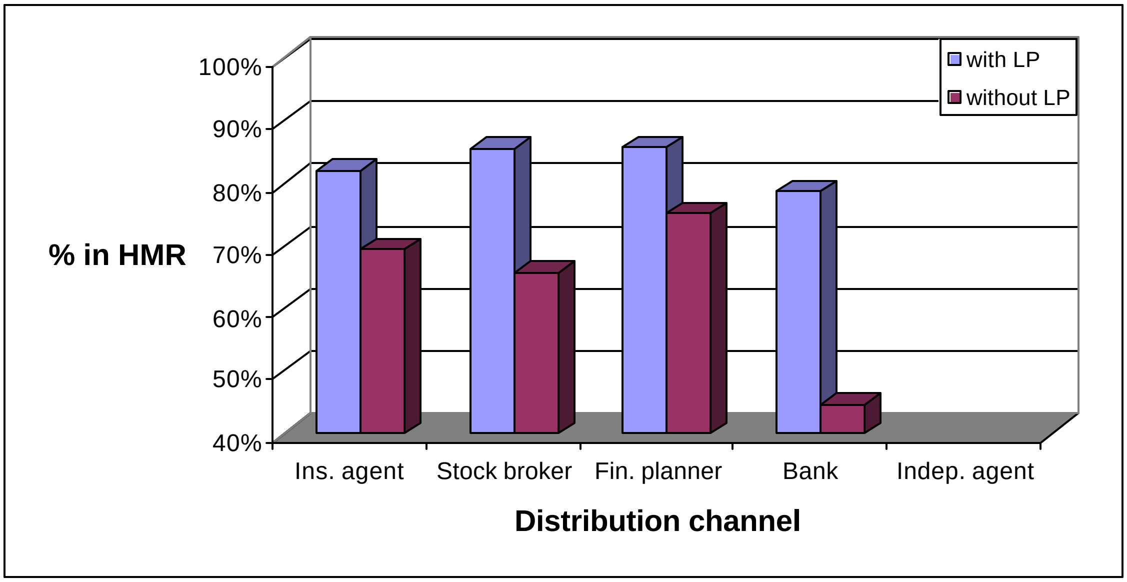
Variable annuities manufactured by company 1 can be purchased through career insurance agents, stock brokers (wirehouses), financial planners and banks. This is called the distribution channel. The above chart illustrates the impact of the distribution channel on the allocation to HMR assets, both with and without guarantees.

Figure #2a: Company 2: Allocation to Risky Assets as a Function of Age



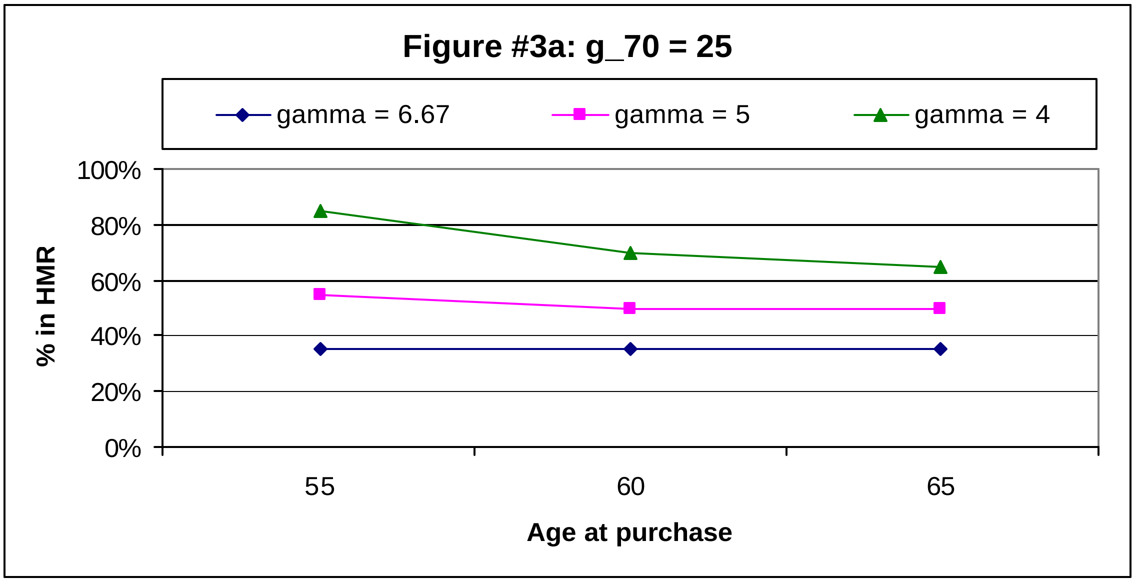
The above figure displays the percentage of the variable annuity sub-account within the policy sold by Company 2, that is allocated to high and medium risk (HMR) asset classes, when the longevity-put is selected/purchased and when no optional guarantee is selected/purchased. Sub-account funds regarded as high or medium risk are as follows: large-cap, mid-cap, and small-cap stock funds, high yield bond funds, balanced funds, specialty/sector funds, international equity funds. The rest of the available fund classes - investment-grade bond funds, money-market funds, and fixed funds - are considered low risk assets in our two-variable analysis.

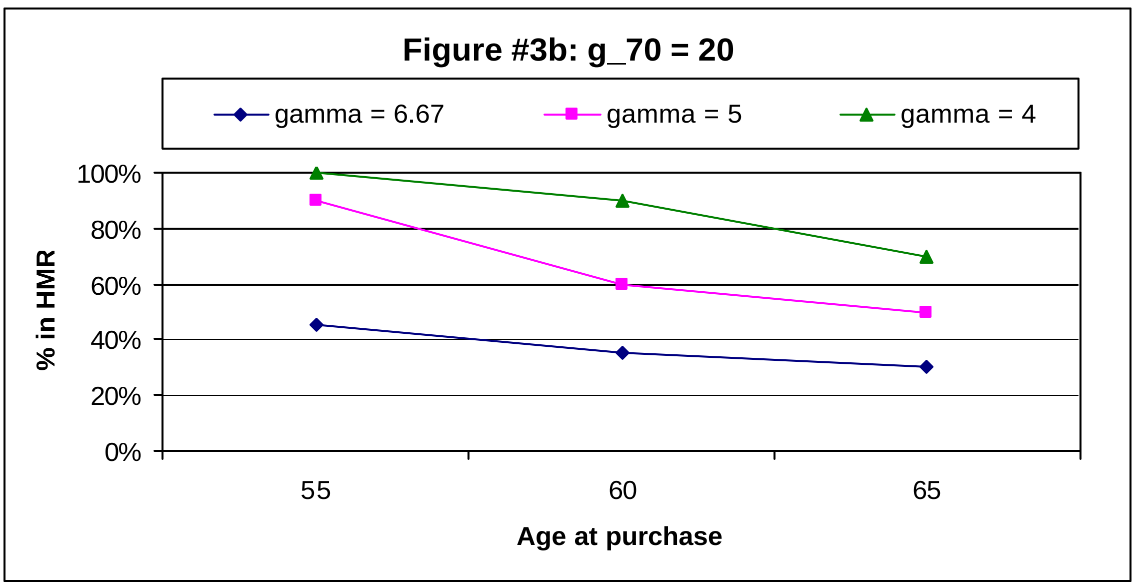
Figure #2b: Company 2: Allocation to Risky Assets as a Function of the Distribution Channel



Variable annuities manufactured by company 2 can be purchased through career insurance agents, stock brokers (wirehouses), financial planners and banks. This is called the distribution channel. The above chart illustrates the impact of the distribution channel on the allocation to HMR assets, both with and without guarantees.

Figure #3: Optimal Allocation to Risky Asset Based on the Model





This figure presents the optimal percentages - as generated by our utility based model - allocated to the risky assets when the longevity-put (LP) is selected (α^{**}). These allocations are based and compared against the initial allocations to the risky assets when no optional guarantee is selected (α^{*}). In Figure 3a, the longevity-put annuity (a.k.a. strike price) factor was assumed to g_{70} = 25, which means that the policyholder is guaranteed a purchase price of no more than $25 per dollar of lifetime income, at age 70. In Figure 3b, the LP annuity factor was assumed to g_{70} = 20. Assumed risk-aversion levels (γ) are 6.67, 5, and 4, which correspond to initial allocations to risky assets equal to 30, 40, and 50 percent.