Rosita P. Chang, Ph.D., CFA, CFP®
Professor of Finance, Department of Financial Economics & Institutions
Shidler College of Business
Univ. of Hawaii at Manoa

Jack C. DeJong, Jr., Ph.D., CFA
Assistant Professor of Finance, H. Wayne Huizenga School of Business and Entrepreneurship, Nova Southeastern University

Qianqiu Liu, Ph.D.
Associate Professor of Finance at the Shidler College of Business
University of Hawaii at Manoa

John H. Robinson
Owner/Founder
Financial Planning Hawaii

Jack P. Suyderhoud, Ph.D.
Professor of Business Economics
Shidler College of Business
University of Hawaii

The Cost of Guaranteed Income: Demystifying the Value Proposition of Variable Annuities with Guaranteed Lifetime Withdrawal Benefit Riders

by Rosita P. Chang, Ph.D., CFA, CFP®;
Jack C. DeJong, Jr. Ph.D., CFA; Qianqiu Liu, Ph.D.;
John H. Robinson; and Jack Suyderhoud, Ph.D.

Abstract

Variable annuities (VAs) are among the most complex and controversial products in the investment universe. Although a fair amount of research regarding the merits of VAs with guaranteed lifetime withdrawal benefit (GLWB) riders has been published over the past decade, to date, few of these papers have been of practical usefulness in guiding consumer decision-making. This paper begins to fill this information gap by (1) identifying the circumstances under which VA contracts with GLWBs seem most rational, and (2) helping consumers and practitioners assess the relative merits of various "real-world" guaranteed lifetime withdrawal riders. Our analysis applies bootstrapping techniques to compare a spectrum of three common forms of GLWB riders and two non-guaranteed index model portfolios. The primary underlying assumption in the study is that the GLWBs are utilized exactly as they are marketed – with a 10-year accumulation period followed by lifetime fixed withdrawals. The results of this analysis are surprising and may reshape practitioners' product recommendations, as well as the public perception of annuity expenses.

Introduction

Variable annuity (VA) contracts with optional lifetime income guarantee features are among the most enigmatic and controversial products in the retail investor marketplace. Conceptually, the introduction of these "guaranteed living benefit" riders (GLBs) filled a void in the investment spectrum that had been identified by academic research decades earlier. Beginning in the 1960s, economists puzzled over why retirees, the most risk-averse segment of the population, have historically eschewed converting their defined benefit pensions and 401(k) plan savings into guaranteed lifetime annuity payments in favor of far riskier self-directed investment schemes (Yaari, 1965). In theory, rational workers, upon reaching retirement, should choose a guaranteed pension option over alternatives that hold the possibility of financial ruin (Benartzi, Previtero, and Thaler, 2011). In practice, however, fewer than 3% of retirees choose annuitization as a distribution option. The desire to leave an estate for one's heirs and an aversion to irrevocable annuitization elections are among two of the most oft-cited explanations for this counterintuitive behavior (Scott, Watson, & Hu, 2007).

The arrival in the late 1990s of GLB riders attached to VA contracts offered retirees (and those approaching retirement) a guaranteed lifetime income solution with the potential to let them have their figurative cake and eat it too. At the heart of these riders is the concept of "deferred annuitization," a financial engineering innovation that allows VA contract buyers to invest in an underlying portfolio of risky assets for capital appreciation while retaining the right to receive a guaranteed lifetime income stream if the investments and/or the overall markets perform poorly and are exhausted through systematic withdrawals (assuming rider terms and conditions are met). Conversely, if the underlying investments perform well, the contract holders retain complete control over the asset during their lifetimes and, upon death, the named beneficiaries receive the remaining assets.

To suggest that the GLB concept resonated well with investors is an understatement. Annual investment flows into VAs rose from approximately $73 billion in 1996 (pre-deferred annuitization options) to a high of $183 billion in 2007.[1] Despite a major upheaval in the list of VA providers and the types and pricing of rider guarantees following the 2008-2009 stock market downturn, demand for VAs has remained strong, with 2012 sales totaling $145 billion.[2] Through the end of 2012, total assets in VA contracts stood at $1.64 trillion.[3]

According to the life insurance industry market research organization, LIMRA, GLB riders are consistently selected on 80-90% of VA contracts issued each year, with the most common rider form – the guaranteed lifetime withdrawal benefit (GLWB) – selected on nearly 75% of contracts on which a GLB rider is chosen.[4] Not surprisingly, strong consumer demand in a competitive free market environment has spurred product innovation among competing carriers. Per the *Insured Retirement Institute 2013 Fact Book* (*IRI Fact Book*), at the end of 2012, 41 insurance companies offered VA contracts and there were 2,051 unique VA products in the marketplace. As noted in the IRI Fact Book, a consequence of this proliferation of contract designs has been that the added complexity has made the products more difficult for consumers to understand and differentiate.

Functionally, the decision by a consumer to purchase a VA contract with a GLB rider involves the transfer of market risk and longevity risk to the insurance carrier in exchange for premium payments. As a practical matter, it is probably reasonable to assume that demand for GLB riders is being driven by the combination of the demographic wave of retiring baby boomers and their dire fear of running out of money before they run out of time – a fear that has been heightened by the impact of two severe, multi-year bear markets since 2000. Given the popularity of VAs and the enormous size of this market, surprisingly little research has been done to assess whether the purchasers of these contracts are well-informed and rational in their decision making.

This paper helps to fill this information gap by conducting a realistic analysis of the most popular forms of lifetime income guarantee riders in the market today. Specifically, this study considers a spectrum of three common GLWB rider structures employed in exactly the manner in which each is designed and marketed – with a 10-year accumulation period followed by deterministic 5% constant withdrawals calculated off of an "accumulated benefit base." In a departure from previous studies, bootstrapping techniques are applied instead of the more common capital markets assumption-based Monte Carlo methodologies. The rider portfolios are illustrated under two allocation scenarios and are analyzed over a range of withdrawal periods. The portfolios are also compared against two lower-cost, non-guaranteed model portfolios with identical allocations to those used in the GLWB riders. Careful consideration has gone into the design of the expense structures of both the annuity models and the two non-guaranteed portfolios. It is believed that results of this analysis go a long way toward reducing current informational asymmetries by helping consumers and advisers (1) quantify failure risk in the absence of income guarantees, (2) understand the cost of risk transference in terms of wealth sacrificed, and (3) provide at least a general basis for comparing common forms of GLWB riders.

The remainder of this paper is organized as follows: the next section reviews the literature which motivated this study. Section 3 describes the model design, data and methodology. Section 4 presents the results and their implications. Section 5 concludes the paper.

Literature Review

The advent of VA contracts with GLB riders in the late 1990s and early 2000s was met with skepticism as consumer watchdog groups, the financial media, and many in the academic community openly questioned whether the high internal fees and expenses associated with the contracts provided any real value to investors or were the guarantees merely clever marketing gimmicks. To address this issue, much of the early empirical research focused on determining the issuing insurance companies' actual hedging cost relative to the rider fees they were charging. The first notable research on this subject was produced by Milevsky and Salisbury (2005). Using an options pricing model they developed to approximate actual rider costs, the authors surprisingly concluded that the rider fees the VA issuers were charging were insufficient to cover their hedging costs, and that the insurers appeared to be grossly underestimating failure risk if market volatility increased. Subsequent research, including published papers by Dai, Kwok, and Zong (2008), Bauer, Kling, and Russ (2008), and Robinson (2008), expanded upon Milevsky and Salisbury's work and applied different methodologies, but reached the same broad conclusion – that the decision to purchase a VA contract with an income rider guarantee does, in fact, result in the transfer of failure risk (i.e., longevity risk and/or market-driven sequential returns risk) from the consumer to the insurance company.[5]

While this conclusion helped establish the legitimacy of VAs paired with GLB riders as an investment product, the research emphasis on pricing relative to cost from the insurance company perspective did little to help consumers evaluate the purchase decision relative to their own circumstances (i.e., age, risk tolerance, income needs, bequest wishes and the like), to competing annuity products, and/or to other potential investment alternatives. More recently, the research emphasis appears to be shifting more to the consumer perspective. Milevsky and Kyrichenko (2008) found that VA contract holders adopt higher equity exposures when living benefit guarantees are selected on the contracts and conclude that such aggressive equity allocations are both rational and justified. Similarly, Robinson (2008) and Parker and Lofties (2011) suggested that an overlooked value of the lifetime income guarantee rider is that it provides the peace of mind necessary to enable investors to remain invested in risky assets and avoid the panic selling that leads to poor market timing decisions in non-guaranteed positions.

The emergence of the GLWB rider as the dominant form of VA income guarantee following the 2008-2009 market shakeout, has begun to lead researchers to narrow their focus on the evaluating merits of this particular contract structure. Xiong, Idzorek, and Chen (2010) apply Monte Carlo analysis to assess the value of GLWB riders and to determine the optimal overall portfolio mix, including VA contracts, which will maximize the investor's utility function at life expectancy. The authors conclude that the GLWB riders offer real value to some consumers in terms of hedging longevity risk and that they are generally best suited for investors with low tolerances for volatility, longer life expectancies, and a strong need for portfolio income to maintain their standards of living. The authors generally discount consumer interest in leaving a remaining balance for heirs.

Steinorth and Mitchell (2012) consider VAs with different forms of GLWBs – one with a plain vanilla initial market value accumulation benefit base and one with annual market ratcheted accumulation benefit base – with a goal of investigating how risk averse consumers would be anticipated to value VA/GLWB forms compared to the observed market prices for the products. The authors conclude that the presence of a plain vanilla GLWB is unlikely to induce risk averse contract holders to begin withdrawals early in retirement and that the riders provide useful protection in the event of extreme longevity. Consistent with other research the authors also find that investment allocation has a greater influence on contract values than fees or mortality and the existence of the GLWB rider prompts risk-averse investors to make riskier portfolio choices up to the point where the insurers should restrict allocations in order to protect against portfolio failure. It should be noted, however, the annuity simulations developed by Steinorth and Mitchell do not seem to closely model real world product designs and are considerably different than the models illustrated in this paper.

Blanchett (2012) asserts that prior research focused on determining the rider cost relative to the actual hedging cost paints an incomplete view of the benefits of annuity guarantees and, from a risk management and insurance perspective, the majority of people who purchase such portfolio insurance should not be better off than if they had not purchased insurance (i.e., consistent with other forms of insurance, they should pay off only in a small number of scenarios). Blanchett contends that it is unfair to compare VA rider guarantees to non-guaranteed model portfolios and that a more appropriate comparison would be relative to an immediate fixed annuity contract. Blanchett concludes that VAs with living benefit riders compare favorably against immediate annuities and that, while annuities with GLWBs may appear inefficient at an individual product level relative to non-guaranteed investment alternatives, they may improve the overall efficiency of a retirement-income portfolio. The Blanchett study is also noteworthy in that it models a GLWB rider with a 10-year accumulation period and a simple form of step-up rider guarantee.

One other recent paper that realistically considers contemporary variable (and immediate) annuity designs is Huang, Grove and Taylor (2012). In this research piece, the authors develop a unique "efficient income frontier" (EIF) for retirement-income planning that balances retiree's concerns for income sustainability with their bequest motives ("legacy potential"). The authors conclude (1) that asset allocations that are considered conservative in the retirement accumulation phase are actually risky and inefficient when retirement withdrawals commence and (2) that the inclusion of annuities in retirement-income portfolios shifts the EIF upward and may both reduce income sustainability risk and increase legacy potential.

In sum, while the body of literature exploring VA contracts with GLWB riders is growing, this paper provides practical insights that may be directly applied by practitioners and consumers in considering product suitability in general and also in comparing specific GLWB riders.

Data and Methodology

Our sample period runs from January 1970, which corresponds to the inception of the MSCI EAFE Index, to December 2010, which represents 41 years or 492 months of data. We use monthly total return data on the S&P 500 Index, the Russell 2000 Index, the MSCI EAFE Index, and 10-year U.S. Treasury bonds as available from CRSP and Datastream. Since the Russell 2000 Index was not established until 1978, we use the total return data for the bottom quintile market cap stocks in the NYSE Index as our proxy for small- and mid–cap stocks for 1970 to 1978, following Siegel (2007).[6]

Using the model proposed in Liu, Chang, De Jong, and Robinson (2011) for our broadly diversified equity portfolio, the equity component for both the annuity models and the benchmark model consists of 45% S&P 500 Index, 30% Russell 2000 Index, and 25% MSCI EAFE Index. This mix generally replicates the equity allocation structure of pre-packaged asset allocation models commonly offered in popular VA contracts. When combined with 10-year Treasury bonds for the fixed income component, this four asset portfolio will be used to compare the accumulation and withdrawal phases of the three annuity portfolios to the benchmark model. We consider the typical balanced allocation of 60% equities and 40% bonds as well as the more aggressive allocation of 100% equities that is permitted under some annuity contracts. The models are rebalanced quarterly to maintain the target bond and equity weights. For the purposes of this analysis, we assume that the benchmark portfolio is held in a tax-deferred account to be consistent with the tax treatment of VA contracts (i.e., tax considerations are irrelevant to this discussion).

To assess whether the current generation of GLWB riders merits consideration by consumers, this study employs three generalized forms of riders that are popular in the marketplace today and compares them to a benchmark index model portfolio with no hedging cost and lower total expenses. Consistent with the manner in which many VA products with GLWB riders are marketed, this study assumes an initial lump sum investment ($100,000) with a ten year holding period, followed by a maximum 30-year withdrawal period. Also consistent with the marketplace, a 5% non-indexed withdrawal rate is applied at the end of the ten year holding period.[7] The three rider forms consist of a model in which the guaranteed withdrawal benefit calculation is based off of (1) annual contract market value step-ups (if the market value has risen), (2) the greater of annual market step-ups or 5% simple interest adjustments for the first 10 years of the contract, and (3) the greater of annual market step-ups or 7% simple interest adjustments for the first 10 years of the contract. These rider structures are summarized in Table 1, below.

TABLE 1: SUMMARY OF VARIABLE ANNUITY RIDER MODEL

Model	Accumulation Benefit	Rider Cost	Withdrawal Terms (same for all 3 models)
1	• Equals the higher of the initial contract value or annual market value step-ups assuming no withdrawals are taken.	0.60%	• 5% annual withdrawals for life based on accumulation benefit • Rider cost assessed quarterly on accumulation benefit less withdrawals
2	• Grow each year by greater of 5% simple interest or market value step-up assuming no withdrawals are taken. • Step-ups only after 10 yrs.	0.90%	
3	• Grows each year by greater of 7% simple interest or market value step-up assuming no withdrawals are taken. • Step-ups only after 10 years	1.15%	

As illustrated in Table 1, annual rider costs are assumed to be .6%, .90%, and 1.15% respectively.[8] Unlike other annuity expenses (e.g., investment, mortality, and administrative expenses), the model rider expenses are calculated against the guaranteed benefit amount, rather than the market value of the contract.[9] Consistent with real-world product design, a 1.25% annual "mortality and administrative" expense ratio charged against the market value on a quarterly basis is applied to all three annuity models. The annual expense for the benchmark portfolios is assumed to be 1%. This allocation and expense design is generally in line with allocation models available in many popular VA contracts, while the 1% expense ratio for the benchmark portfolios seems reasonably consistent with the asset based fee that a practitioner might charge.[10]

Both the VA models and the benchmark index models are rebalanced quarterly to maintain the target equity vs. bond weights, as well as the diversified equity portfolio weights of 45% invested in the S&P 500 Index, 30% invested in the Russell 2000 Index, and 25% invested in the MSCI EAFE Index.

With the 1970 to 2010 total return data, we apply a bootstrapping algorithm to each of the three VA models and our benchmark index model using both a 60% equity/40% bond allocation and a 100% equity/0% bond allocation for a retirement accumulation horizon of 10 years and retirement withdrawal horizons of 10, 15, 20, 25, and 30 years. We ran 5,000 bootstrapping simulations for each scenario.[11] Our bootstrapping algorithm drew months randomly with replacement from our 492 months of data. To maintain the normal cross–sectional correlations, the monthly returns for our 10-year Treasury Bond Index and our three equity indices were drawn together from the same randomly selected month in our accumulation and withdrawal analysis. To compare the three VA models to benchmark models during the accumulation phase for both asset allocations, we compute the mean and standard deviation of the accumulated portfolio value at the retirement date, as well as the median and various quintiles. In each sample, the guaranteed benefit amount was recalculated at the end of each of the first 10 years for each of the three rider guarantees.[12]

Quarterly withdrawals at the end of each quarter commence during the 11th year with the 5% annual withdrawal calculation initiated off the 10th year guaranteed benefit amount for the three VA models. In the case of the benchmark model, the 5% annual withdrawal amount is based off the market value at the end of the 10th year and is maintained through the end of the withdrawal period unless all accumulated funds are depleted. To compare the three VA models to benchmark models during the withdrawal phase for both asset allocations and for withdrawal periods of 10, 15, 20, 25, and 30 years, we compute the probability of success during retirement withdrawals for different withdrawal periods. We define a successful portfolio as one that has enough funds to pay all the constant retirement withdrawals for the given retirement horizon; unsuccessful portfolios run out of funds before the retirement withdrawal horizon ends. The portfolio success rates compute the percentage of times out of 5,000 samples that the particular model is successful, or has a non–negative remaining balance at the end of the retirement withdrawal horizon.

In addition, for the various withdrawal periods, we compute the mean and standard deviation of the remaining portfolio value after quarterly withdrawals and fees, as well as the median and various quintiles of the remaining portfolio value after quarterly withdrawals and fees.

Results

Accumulation Period Findings

The accumulation period simulation results are presented in Tables 2 and 3, next two pages. Table 2 presents the benefit base for each of the eight model portfolios at the end of the prescribed 10-year accumulation period. For the two non-guaranteed

Table 2: Accumulated Withdrawal Benefit Balance after 10 Years with $100,000

	Variable Annuities with 5% Guaranteed Lifetime Withdrawal Riders						Non-Guaranteed	
	Model 1 60:40	Model 1 100%	Model 2 60:40	Model 2 100%	Model 3 60:40	Model 3 100%	Index Model 60:40	Index Model 100%
95th Percentile	$ 321,912	$ 446,697	$ 317,238	$ 437,596	$ 317,728	$ 437,446	$ 369,919	$ 504,081
80th Percentile	$ 250,908	$ 312,783	$ 250,698	$ 313,191	$ 259,405	$ 321,243	$ 286,721	$ 344,809
60th Percentile	$ 210,758	$ 237,512	$ 215,621	$ 245,252	$ 228,692	$ 258,579	$ 240,168	$ 256,047
Median	$ 195,800	$ 213,529	$ 202,483	$ 223,488	$ 218,688	$ 239,893	$ 222,081	$ 228,428
40th Percentile	$ 180,885	$ 191,234	$ 191,899	$ 206,004	$ 210,309	$ 224,623	$ 204,393	$ 201,076
20th Percentile	$ 152,109	$ 151,999	$ 171,648	$ 176,691	$ 200,160	$ 200,160	$ 169,210	$ 151,206
5th Percentile	$ 123,983	$ 115,836	$ 164,362	$ 164,362	$ 200,160	$ 200,160	$ 131,361	$ 101,950
Mean	$ 205,255	$ 239,125	$ 216,049	$ 252,501	$ 233,430	$ 268,611	$ 232,407	$ 255,604
Std. Deviation	$ 62,249	$ 109,314	$ 51,677	$ 96,426	$ 42,351	$ 86,474	$ 75,613	$ 132,035

Notes:

(1) 60:40 portfolio has a constant allocation of 60% equity and 40% bonds and 100% portfolio has 100% equity allocation. The bond portion is invested in 10-year Treasury bonds. The diversified equity portfolio consists of 45% invested in the S&P 500 Index, 30% invested in the Russell 2000 Index, and 25% invested in the MSCI EAFE Index.

(2) Since the Russell 2000 Index started in 1978, we use the bottom quintile, by market capitalization, of NYSE stocks as our proxy for small- and mid-cap stocks from 1970 to 1978 as suggested by Siegal (2007).

(3) The start of our sample in 1970 corresponds with the inception of the MSCI EAFE Index for our international equity portfolio.

(4) Model 1 is a variable annuity with a rider cost of 0.60% and an accumulation benefit equals the higher of the initial contract value or annual market value step-ups.

(5) Model 2 is a variable annuity with a rider cost of 0.90% and an accumulation benefit grows each year by greater of 5% simple interest or market value step-up and Step-ups only after 10 years.

(6) Model 3 is is a variable annuity with a rider cost of 1.15% and an accumulation benefit grows each year by greater of 7% simple interest or market value step-up and Step-ups only after 10 years.

(7) $100,000 is invested in the accumulation portfolio ten years prior to retirement.

(8) Rider cost assessed quarterly on accumulation benefit less withdrawals.

index models, the values presented for each quintile and the median simply represent the market values of the portfolios at the end of ten years. For the six annuity model portfolios, the values represent the maximum guaranteed benefit base according to the terms of each GLWB rider net of expenses.

As expected, Table 2 illustrates the effect of expenses on wealth accumulation as both the 60:40 and 100% equity index models have considerably higher 10-year accumulated balances and 5% cash flow figures than the corresponding annuity models with the same respective allocations for the top simulation percentiles. However, the results also suggest that the rider guarantees may add value "as advertised" in normal and weaker market environments, given that Models 2 and 3 produced higher 10-year accumulation benefit bases and higher 5% fixed withdrawal amounts than the corresponding 10-year values for the 60:40 and 100% equity index model portfolios for the 60% quintile and below. Since risk aversion tends to increase and tends to outweigh growth objectives as investors approach retirement, this finding is likely an important contribution to the consumer knowledge base.

Table 3: 5% Constant Annual Withdrawal Amount

	Variable Annuities with 5% Guaranteed Lifetime Withdrawal Riders						Non-Guaranteed 5% Withdrawal Amounts	
	Model 1 60:40	Model 1 100%	Model 2 60:40	Model 2 100%	Model 3 60:40	Model 3 100%	Index Model 60:40	Index Model 100%
95th Percentile	$ 16,096	$ 22,335	$ 15,862	$ 21,880	$ 15,886	$ 21,872	$ 18,496	$ 25,204
80th Percentile	$ 12,545	$ 15,639	$ 12,535	$ 15,660	$ 12,970	$ 16,062	$ 14,336	$ 17,240
60th Percentile	$ 10,538	$ 11,876	$ 10,781	$ 12,263	$ 11,435	$ 12,929	$ 12,008	$ 12,802
Median	$ 9,790	$ 10,676	$ 10,124	$ 11,174	$ 10,934	$ 11,995	$ 11,104	$ 11,421
40th Percentile	$ 9,044	$ 9,562	$ 9,595	$ 10,300	$ 10,515	$ 11,231	$ 10,220	$ 10,054
20th Percentile	$ 7,605	$ 7,600	$ 8,582	$ 8,835	$ 10,008	$ 10,008	$ 8,460	$ 7,560
5th Percentile	$ 6,199	$ 5,792	$ 8,218	$ 8,218	$ 10,008	$ 10,008	$ 6,568	$ 5,097
Mean	$ 10,263	$ 11,956	$ 10,802	$ 12,625	$ 11,671	$ 13,433	$ 11,620	$ 12,780
Std Deviation	$ 1,556	$ 2,733	$ 1,292	$ 2,411	$ 1,059	$ 2,162	$ 1,890	$ 3,301

Notes:

(1) The values from Models 1-3 represent the 5% constant annual withdrawal amount guaranteed by the GLWB rider whereas the amounts generated by the Index models are not guaranteed. Consistent with the VA contracts, the 5% constant annual withdrawal amounts are not adjusted for inflation for any model above.

(2) 60:40 portfolio has a constant allocation of 60% equity and 40% bonds and 100% portfolio has 100% equity allocation. The bond portion is invested in 10-year Treasury bonds. The diversified equity portfolio consists of 45% invested in the S&P 500 Index, 30% invested in the Russell 2000 Index, and 25% invested in the MSCI EAFE Index.

(3) Model 1 is a variable annuity with a rider cost of 0.60% and an accumulation benefit equals the higher of the initial contract value or annual market value step-ups.

(4) Model 2 is a variable annuity with a rider cost of 0.90% and an accumulation benefit grows each year by greater of 5% simple interest or market value step-up and step-ups only after 10 years.

(5) Model 3 is a variable annuity with a rider cost of 1.15% and an accumulation benefit grows each year by greater of 7% simple interest or market value step-up and step-ups only after 10 years.

(6) All three variable annuity models have the same 5% annual withdrawals for life based upon accumulation benefit.

(7) $100,000 is invested in the accumulation portfolio ten years prior to retirement.

Similarly, annuity Models 2 and 3 with 100% equity allocations produced higher 10-year accumulated balances and higher 5% cash flows than the 60:40 Index Model in all simulations. The implication of this finding is that, all other factors being equal, investors choosing among competing annuity contracts may do well to choose the one with the rider guarantee that allows the most aggressive equity allocation during the accumulation period.

Interestingly, annuity Model 1 (both allocation portfolios), with the lowest expenses and least robust guarantee (i.e., annual market value step-up rider), generated the lowest 10-year accumulation benefit base value in all but the worst simulations, suggesting that this particular rider form offers the least value to consumers during the accumulation period. This finding runs directly counter to the prevailing popular mantra that consumers should generally select VA contracts with the lowest total expenses. For risk averse investors looking to maximize future guaranteed income, Tables 2 and 3 make a strong case for the higher expense models with more robust guarantees.

Table 4: Probability of Success

# of Years	Variable Annuities with 5% Guaranteed Lifetime Withdrawal Riders						Non-Guaranteed 5% Withdrawal Amounts	
	Model 1 60:40	Model 1 100%	Model 2 60:40	Model 2 100%	Model 3 60:40	Model 3 100%	Index Model 60:40	Index Model 100%
10 Years	99.90%	98.12%	98.70%	91.40%	93.06%	80.64%	100.00%	99.98%
15 Years	99.28%	92.24%	92.06%	77.58%	75.32%	61.20%	99.96%	99.44%
20 Years	96.78%	84.10%	81.74%	64.74%	56.12%	46.76%	99.78%	97.56%
25 Years	92.34%	75.92%	70.78%	55.58%	42.82%	37.50%	99.28%	95.14%
30 Years	87.58%	70.70%	62.76%	49.82%	33.82%	31.66%	98.66%	92.58%

Notes:
(1) Success is defined as having a positive remaining balance value at the end of the distribution period.
(2) 60:40 portfolio has a constant allocation of 60% equity and 40% bonds and 100% portfolio has 100% equity allocation. The bond portion is invested in 10-year Treasury bonds. The diversified equity portfolio consists of 45% invested in the S&P 500 Index, 30% invested in the Russell 2000 Index, and 25% invested in the MSCI EAFE Index.
(3) Model 1 is a variable annuity with a rider cost of 0.60% and an accumulation benefit equals the higher of the initial contract value or annual market value step-ups.
(4) Model 2 is a variable annuity with a rider cost of 0.90% and an accumulation benefit grows each year by greater of 5% simple interest or market value step-up and step-ups only after 10 years.
(5) Model 3 is is a variable annuity with a rider cost of 1.15% and an accumulation benefit grows each year by greater of 7% simple interest or market value step-up and step-ups only after 10 years.
(6) All three variable annuity models have the same 5% annual withdrawals for life based upon accumulation benefit.
(7) Rider cost assessed quarterly on accumulation benefit less withdrawals.
(8) $100,000 is invested in the accumulation portfolio ten years prior to retirement.

Withdrawal Period Results

Table 4, above, reports the success rates for each of the six annuity model portfolios and for the two index models, where success is defined as having a positive remaining balance value at the end of the distribution period.

Perhaps the most important observation to be gleaned from these results is that the success rates for the index models under the 5% constant withdrawal condition are greater than 90% across all distribution periods.[13] This lends support to the commonly applied financial planning guideline that a 60:40 allocation may be effective for helping investors achieve income sustainability, as this model failed in less than 2% of simulations in even the longest distribution period. To the extent that some portion of annuity VA sales have been driven by fear in the absence of data, this information may help investors better quantify failure risk (i.e., sequential returns risk and longevity risk) in order to determine whether they wish to insure against it.

Another observation from the output in Table 4 is the startlingly high failure rates of the annuity models. In reviewing these results, it is important to keep in mind that failure in the annuity models does not mean that the contract holder's cash flow payments will stop, but rather that there will be no remaining balance left for the contract holder's heirs. Such high failure rates among the annuity models clearly suggest that the insurance companies must be prepared to pay claims on contracts with longer withdrawal periods and that they should be vigilant in their internal hedging

Table 5: Remaining Balance for 10-30 Year Retirement after Withdrawals and Fees

	Variable Annuities with 5% Guaranteed Lifetime Withdrawal Riders						Non-Guaranteed 5% Withdrawal Amounts	
	Model 1 60:40	Model 1 100%	Model 2 60:40	Model 2 100%	Model 3 60:40	Model 3 100%	Index Model 60:40	Index Model 100%
PANEL A: 10-Year Distribution Period								
95th Percentile	$ 486,039	$ 765,782	$ 439,925	$ 700,590	$ 397,418	$ 637,143	$ 720,292	$ 1,127,402
80th Percentile	$ 322,807	$ 402,635	$ 86,524	$ 354,885	$ 248,162	$ 308,950	$ 485,891	$ 621,048
60th Percentile	$ 239,103	$ 252,233	$ 203,090	$ 207,153	$ 263,010	$ 163,624	$ 368,017	$ 407,011
Median	$ 207,275	$ 199,311	$ 170,570	$ 157,070	$ 130,463	$ 116,675	$ 321,223	$ 330,885
40th Percentile	$ 178,933	$ 159,573	$ 143,819	$ 117,871	$ 102,995	$ 75,908	$ 280,565	$ 270,080
20th Percentile	$ 125,389	$ 88,242	$ 88,846	$ 45,526	$ 47,710	$ 2,825	$ 205,413	$ 170,230
5th Percentile	$ 73,656	$ 25,689	$ 32,712	$ 0	$ 0	$ 0	$ 131,448	$ 86,117
Mean	$ 234,119	$ 271,412	$ 196,849	$ 227,034	$ 157,078	$ 187,109	$ 360,025	$ 431,819
Std Deviation	$ 134,341	$ 254,649	$ 132,289	$ 244,332	$ 129,993	$ 232,805	$ 191,056	$ 361,764
PANEL B: 15-Year Distribution Period								
95th Percentile	$ 642,988	$ 1,068,459	$ 563,258	$ 955,834	$ 482,986	$ 851,268	$ 1,055,619	$ 1,773,420
80th Percentile	$ 399,166	$ 514,471	$ 331,241	$ 422,287	$ 254,178	$ 329,261	$ 671,933	$ 898,211
60th Percentile	$ 271,309	$ 277,811	$ 206,585	$ 197,721	$ 135,402	$ 122,876	$ 479,136	$ 528,325
Median	$ 225,136	$ 207,166	$ 163,226	$ 133,813	$ 90,999	$ 57,916	$ 406,363	$ 421,294
40th Percentile	$ 189,793	$ 151,980	$ 127,017	$ 80,306	$ 54,177	$ 4,691	$ 349,197	$ 333,274
20th Percentile	$ 118,040	$ 61,174	$ 55,942	$ 0	$ 0	$ 0	$ 237,329	$ 180,874
5th Percentile	$ 50,410	$ 0	$ 0	$ 0	$ 0	$ 0	$ 133,927	$ 70,795
Mean	$ 271,151	$ 332,949	$ 207,805	$ 260,760	$ 144,695	$ 199,827	$ 476,996	$ 607,567
Std Deviation	$ 195,437	$ 411,787	$ 186,700	$ 383,076	$ 172,491	$ 351,614	$ 302,829	$ 639,166
PANEL C: 20-Year Distribution Period								
95th Percentile	$ 895,679	$ 1,546,907	$ 757,477	$ 1,328,765	$ 601,940	$ 1,116,360	$ 1,602,787	$ 2,766,946
80th Percentile	$ 500,668	$ 700,167	$ 385,280	$ 538,143	$ 259,075	$ 368,560	$ 951,741	$ 1,368,643
60th Percentile	$ 321,344	$ 325,257	$ 217,691	$ 193,613	$ 91,985	$ 62,226	$ 649,884	$ 740,274
Median	$ 257,987	$ 223,953	$ 156,982	$ 100,209	$ 32,216	$ 0	$ 544,283	$ 558,794
40th Percentile	$ 204,970	$ 147,392	$ 102,951	$ 33,326	$ 0	$ 0	$ 452,743	$ 425,169
20th Percentile	$ 102,647	$ 21,616	$ 9,510	$ 0	$ 0	$ 0	$ 280,810	$ 197,643
5th Percentile	$ 18,250	$ 0	$ 0	$ 0	$ 0	$ 0	$ 135,605	$ 43,754
Mean	$ 329,920	$ 435,639	$ 232,432	$ 325,371	$ 143,402	$ 235,345	$ 661,260	$ 895,654
Std Deviation	$ 292,360	$ 640,834	$ 268,197	$ 581,061	$ 230,555	$ 516,788	$ 492,425	$ 1,085,411
PANEL D: 30-Year Distribution Period								
95th Percentile	$1,746,790	$ 3,530,387	$ 1,371,957	$ 2,826,370	$ 948,961	$ 2,200,330	$ 3,766,492	$ 7,489,947
80th Percentile	$ 871,835	$ 1,234,667	$ 590,008	$ 838,050	$ 244,536	$ 398,120	$ 2,058,090	$ 3,056,671
60th Percentile	$ 475,596	$ 459,491	$ 230,843	$ 164,160	$ 0	$ 0	$ 1,257,344	$ 1,470,925
Median	$ 352,466	$ 274,691	$ 114,391	$ 0	$ 0	$ 0	$ 1,015,042	$ 1,050,085
40th Percentile	$ 243,385	$ 123,063	$ 26,960	$ 0	$ 0	$ 0	$ 797,675	$ 736,789
20th Percentile	$ 62,979	$ 0	$ 0	$ 0	$ 0	$ 0	$ 435,030	$ 263,505
5th Percentile	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 139,941	$ 0
Mean	$ 541,750	$ 834,640	$ 342,220	$ 594,330	$ 174,992	$ 397,906	$ 1,366,296	$ 2,080,499
Std Deviation	$ 646,777	$ 1,644,746	$ 552,972	$ 1,443,100	$ 427,026	$ 1,234,505	$ 1,288,171	$ 3,274,353

Notes:

(1) We consider withdrawal horizons of 10, 15, 20, and 30 years.

(2) 60:40 portfolio has a constant allocation of 60% equity and 40% bonds and 100% portfolio has 100% equity allocation. The bond portion is invested in 10-year Treasury bonds. The diversified equity portfolio consists of 45% invested in the S&P 500 Index, 30% invested in the Russell 2000 Index, and 25% invested in the MSCI EAFE Index.

(3) Model 1 is a variable annuity with a rider cost of 0.60% and an accumulation benefit equals the higher of the initial contract value or annual market value step-ups.

(4) Model 2 is a variable annuity with a rider cost of 0.90% and an accumulation benefit grows each year by greater of 5% simple interest or market value step-up and step-ups only after 10 years.

(5) Model 3 is is a variable annuity with a rider cost of 1.15% and an accumulation benefit grows each year by greater of 7% simple interest or market value step-up and step-ups only after 10 years.

(6) All three variable annuity models have the same 5% annual withdrawals for life based upon accumulation benefit.

(7) Rider cost assessed quarterly on accumulation benefit less withdrawals.

(8) $100,000 is invested in the accumulation portfolio ten years prior to retirement.

Key: Winner 2nd Place 3rd Place

policies and prudent in their contract holder behavioral assumptions.

From the investor perspective, while it may be wise for annuity investors to adopt an aggressive allocation strategy during the accumulation period, the output in Table 4 also suggests that they may be wise to adopt a more balanced asset allocation once they begin to withdraw from the contracts insofar as the contract holders retain even a nominal desire to leave a balance for heirs. For all three annuity models, the success rates are higher across all distribution periods for the 60:40 allocation models than for the corresponding 100% equity models.

In comparing the success rates of the three annuity models to each other, as expected, relative success rates across all distribution periods are purely a function of internal expenses. The annuity model with the lowest internal expenses (Model 1) exhibits the highest success rates while the most expensive model (Model 3) has the lowest success rate. This does not necessarily suggest that Model 1 is the superior choice, however, since, as discussed earlier, the 5% guaranteed cash flow derived from the 10-year accumulated balance is lower for Model 1 than for the other two models across all but the top performing simulations.

Table 5, prior page, reports the remaining balances for withdrawal periods ranging from 10-30 years for the six VA/GLWB models and the two index models.

Complimentary to the findings in Table 4, the non-guaranteed index equity models not only have the highest probabilities of success but also have the highest remaining balances across all distribution periods. This data helps quantify the net worth sacrifice consumers may make in return for guaranteed cash flow and suggests that consumers with a strong desire to leave an estate for their heirs may wish to think carefully before investing in a VA contract. It is also interesting to note that, under the 5% withdrawal constraint, the 100% equity index model still has a sizeable remaining balance even as low as the 20% quintile simulation.

To further evaluate and compare the effectiveness of the annuity models relative to each other and to the two non-guaranteed index models, Table 6, next page, summarizes the combined total nominal cash flow distributed and remaining balance (if any) for each model across all four illustrated distribution periods.[14]

As in Table 5, these results show that the total cash flow returns from the non-guaranteed models are dramatically higher than for the annuity models in all but the worst performing simulations across all illustrated distribution periods. Although this result may not intuitively be surprising, in light of the low probability of portfolio failure for the non-guaranteed index portfolios shown in Table 4, it further articulates and quantifies the consumer opportunity cost of VA rider guarantees. The magnitude of this tradeoff is likely to be valuable information for consumers' decision making processes.

In comparing the total cash flows produced by the annuity models, Table 6, next page, also shows that Model 1 tends to produce the greatest total cash flow returns for the top 80% of simulations while Model 3 generally produces the highest total cash flow returns of the three annuity models in the worst simulation decile. It might be tempting to conclude from this that annuity contracts with low cost, plain vanilla, market step-up riders may be a valid choice for consumers who wish to balance their desire for a lifetime income guaranteed with leaving an estate for their heirs. However, in the broader context, there are few scenarios in which Model 1 appears to be a better choice than the unhedged index models. Simply put, investors who are primarily concerned with maximizing guaranteed cash flow can make a rational case for purchasing expensive VAs with robust rider guarantees. Investors who are concerned with total distributions and/or who have a bequest motive may be better served by forgoing the VA purchase entirely.

Table 6: Total Cash Flow: Distributed Plus Remaining Balance

	Variable Annuities with 5% Guaranteed Lifetime Withdrawal Riders						Non-Guaranteed 5% Withdrawal Amounts	
	Model 1 60:40	Model 1 100%	Model 2 60:40	Model 2 100%	Model 3 60:40	Model 3 100%	Index Model 60:40	Index Model 100%
PANEL A: 10-Year Distribution Period								
95th Percentile	$ 622,929	$ 939,301	$ 579,879	$ 868,788	$ 536,272	$ 805,182	$ 875,802	$ 1,338,100
80th Percentile	$ 442,574	$ 547,234	$ 408,198	$ 502,045	$ 372,514	$ 460,177	$ 624,952	$ 784,305
60th Percentile	$ 345,229	$ 373,487	$ 312,011	$ 334,259	$ 279,071	$ 297,475	$ 488,692	$ 533,775
Median	$ 306,946	$ 317,162	$ 276,206	$ 278,266	$ 243,844	$ 244,509	$ 434,886	$ 454,351
40th Percentile	$ 274,502	$ 263,090	$ 245,423	$ 230,922	$ 213,653	$ 199,126	$ 388,206	$ 380,978
20th Percentile	$ 212,142	$ 178,343	$ 185,183	$ 149,294	$ 156,028	$ 129,216	$ 301,258	$ 261,481
5th Percentile	$ 146,941	$ 105,388	$ 120,954	$ 91,070	$ 103,578	$ 100,080	$ 210,129	$ 157,285
Mean	$ 336,747	$ 390,975	$ 304,873	$ 353,284	$ 273,793	$ 321,440	$ 476,229	$ 559,620
Std Deviation	$ 153,947	$ 288,284	$ 147,516	$ 272,890	$ 141,186	$ 257,206	$ 215,680	$ 404,654
PANEL B: 15-Year Distribution Period								
95th Percentile	$ 842,479	$ 1,339,055	$ 762,945	$ 1,217,810	$ 673,214	$ 1,108,677	$ 1,277,676	$ 2,097,976
80th Percentile	$ 573,996	$ 715,161	$ 509,060	$ 632,082	$ 442,464	$ 547,842	$ 878,465	$ 1,128,112
60th Percentile	$ 430,140	$ 460,915	$ 372,232	$ 393,369	$ 310,331	$ 329,046	$ 659,206	$ 727,636
Median	$ 377,119	$ 378,877	$ 322,284	$ 316,164	$ 260,324	$ 261,922	$ 576,086	$ 603,944
40th Percentile	$ 332,094	$ 313,870	$ 281,143	$ 255,307	$ 223,133	$ 216,762	$ 509,558	$ 501,030
20th Percentile	$ 249,872	$ 205,236	$ 200,165	$ 170,965	$ 165,997	$ 163,434	$ 384,906	$ 327,497
5th Percentile	$ 164,998	$ 120,270	$ 133,441	$ 123,271	$ 150,120	$ 150,120	$ 259,341	$ 184,173
Mean	$ 425,092	$ 512,293	$ 369,841	$ 450,136	$ 319,767	$ 401,322	$ 651,300	$ 799,143
Std Deviation	$ 220,170	$ 454,029	$ 206,180	$ 419,144	$ 186,983	$ 382,470	$ 334,078	$ 693,580
PANEL C: 20-Year Distribution Period								
95th Percentile	$ 1,145,100	$ 1,870,240	$ 1,007,233	$ 1,666,576	$ 859,220	$ 1,457,025	$ 1,915,508	$ 3,153,223
80th Percentile	$ 730,356	$ 972,224	$ 619,737	$ 822,671	$ 507,922	$ 668,867	$ 1,212,729	$ 1,673,944
60th Percentile	$ 531,582	$ 571,252	$ 434,092	$ 455,640	$ 329,019	$ 361,348	$ 889,478	$ 994,483
Median	$ 459,879	$ 458,866	$ 368,223	$ 360,720	$ 275,238	$ 298,083	$ 768,951	$ 810,461
40th Percentile	$ 397,022	$ 368,246	$ 311,965	$ 291,047	$ 243,428	$ 259,363	$ 671,677	$ 657,590
20th Percentile	$ 285,800	$ 235,407	$ 217,521	$ 204,285	$ 204,502	$ 209,587	$ 482,787	$ 400,362
5th Percentile	$ 182,150	$ 143,281	$ 165,801	$ 164,362	$ 200,160	$ 200,160	$ 312,405	$ 209,335
Mean	$ 535,175	$ 674,764	$ 448,480	$ 577,871	$ 376,832	$ 504,006	$ 893,607	$ 1,150,211
Std Deviation	$ 320,279	$ 688,126	$ 290,230	$ 621,425	$ 246,928	$ 551,136	$ 528,197	$ 1,147,501
PANEL D: 30-Year Distribution Period								
95th Percentile	$ 2,102,105	$ 3,970,986	$ 1,742,994	$ 3,309,100	$ 1,328,895	$ 2,689,708	$ 4,154,003	$ 7,983,763
80th Percentile	$ 1,210,953	$ 1,635,890	$ 938,224	$ 1,247,659	$ 613,927	$ 854,868	$ 2,431,339	$ 3,461,303
60th Percentile	$ 785,363	$ 819,992	$ 560,280	$ 590,851	$ 394,668	$ 468,550	$ 1,617,788	$ 1,850,090
Median	$ 656,320	$ 634,404	$ 452,315	$ 469,358	$ 356,525	$ 406,846	$ 1,342,594	$ 1,429,841
40th Percentile	$ 543,595	$ 495,586	$ 372,602	$ 385,006	$ 332,284	$ 363,437	$ 1,132,123	$ 1,087,116
20th Percentile	$ 358,509	$ 309,534	$ 285,537	$ 286,594	$ 300,240	$ 306,040	$ 746,892	$ 575,016
5th Percentile	$ 230,106	$ 200,791	$ 246,543	$ 246,543	$ 300,240	$ 300,240	$ 431,848	$ 245,599
Mean	$ 849,633	$ 1,193,328	$ 666,293	$ 973,081	$ 525,136	$ 800,897	$ 1,714,086	$ 1,150,211
Std Deviation	$ 678,284	$ 1,700,656	$ 578,257	$ 1,491,386	$ 445,273	$ 1,275,445	$ 1,330,520	$ 3,351,910

Notes:

(1) 60:40 portfolio has a constant allocation of 60% equity and 40% bonds and 100% portfolio has 100% equity allocation. The bond portion is invested in 10-year Treasury bonds. The diversified equity portfolio consists of 45% invested in the S&P 500 Index, 30% invested in the Russell 2000 Index, and 25% invested in the MSCI EAFE Index.

(2) Model 1 is a variable annuity with a rider cost of 0.60% and an accumulation benefit equals the higher of the initial contract value or annual market value step-ups.

(3) Model 2 is a variable annuity with a rider cost of 0.90% and an accumulation benefit grows each year by greater of 5% simple interest or market value step-up and step-ups only after 10 years.

(4) Model 3 is is a variable annuity with a rider cost of 1.15% and an accumulation benefit grows each year by greater of 7% simple interest or market value step-up and step-ups only after 10 years.

(5) All three variable annuity models have the same 5% annual withdrawals for life based upon accumulation benefit.

(6) Rider cost assessed quarterly on accumulation benefit less withdrawals.

(7) $100,000 is invested in the accumulation portfolio ten years prior to retirement.

(8) Total cash flow is the sum of all quarterly distributions plus the remaining balances after all fees and quarterly withdrawals have been deducted.

Key: Winner 2nd Place 3rd Place

Summary

To the extent that consumer decisions to purchase VAs with lifetime income guarantees have heretofore been made based largely on fear and in the absence of empirical data, this analysis has produced a number of findings which, collectively, may lead to more informed decision making. In the wake of much publicized research on income sustainability (e.g., the "4% rule" and the like), one of the most important concepts for consumers to understand is that the constant withdrawal guarantees offered under most GLWB riders are not equivalent to the inflation-adjusted withdrawal rates discussed in most sustainability studies or in the popular press. This point was made effectively in a recent thought piece by Pfau (2011) but is likely still a source of confusion in the retail marketplace. In terms of quantifying the value of the GLWB rider guarantees, two of the most salient findings in this paper are (1) that the probability of portfolio failure based upon a 5% constant withdrawal rate over withdrawal periods as long as 30 years is exceedingly low – less than 2% for the 60:40 index model illustrated in this paper; and (2) that the decision to purchase a VA to insure against failure risk will most likely result in a substantially lower remaining balance for heirs (or no remaining balance at all).

These two pieces of information do not necessarily mean that the decision to purchase an annuity contract with a GLWB rider is irrational. Indeed, this analysis suggests that such contracts' greatest value proposition may be in helping consumers maximize income after a 10-year accumulation period. On this score, a counter-intuitive finding is that the most robust and most expensive guarantee riders seem to produce the highest guaranteed cash flows, particularly in contracts that permit investors to invest aggressively in equities. To the extent that remaining balance considerations are unimportant and the consumer intends to use the VA contracts in the manner in which the rider guarantees are marketed (i.e., 10-year accumulation followed by (long) lifetime withdrawals), it can even be argued that annuity expenses are irrelevant to the purchase decision and that investors may be entirely rational in paying more for features (e.g., age-banded withdrawal rates, guaranteed 2x or 2.5x benefit base, 100% equity allocations, etc.) that may lead to higher accumulation benefits and/or higher guaranteed cash flows. Conversely, this study seems to suggest that the simplest, lowest cost riders, such as the annual market value step-up rider illustrated in Model 1, may not offer much value to consumers. While such riders will likely produce greater remaining balances and greater total cash flows than the more robust/costly guarantees, in instances where the consumer has a bequest motive, it is difficult to see how the choice of such a rider would ever be an optimal choice relative to a non-guaranteed 60:40 allocation.

In summation, this paper is generally consistent with past research in concluding that VA contracts may be a rational choice for risk-averse consumers with long anticipated distribution horizons and little bequest motive. This paper also adds to the previous research body by providing both qualitative and quantitative data to help guide consumers in the decision whether or not to purchase a VA contract and in choosing between common GLWB rider features. ■

Footnotes:

1 Source: Insured Retirement Institute (2013)

2 Ibid

3 Ibid

4 Source: LIMRA VA GLB Election Tracking Survey Fourth Quarter 2012

5 This conclusion was ultimately tested and borne out by the global financial crisis that began in 2008 and resulted in a 50% stock market

Footnotes continued:

decline through March 2009. Forced to pony up millions of dollars in reserves, scores of insurance companies that had issued VA contracts with income guarantees exited the marketplace, stopped issuing new contracts with income rider guarantees, or revamped their product offerings with different guarantee structures and different pricing.

6 Although many simulation-based studies elect to use S&P 500 Index monthly return data going back to the 1920s, we prefer the more current start date because it represents the modern trading era and covers the period in which computers and program trading have been in existence. This period also incorporates the three worst bear markets since the great depression. We also maintain that 41 years of monthly return data provides a sufficiently large sample size to produce meaningful results.

7 This represents the most common GLWB rider withdrawal format. In some cases, guaranteed withdrawal rates follow an age-based tier structure in which contract holders may be permitted to increase their withdrawal rates to 6% or 7% as they get older (e.g. at age 75 or 80). Inflation-indexed withdrawals do not exist among the leading GLWB riders.

8 These expenses were obtained from similar riders offered in actual variable annuity contracts. In general, it is observed that rider costs increase as the guarantees become more generous.

9 This is consistent with the manner in which all insurance carriers calculate the expense. It is worth noting that most previous studies have calculated rider expenses on the contract market value, which tends to understate consumer cost over time.

10 It is assumed that the underlying index portfolios for both the benchmarks models and the annuity models are identical. As such, we excluded underlying sub-account/mutual fund expense ratios from this analysis.

11 Our results are robust to the different number of bootstrapping simulations. We have experienced 1000, 2500, 5000, and 10000 simulations with qualitatively similar results. These results are available upon request.

12 Market value step-up calculations are applied annually as the simulations dictate for the entire 40 year period (i.e., only the 5% and 7% simple interest adjustments cease at the end of ten years).

13 The success rates reported in Table 3 are far greater than those reported in many other published papers on sustainable withdrawal rates. This difference is attributable to the fact that most of these papers consider inflation-adjusted withdrawal rates. In contrast, this paper compares 5% constant (i.e., non-inflation-adjusted) withdrawals because that is the withdrawal format required under virtually all GLWB riders in the marketplace. The results are decidedly consistent with those reported by Cooley, Habbard & Walz (1998) in a study that examined sustainable withdrawal rates using constant withdrawals.

14 Consistent with real world investor behavior, it is assumed that the withdrawals from each model are immediately spent by the contract holder and, as such, the reinvestment return on cash flow distributions is 0%.

References:

- Bauer, D., Kling, A., and Russ A. (2008). “A universal pricing framework for guaranteed minimum benefits in variable annuities.” ASTIN Bulletin 38: 621 – 651
- Benartzi, S., Previtero, A., and Thaler, R. (2011). “Annuitization puzzles.” *Journal of Economic Perspectives*. 25(4): 143-164
- Blanchett, D. (2012). “Optimal portfolio allocations with GMWB annuities.” *Journal of Financial Planning*. 23(2): 46-56
- Cooley, P., Hubbard, C., and Walz, D. (1998). “Retirement spending: choosing a sustainable withdrawal rate.” *Journal of the American Association of Individual Investors*. 20(2): 16-21
- Dai, M., Kwok, Y., and Zong, J. (2008). “Guaranteed minimum withdrawal benefits in variable annuities.” *Mathematical Finance*. 18(4): 595-611
- Huang, D., Grove, M., and Taylor, T. (2012) “The Efficient Income Frontier: A Product Allocation Framework for Retirement.” *Retirement Management Journal*, 2(1): 9-22
- Insured Retirement Institute. 2013 Annuity Fact Book. Washington, DC: IRI
- LIMRA (2012): Variable annuity guaranteed living benefit election tracking survey report, 4th quarter, 2012. http://www.limra.com/Posts/PR/Data_bank.aspx. Download 04/12/2013

References continued:

- Liu, Q., Chang, R., Robinson, J., and DeJong, J. (2011). "Are lifecyle funds getting a bum rap? A comprehensive comparison of lifecyle versus lifestyle retirement strategies from accumulation through withdrawal." *The Journal of Wealth Management*, 14(2): 68-84
- Milevsky, M., and Salisbury, T. (2005). "Financial valuation of guaranteed minimum withdrawal benefits." *Insurance Mathematics & Economics*, 38(1), 21-38
- Milevsky, M., and Kyrychenko, V. (2008). "Portfolio choice with puts: Evidence from variable annuities." *Financial Analysts Journal*, 64(2): 1-30
- Pfau, W. (2011). "GLWBs: Retiree Protection or Money Illusion?" *Advisor Perspectives*
- Parker, Z. and Lofties, P., (2011) "Capturing the Income-Distribution Opportunity: A Historical Analysis of Distribution Philosophies and a Solution for Today." *Retirement Management Journal*, 1(1): 43-56
- Robinson, J. (2008). "A context for considering variable annuities with contemporary living benefit riders." *Journal of Financial Planning*, 21(5): 56-69
- Scott, J., Watson, J., and Hu, W. (2007). "Efficient annuitization: Optimal strategies for hedging mortality risk." Pension Research Council Working Paper
- Steinorth P., and Mitchell, O. (2012). "Valuing variable annuities with guaranteed minimum lifetime withdrawal benefits." Pension Research Council Working Paper
- Xiong, J., Idzorek, T., and Chen, P. (2010). "Allocation to deferred variable annuities with GMWB for life." *Journal of Financial Planning*. 23(2): 42-50
- Yaari, M. (1965). "Uncertain lifetime, life insurance, and the theory of the consumer." *Review of Economic Studies*. 32: 137-150