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Risks & Rewards

SOCIETY OF ACTUARIES
INVESTMENT SECTION

Hedging Variable Annuities: How Often Should the Hedging Portfolio be Rebalanced?

By Maciej Augustyniak and Mathieu Boudreault

In the last decade, many insurers have implemented dynamic hedging programs to defend against market risks embedded in their variable annuity (VA) blocks of business. At the core of these programs are the so-called Greeks which correspond to price sensitivities with respect to various market risks such as movements in equity indices, interest rates and volatility. These Greeks indicate to the insurer how much to invest in equities, bonds and financial derivatives to offset market exposures in its VA contracts. Due to changes in market factors, Greeks vary in time and the insurer is therefore required to rebalance its hedging portfolio (i.e., adjust its hedging positions) periodically to ensure that the hedging strategy is achieving its objective.

When managing a VA hedging program, the choice of the rebalancing frequency is an important practical issue because of the high monitoring and trading costs that ensue when hedging positions are revised. It is well-known that in a Black-Scholes world hedging more frequently reduces the hedging error. In fact, groundbreaking work in financial theory showed that this error can theoretically be eliminated in a Black-Scholes setting with a continuously rebalanced delta hedge. However, in the real world perfect hedging is generally not feasible due to sudden price jumps, to market frictions, to the impossibility of trading in continuous time and to the limited availability of traded assets. Therefore, hedging

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in real market conditions entails a risk. It would be tempting to conclude based on Black-Scholes theory that this risk can be reduced with a more frequent rebalancing of the hedging portfolio. However, this is not necessarily the case because every hedging strategy carried out in the real world is exposed to model risk; that is, there is inevitably a discrepancy between the insurer's hedging model used to compute Greeks and the true (unknown) financial model or data-generating process. Consequently, adjusting hedging positions too often with the wrong model can lead to a larger accumulation of hedging errors than if less frequent revisions were made. This issue is especially important to investigate in the context of VAs because hedging is performed over long-term periods.

The objective of this article is to investigate how the choice of the rebalancing frequency in a VA hedging program impacts hedging effectiveness. More precisely, we examine the performance of daily, weekly, monthly and move-based delta hedging strategies for managing the underlying equity risk of a simple guaranteed minimum accumulation benefit (GMAB) VA indexed to historical S&P 500 returns. This allows us to conduct a back-testing exercise and determine what choice of rebalancing strategy would have been preferable to use in the past. Overall, we find that a monthly rebalanced delta hedging strategy consistently led to the smallest losses when dynamically hedging 10-year GMAB contracts maturing in the period 1990–2017. It must be emphasized that this conclusion is valid with and without transaction costs. Therefore, recent empirical evidence strongly favors a less frequent rebalancing of the hedging portfolio and we examine some explanations of this phenomenon.

The objective of this article is to investigate how the choice of the rebalancing frequency in a VA hedging program impacts hedging effectiveness.

GMAB CONTRACT AND ASSUMPTIONS

We assume that the insurer sells 10-year VA contracts with a GMAB rider. The value of the VA account in time is denoted by $\{A_t: t = 0,1,\dots,T\}$, where t is measured in trading days from inception of the contract. Since there are approximately 252 trading days in each calendar year, the term-to-maturity of the contract is set to $T = 2520$ days. The VA account is invested in an investment fund, denoted by $\{S_t: t = 0,1,\dots,T\}$ (in our hedging experiment, this investment fund will mimic historical returns on the S&P 500 price index). We assume an initial investment of $A_0 = S_0 = \$100$. The GMAB rider ensures that the policyholder will be able to recover the greater of the account value A_T and a guaranteed amount $G = 116$ at maturity (the guaranteed amount corresponds to the initial investment accumulated at an effective annual roll-up rate of 1.5 percent). The GMAB rider therefore creates a liability for the insurer in the form of a long-term put option guarantee; the insurer's liability at maturity is $\max(G - A_T, 0)$. This guarantee is financed via a fee withdrawn daily as a fraction of the account value at an annual nominal rate of $\alpha = 2\%$, that is, at the beginning of each trading day the insurer withdraws $A_t(\alpha/252)$ from the account value. As a result, fee cash flows are risky and should be hedged along with the guarantee. The relationship between the investment fund S_t and the VA account A_t at time t (right before the withdrawal of fees) is therefore given by:

$$A_t = S_t(1 - \alpha/252)^t.$$

Finally, we suppose that the VA contract is held to maturity (i.e., surrender and death are not possible) and assume a continuously compounded annual risk-free rate of r = 3%.

HEDGED LOSS

If the insurer does not use a hedging strategy, its **unhedged loss** on the VA contract at maturity, denoted by L_T, corresponds to the payoff on the GMAB rider less accumulated fees that were collected throughout the contract:

$$\begin{aligned} L_T &= \text{GMAB payoff} - \text{accumulated fees} \\ &= \max(G - A_T, 0) - \sum_{t=0}^{T-1} A_t(\alpha/252)\, e^{r(T-t)/252}. \end{aligned}$$

To manage the market risk embedded in the GMAB rider, we assume that the insurer establishes a dynamic delta hedging strategy under the Black-Scholes model. This strategy entails

CONTINUE ON PAGE 4

holding a position of Δ_t (the Greek *delta*) in the fund S_t at time t (the computation of Δ_t is detailed in the following section). This can be accomplished using futures or, equivalently, by taking a long position in Δ_t shares of the underlying fund and borrowing the costs or lending the proceeds.

The **hedged loss** on the VA contract at maturity, denoted by HL_T, corresponds to:

$$HL_T = \text{unhedged loss} - \text{cumulative mark-to-market gains on the hedge} = L_T - H_T.$$

The mark-to-market gain at time $t+1$ associated with the delta hedge established at time t is:

$$\Delta_t(S_{t+1} - S_t e^{r/252}).$$

The **cumulative mark-to-market gains** on the hedge, denoted by H_T, correspond to the accumulated values of these gains to maturity:

$$H_T = \sum_{t=0}^{T-1} \Delta_t\left(S_{t+1} - S_t e^{r/252}\right) e^{r(T-t-1)/252}.$$

The objective of the delta hedging strategy is to generate cumulative mark-to-market gains at maturity that will allow the insurer to offset its loss on the VA contract.

COMPUTATION OF DELTA

To achieve its objective, the delta hedging strategy must protect the insurer against changes in the net value of the VA contract due to fluctuations in the underlying investment fund S_t. In a Black-Scholes setting, the net value of the VA contract is computed as an expected present value (PV) under the risk-neutral measure. The net value of the VA contract at time t (in the eyes of the insurer), denoted by V_t, corresponds to:

$$V_t = \text{Black-Scholes put price} - \text{expected PV of future fees} - \text{past fees accumulated to time t}.$$

Note that the first two terms on the right-hand side of this equation are a function of S_t (or A_t) whereas the last term is not. The position Δ_t is then defined as the first-order sensitivity of V_t with respect to a change in S_t:

$$\Delta_t = \frac{\partial V_t}{\partial S_t} = \Delta_t^{\text{put}} - [(1-\alpha/252)^t - (1-\alpha/252)^T],$$

where

$$\Delta_t^{\text{put}} = -(1-\alpha/252)^T \Phi(-d_1),$$

$$d_1 = \frac{\log\left(\frac{A_t(1-\alpha/252)^{T-t}}{G}\right) + (r + \sigma_t^2/2)(T-t)}{\sigma_t\sqrt{T-t}}$$

is the formula for the *delta* of a put option (a document detailing the derivation of Δ_t is available on the author's website). Note that delta hedging the net value of the contract entails hedging both the guarantee offered **and** future fee cash flows.

We remark that the hedge ratio Δ_t is computed from the above formula only when the hedging position is revised. Otherwise, when the portfolio is not rebalanced at time t, we simply set $\Delta_t = \Delta_{t-1}$.

DATA AND VOLATILITY CALIBRATION

The variable of interest in our hedging experiment is the insurer's hedged loss at maturity denoted by HL_T. The goal of our back-test is to compute the realized values of HL_T assuming that the VA is exposed to 10-year rolling S&P 500 daily return data over the period 1960–2017. More precisely, the first VA contract is assumed to be issued on Dec. 31, 1959, and matures 2520 trading days later on Feb. 13, 1970. The second contract is issued on the following trading day, that is, on Jan. 4, 1960, and matures on Feb. 16, 1970. The process then continues until the final 10-year period which begins on Aug. 29, 2007, and ends on Aug. 31, 2017. In total, we obtain 11,998 10-year return paths. It must be noted that since these paths are based on series of overlapping returns, the hedging losses computed on these paths are not all independent. Nevertheless, the back-testing experiment allows us to assess the effectiveness of delta hedging strategies over time and determine what choice of rebalancing strategy would have been preferable to use in the past.

The computation of the Black-Scholes hedge ratio Δ_t requires a volatility assumption σ_t. Due to the long-term nature of the contract, we allow this parameter to be time-varying. In fact, it would be unrealistic to use a constant volatility assumption over a 10-year period. In our analysis, we assume that σ_t is calibrated at time t to the past annualized realized volatility computed from daily returns over a three-year period (756 trading days). We experimented alternative ways to set this parameter and found that our conclusions are robust to different calibration methods.

RESULTS

Figure 1 (page 5) illustrates the results of our back-testing exercise. We consider daily, weekly, monthly and move-based delta hedging strategies. The daily, weekly and monthly strategies are rebalanced every one, five and 21 trading days, respectively. The move-based strategy is rebalanced only when the value of the hedge ratio Δ_t changes by more than 0.05 in absolute value.

The chart in the upper part of Figure 1 shows the insurer's hedged loss at maturity (HL_T) for 10-year VA contracts maturing every trading day over the period 1970–2017 (the horizontal axis corresponds to the contract's maturity date). Note that whenever $HL_T < 0$, the hedging strategy results in a terminal gain for the insurer. We have not incorporated transaction costs into the variable HL_T because we first want to evaluate the performance of the rebalancing strategies without imposing a penalty for more frequent trading. In other words, the deck is somewhat stacked in favor of the daily strategy. The impact of transaction costs is discussed separately in a subsequent section.

The chart in the lower part of Figure 1 displays the terminal fund value (A_T) for every contract maturity. The shaded areas in the charts indicate maturities where the VA contract terminated in-the-money (i.e. $A_T < G$).

For contracts maturing in the period 1970–1990, the daily rebalanced delta hedge led to the smallest hedging losses among the strategies considered. However, for contracts maturing after 1990, the tide turned and the monthly rebalancing scheme generally resulted in the best performance. The outperformance of this strategy is particularly evident for contracts maturing in the last decade. The move-based strategy never surpassed all of its competitors and performed particularly poorly during 1990–2000. We experimented with alternative threshold levels, but the overall performance of these move-based strategies remained inferior.

EXPLANATION OF RESULTS

The fact that a monthly rebalanced delta hedge displays the best performance over an extended period may at first sight seem surprising. After all, in a Black-Scholes setting a more frequent rebalancing leads to a more effective hedge. However, this well-known result derived from financial theory assumes that the hedger uses the true data-generating model to construct his positions, that is, the hedging strategy is not exposed to model risk.

In the past 50 years, the financial econometrics literature has vastly documented a set of statistical properties which are common to a large number of financial series: these are known as **stylized facts**. They include fat tails of the return's distribution and volatility clustering, among others (see Cont., 2001), and strongly contradict the assumption underlying the Black-Scholes model that financial assets follow geometric Brownian motions (i.e., returns are independent and identically distributed according to a normal distribution). Therefore, a Black-Scholes

Figure 1
Results of the Back-Testing Experiment

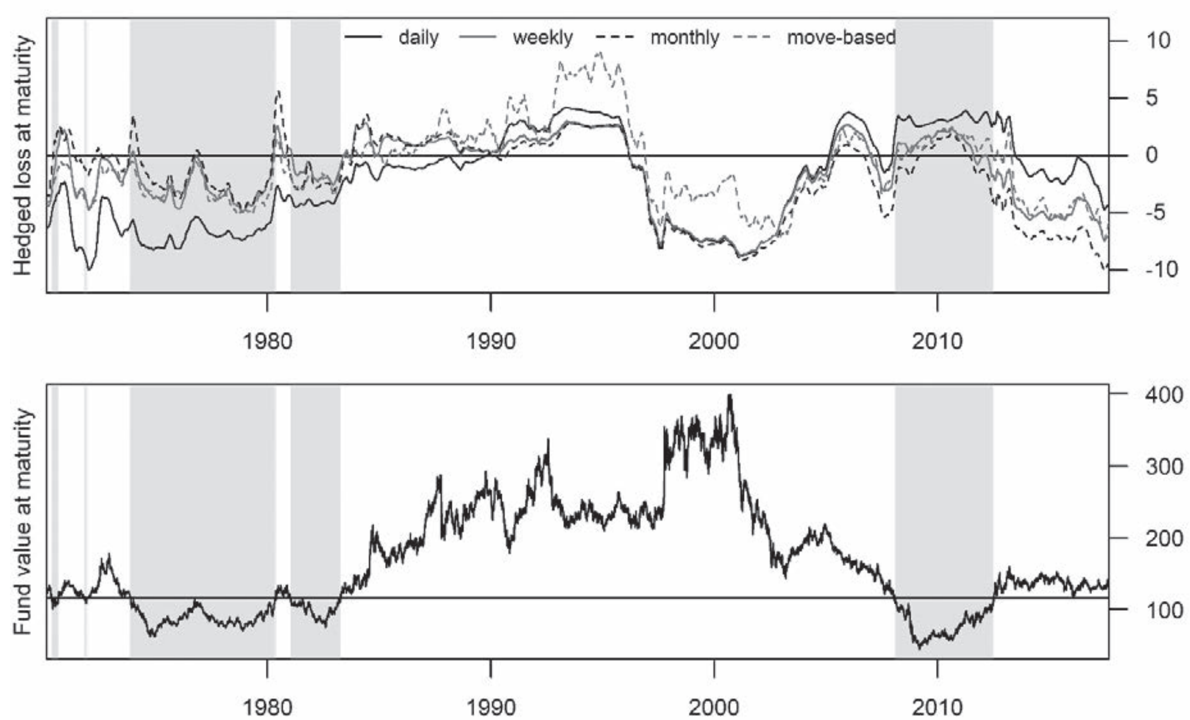
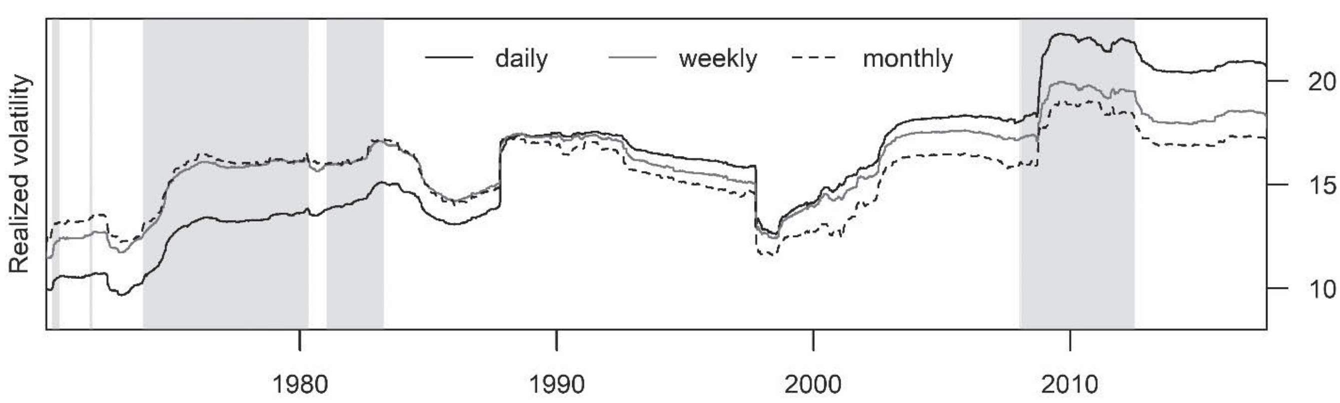


Figure 2
Annualized realized Volatilities



delta hedge in the real world is exposed to a large amount of model risk and there is no guarantee that conclusions derived in the idealized Black-Scholes setting will continue to hold in reality.

Aggregational Gaussianity (see Cont., 2001) is a stylized fact of financial data that stipulates that as one increases the time scale over which returns are calculated, their distribution looks more and more like a normal distribution. In particular, monthly returns tend to conform better to the Gaussian hypothesis than daily returns. One way to illustrate this statistically is to compare the kurtosis of daily and monthly returns (see also Table 1 of Boudreault, 2013). The kurtosis is a statistical measure of whether the data are heavy-tailed or light-tailed; data sets with high kurtosis tend to have heavy tails (data conforming to a Gaussian assumption have a kurtosis of three). Over the period 1995–2005, the kurtosis of S&P 500 daily returns is 6.1 versus 3.4 for monthly returns, whereas over the period 2007–2017, these numbers are 13.5 and 5.7, respectively. Consequently, a monthly Black-Scholes delta hedge is generally exposed to less model risk than a daily hedge.

A further reason that is perhaps more vital in explaining the better performance of the monthly hedge for contracts maturing after 1990 relates to the fact that S&P 500 daily returns exhibited from that time downward trending negative autocorrelations at short lags. For instance, during the 10-year period 2007–2017, the autocorrelations of S&P 500 daily returns at lags 1 and 2 were -10 percent and -6 percent, respectively. Such negative autocorrelations, although small, contribute to reducing the noise and volatility of aggregated returns.

Figure 2 illustrates the annualized realized volatilities of daily, weekly and monthly returns computed over rolling periods of 10 years (the horizontal axis indicates the date when the 10-year period ends). Note that daily volatilities are based on 2520 daily returns, whereas monthly volatilities are based on 120 returns constructed by aggregating daily returns over periods of 21 trading days. A monthly return therefore does not necessarily refer to the return in a calendar month.

We observe that for 10-year periods ending after 1990, the annualized volatility of monthly returns is below that of daily and weekly returns. This is a direct consequence of negative autocorrelations observed in daily returns. In fact, it can be shown (see Campbell et al., 1997, chapter 2) that the ratio of the annualized variance of h-period aggregated returns to one-period returns is theoretically equal to:

$$\frac{\text{annualized variance of } h\text{-period aggregated returns}}{\text{annualized variance of one-period returns}} = 1 + 2\sum_{k=1}^{h-1}(1 - k/h)\rho(k),$$

where $\rho(k)$ corresponds to the return autocorrelation at lag k. This result explains the pattern observed in Figure 2. For instance, returns prior to 1990 generally displayed positive autocorrelations at short lags (e.g., over the period 1970–1980, the return autocorrelation at lag 1 was 25 percent), which resulted in larger volatilities at a monthly frequency. Since the discrepancies between daily and monthly volatilities have been growing in recent 10-year periods, this indicates that autocorrelations have overall been trending downwards in recent years.

These observations offer an explanation as to why the monthly rebalanced Black-Scholes delta hedge performed better in our hedging experiment for contracts maturing after 1990: this

> On average, the turnover for the daily rebalancing strategy was four times greater than the one for the monthly strategy. …

strategy was exposed to returns exhibiting less noise and volatility. Moreover, the distribution of these returns was closer to the normal due to aggregational Gaussianity which implies a smaller degree of model risk in the hedging strategy. This also explains the underperformance of move-based strategies as they require more frequent rebalancing in periods of higher volatility/kurtosis (i.e., when returns further deviate from normality).

IMPACT OF TRANSACTION COSTS

The accumulated value of transaction costs to maturity can be taken as approximately proportional to the total turnover in the hedging position defined as:

$$\text{total turnover in the hedging position} = \sum_{t=1}^{T-1} S_t|\Delta_t - \Delta_{t-1}|e^{r(T-t)}.$$

On average, the turnover for the daily rebalancing strategy was four times greater than the one for the monthly strategy, which implies that transactions costs would be expected to be four times greater as well. Assuming that these costs are 0.25 percent times the turnover in the hedging position, the margin by which the daily strategy performed better than the monthly one for contracts maturing before 1990 is almost completely erased by trading frictions. Therefore, after accounting for transactions costs, there are essentially no 10-year periods in our hedging experiment where a daily rebalancing strategy performed significantly better than the others.

Finally, we note that the ratio of the turnover between the move-based and monthly strategies fluctuated between 0.5 and 1.5, which entails that the move-based method sometimes required less frequent trading than the monthly rebalancing scheme. However, whenever it involved less transaction costs, its performance still remained inferior to the monthly strategy.

CONCLUSION

Based on S&P 500 return data over the period 1960–2017, we have provided empirical evidence suggesting that hedging effectiveness may be improved by rebalancing the hedging portfolio less frequently than on a daily time scale. This conclusion emerges from three observations: (1) returns on larger time scales such as monthly are closer to being normally distributed than daily returns; this stylized fact known as aggregational Gaussianity implies that a Black-Scholes hedging strategy is exposed to less model risk at larger time scales, (2) negative autocorrelations in daily returns at short lags were observed in our data set; they imply some level of short-term mean reversion which contributes to reducing noise and volatility in aggregated returns, and (3) a more frequent rebalancing of the hedging portfolio entails larger transaction costs. ■

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Chairperson's Corner

By Kelly Featherstone

"When I grow up I want to be an actuary, an artist and a queen. …" I have a young daughter at home and I love the enthusiasm and the infinite possibilities that she sees in the world around her. Yet while I hear her dreaming about the future I can't help but wonder if anyone can imagine what the world will be like when she grows up and what being an actuary will mean when she enters adulthood. The pace of technological change is accelerating at a dramatic rate—machines are replacing many manual jobs and are even learning to do analysis faster and better than humans can program them. However, periods of dramatic technological change have happened in the past and the types of human employment have changed rather than be eliminated altogether. In the face of Big Data, predictive analytics and machine learning, actuaries need to continually evolve and reaffirm our position as leaders in measuring and managing risk to improve financial outcomes. Thus, positioning ourselves as professionals who provide solutions to complex problems.

I find the fields of predictive analytics and machine learning immensely fascinating, but also more than a little intimidating as someone who went through the educational process quite a few years ago. Several large asset management firms are beginning to launch ETFs curated by computers, an incremental shift for those companies who already heavily utilize quantitative investment programs. But I am not afraid of being replaced by robots, at least not yet, because investing is every bit as much an art as it is a science and the world of investments continues to increase in complexity.

At the time of writing, we are in the second longest bull market in history. However, many central banks are beginning to raise interest rates and central bank balance sheets are expected to gradually shrink. This bull market may age gracefully and extend to become the longest bull market on record, or perhaps the tides may turn soon. Amidst rapid technological change and across market environments, the Investment Section is responsible for providing relevant, timely investment content for the actuarial profession and we are excited about what we have planned in 2018 to help members navigate whatever markets have in store.

In 2016, you may have heard about the Section Council's Double for Five strategic initiative to double the value of section membership each year for a period of at least five years. Since then we have increased the number of webcasts that we have sponsored to six per year and brought in an exciting keynote speaker for our 2017 Investment Symposium. In 2018, we will continue to find ways to bring value to our Section members and the general actuarial profession to help actuaries remain relevant in an evolving investment environment. I can't think of an actuarial job that doesn't interact in some way with financial markets either directly or indirectly and the Investment Section is increasing our focus on providing professional development investment content to actuaries not practicing directly in the investment space.

As chair of the Investment Section, I encourage you to be a part of the conversation—volunteer, attend a webcast or perhaps attend the 2018 Investment Symposium being held March 8, 2018, in New York City. We would love to hear from you, please contact myself or David Schraub (*dschraub@soa.org*) if you have any questions or comments. ■

Kelly Featherstone, FSA, CFA, ACIA, is director, Client Relations for Alberta Investment Management Corporation and chair of the Investment Section Council. She can be contacted at *kelly.featherstone@aimco.alberta.ca.*

Can Large Pension Funds Use Derivatives to Effectively Manage Risk and Enhance Investment Performance—Case Study: Key Rate Duration Adjustment

By David Gibbs

This paper was originally presented in January 2017 shortly after the U.S. General Elections. We decided to keep the data as-is from that time (vs. refreshing it) for a few reasons: (1) the lessons to be taken from that time are just as relevant today, (2) the rates market has not seen much material change since that time and (3) the examples can provide a better illustration, from that time period than later in the same year. The election results, especially for President, resulted in a short-term spike in volatility as well as a significant move higher in U.S. interest rates. The move in rates was great enough (approximately 50.0 bps in 10-year equivalents) to get the attention of risk managers and risk traders.

Since the initial move higher in rates (to roughly 2.63 percent in UST 10-year in mid-December 2016) yields have traded lower reaching an intra year low of approximately 2.04 percent in early September 2017. Currently, 10-year yields are around 2.40 percent close to the mid-range for the year.

Additionally, from November 2016 to November 2017 the average duration and rough composition of the Citi World Government Bond Index (WGBI) is basically unchanged.

Likewise, the CTD considerations, basis point values, and resulting hedge ratios of the CME Group U.S. Treasury futures contracts from November 2016 to present (adjusting for contract month) are very similar.

Due to all these factors, the concepts and results presented in the paper are as valid today as when originally written. Given the magnitude of the initial reaction to the election, the trading activity during that time frame provided an excellent laboratory to test the key rate duration adjustment with real market data.

When traders and risk managers evaluate a security or portfolio's sensitivity to changes in interest rates, they usually refer to two measurements: 1) basis point value, sometimes expressed as BPV, VBP and DV01, which measures the financial change to a 0.01 percent change in yield; or 2) modified duration, sometimes referred to as duration, which expresses the financial change expressed in percentage change to a 1 percent change in yield. For example, a security could have a basis point value of $646 per million and a modified duration of 6.501 years. If the yield to maturity of this security rose from 2.36 percent to 2.37 percent it is said to have gone up by 1 basis point (0.01 percent) and the financial change to the holder would be a loss of $646 per million. If that same security's yield rose to 3.36 percent, or 1.00 percent (100 basis points) the security's financial change would be a loss of approximately 6.501 percent in value.

Most portfolio managers (PM) tend to evaluate their exposure to interest rate risk using duration. Additionally, they are frequently evaluated by how well or poorly their management of the fixed income portfolio performs versus a recognized benchmark or index. PMs routinely monitor and adjust their portfolio's target duration either to maintain an alignment to a benchmark or for tactical trading reasons.

One consequence of the long bull market in interest rates is the steady extension of portfolio and benchmark bond index duration. Even if positions are left unchanged the gradual and steady rise in bond prices resulting from historically low global interest rates causes the duration of portfolios and benchmark indices to "creep" out to higher levels. (see Figure 1, page 10)

Figure 1
Barclays Aggregate: Yield and Duration

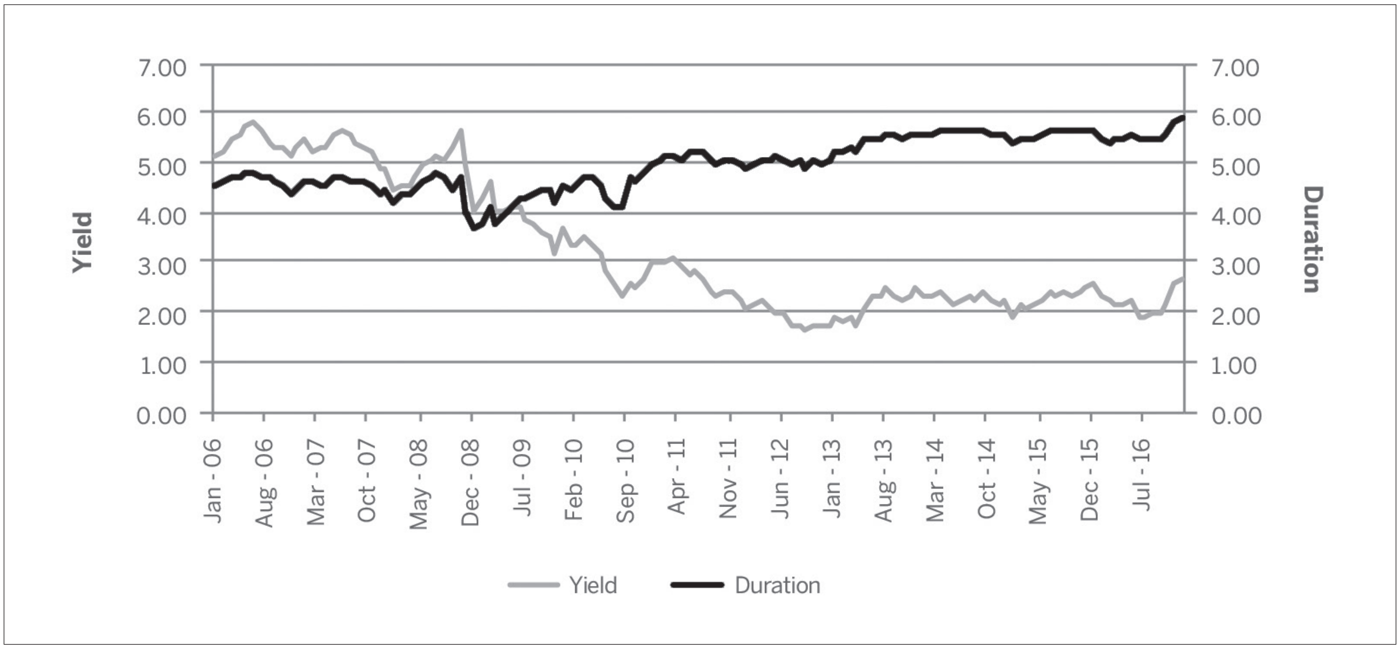


Figure 1 shows the gradual decline in average yield and increasing level of duration of the Barclays Aggregate Bond Index, one of the most referenced benchmarks for fixed income portfolio managers. Beginning in 2009 with interest rates moving sharply lower (blue line) notice the diverging increase in duration (red line). One consequence of higher duration portfolios in an historically low interest rate environment is the "break-even" rate, or the interest rate at which the portfolio produces zero return, moves lower and closer to current interest rate levels. For example, one global bond benchmark is the Citi World Government Bond Index (WGBI). According to the November 2016 report Citi marks the North American (largely USD) average yield-to-maturity of the index at 1.79 percent and its duration at 6.10 years. The break-even rate (B/E) is defined as YTM (in basis points) divided by the duration (in years). In this example it would look like this: B/E = 179 / 6.10 = 29.3 bps.

In other words if interest rates were to rise by 29.3 bps over the next 12 months, the portfolio's return for the year would be zero. Any interest rate move higher than 29.3 bps would result in a negative annual return on the portfolio.

PMs have many ways to modify their portfolios to adjust the target duration. They can buy and sell securities and move weightings up or down the maturity curve. This takes time and can be expensive given transaction and market impact costs. An alternative is to use US Treasury futures and options traded and cleared at CME Group to effectively adjust key rate duration (KRD) targets across the entire portfolio.

CASE STUDY #1: KEY RATE DURATION ADJUSTMENT USING FUTURES

Assume you are a portfolio manager (PM) with $10 Billion exposure to U.S. interest rates. The portfolio is diversified across the yield curve according to the maturity allocations of the WGBI.

If provided with the current portfolio and the new benchmark weightings, can the PM use CME Group U.S. Treasury futures to adjust the portfolio closer to the benchmark, or some other tactical duration target?

Table 1 (page 11) shows the current portfolio. Table 2 (page 11) shows the targeted duration of the benchmark and the change needed to the portfolio.

In order to determine the proper hedge ratio per futures contract we need more information about the values attributed to CME Group's U.S. Treasury futures. (see Table 3, page 11)

Now that we have more information about the futures contracts we can begin to calculate our key rate duration (KRD) adjustment bringing our current portfolio into closer alignment to the desired benchmark.

Table 1
Theoretical Portfolio

Tranche	Yield	Modified Duration (years)	DV01 (per $1mm face value)	Position (in $1mm face value)	Aggregate DV01
1-3 years	0.591%	2.16	$218.80	2,375	$519,650
3-5 years	0.905%	4.51	$457.10	1,950	$891,345
5-7 years	1.188%	6.37	$652.60	1,325	$864,695
7-10 years	1.374%	8.45	$916.30	1,375	$1,259,912
10+ years	2.042%	18.24	$2,222.00	2,975	$6,610,450
		8.82		$10 billion	$10,146,052

Theoretical data

Table 2
Benchmark or Target Portfolio Durations

Tranche	Benchmark Duration	Duration Adjustment
1-3 years	1.92	-0.111
3-5 years	3.85	-0.146
5-7 years	5.66	-0.111
7-10 years	7.91	-0.064
10+ years	16.24	-0.110
	7.81	

Source: Citigroup Index LLC. Data as of 11/30/2016

Table 3
Futures Contract BPVs Based on CTD Issue Analysis

CME Group CTD Analysis			
U.S. Treasury Contract	CTD Issue (Dec-2016 contracts)	Modified Duration (CTD)	DV01 (per contract $100K)
2-Year	1-3/8% 9/30/2018	1.80	$39.15*
5-Year	1-1/8% 2/28/2021	4.11	$48.64
10-Year	2-1/2% 8/15/2023	6.10	$76.75
Ultra 10-Year	1-5/8% 5/15/2026	8.66	$116.18
Long Bond	5% 5/15/2037	13.89	$209.89
Ultra Bond	3-1/8% 2/15/2042	17.22	$277.38

* adjusted for 2-Year Note $200,000 notional amount
Source Bloomberg, and CME Group

Typically a futures hedge ratio (HR) is defined as the value at-risk divided by the value of the futures contract. In this example the value at-risk is the individual tranche Aggregate DV01 (basis point value or dollar value of a 0.01 percent) shown in the last column of Table 1. The values for each futures contract are shown in the last column of Table 3. If we were constructing a simple HR with futures the equation might look like this:

HedgeRatio (HR) = BPVrisk ÷ BPVcontract.

But in this exercise, we take an additional step of adjusting the duration target for each tranche of the portfolio to bring it into alignment with the benchmark. This requires adding a duration adjustment factor to our simple hedge ratio equation. The duration adjustment factor can be expressed as:

Duration adjustment (DA) = (Dtarget – Dcurrent) ÷ Dcurrent.

We will include the DA factor in the adjusted hedge ratio calculation for each tranche. (see Table 4, page 12)

Table 4
Portfolio Duration Adjustments by Tranche

Tranche	Dcurrent	Dtarget	Dadjustment	Aggregate DV01
1-3 years	2.16	1.91	-0.111	$519,650
3-5 years	4.51	3.85	-0.146	$891,345
5-7 years	6.37	5.66	-0.111	$864,695
7-10 years	8.45	7.91	-0.064	$1,259,912
10+ years	18.24	16.24	-0.110	$6,610,450
	8.82	7.81		$10,146,052

Table 5
Futures Contract Hedge Ratios by Tranche

Tranche	BPV risk	BPV contract	DA factor	HR = (Risk ÷ contract) x DA	Contract (Globex code)
1-3 years	$519,650	$39.15	-0.111	**-1,473**	ZT
3-5 years	$891,345	$48.64	-0.146	**-2,576**	ZF
5-7 years	$864,695	$76.75	-0.111	**-1,251**	ZN
7-10 years	$1,259,912	$116.18	-0.064	**-694**	TN
10+ years	$6,610,450	$277.38	-0.110	**-2,621**	ZB

Now, with all inputs available, we calculate our adjusted hedge ratio per tranche (see Table 5) as:

HR = (BPVrisk ÷ BPVcontract) x DA

Simply apply this calculation for each tranche and round to a whole number. Notice the results in the fifth column of Table 5. Each result is a negative number. This shows us the duration is being adjusted lower from the current level to the new lower target level. In this case the negative number also denotes selling of futures contracts. For example, to adjust the one to three year tranche the PM would sell 1,473 U.S. Treasury Two-Year Note (ZTZ6) contracts. By placing all of these hedge positions versus the physical positions in the portfolio, the PM effectively reduces the portfolio's duration to the benchmark or new target levels. Also, the same approach can be used to express tactical views on interest rates. In this example we reduced the portfolio's duration by selling U.S. Treasury futures. We could just as easily added duration by buying futures contracts if that fits with a tactical trading decision.

Referring to Figure 2 (page 13) one can see a key benefit of using CME Group U.S Treasury futures as a duration adjustment tool is the deep pool of actionable liquidity available to traders, even during non-U.S. trading hours. The duration adjustment hedge ratios above are of a scale easily executed on CME Globex even during Asian and European trading hours. Additional benefits of this type of overlay strategy include ease of execution and lower transaction costs of futures over physical bonds.

CASE STUDY #1 (CONTINUED): MARKET SIMULATION

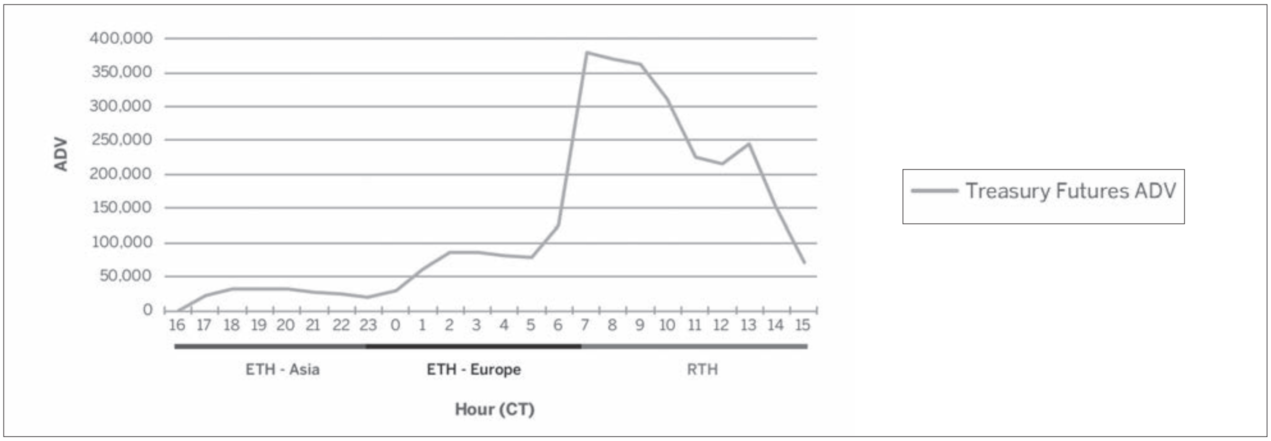
What happens to our model portfolio under a rising interest rate environment?

Tables 1 and 5 show the unhedged portfolio and suggested hedge ratios per tranche to adjust the duration lower, in line with targeted duration of the benchmark.

The price/yield movements from Oct. 14 to Nov. 23, 2016, provide a good laboratory to test our duration adjustment strategy. This time frame overlaps the U.S. general election held on Nov. 8, 2016. The U.S. election, especially for president, was highly contested and the outcome was unclear up to election day despite most media prognosticators pointing decidedly in one direction. When it became clear the outcome was different than expected the markets reacted swiftly with big swings in prices and volatility. U.S. Treasury futures sold off as market expectations for higher yield drove Asian-trading zone (U.S. nighttime) volumes to new record highs. The selloff in Treasuries continued over the next couple of weeks.

Let's consider the results. To measure the impact let's use the on-the-run (OTR) 2-, 5-, 7-, 10-, and 30-year U.S. Treasuries as surrogates

Figure 2
Q416 Treasury Futures Hourly ADV



Source: CME Group

Table 6
Unhedged Portfolio Performance

Tranche	OTR Treasury	14-Oct Price/yield	23-Nov Price / yield	Change P&L
1-3 years	0.75% 9/30/18	99-26+ / 0.837%	99-11 / 1.108%	**-($11,503,906)**
3-5 years	1.125% 9/30/21	99-07 / 1.287%	96-21 / 1.851%	**-($49,968,750)**
5-7 years	1.375% 9/30/23	98-19 / 1.591%	95-01 / 2.158%	**-($47,203,125)**
7-10 years	1.50% 8/15/26	97-10 / 1.799%	92-16 / 2.369%	**-($66,171,875)**
10+ years	2.25% 8/15/46	93-19 / 2.559%	84-18 / 3.042%	**-($268,679,688)**
		Unadjusted portfolio	Total =	**($443,527,344)**

Table 7
Futures Hedge Overlay Performance

Tranche	Contract (Globex code)	HR = (Risk ÷ contract) x DA	14-Oct Price	23-Nov Price	Change P&L
1-3 years	ZT	-1,473	109-01	108-19+	**$5,753,906**
3-5 years	ZF	-2,576	120-26+	118-11	**$6,399,750**
5-7 years	ZN	-1,251	129-27+	125-11+	**$5,629,500**
7-10 years	TN	-694	141-29+	135-01+	**$4,771,250**
10+ years	ZB	-2,621	176-19	161-29	**$38,495,937**
				Total =	**$61,050,343**

for our respective portfolio tranches. Then compare the results of our model portfolio with and without the futures key rate duration adjustment. (see Table 6)

If we look at just the 10-year OTR (seven to 10 years tranche) price/yield move we see yields rose from 1.799 percent to 2.369 percent or a 57.0 bps rise over this short period. The portfolio's total loss is consistent with expectations given an average duration of 8.82 years and an average rate increase of roughly 50.0 bps. What about the futures duration adjustment hedge? (see Table 7)

($443,527,344) + $61,050,343 = ($382,447,001) net loss.

This is reasonable considering the $382.5 million dollar net loss represents roughly a 7.64 year duration (versus a

Table 8
Initial Futures Contract Margin Requirement

Contract (Globex code)	HR = (Risk ÷ contract) x DA	Initial margin Per contract*	Initial capital requirement
ZT	-1,473	$660	$972,180
ZF	-2,576	$935	$2,408,560
ZN	-1,251	$1,595	$1,995,345
TN	-694	$2,420	$1,679,480
ZB	-2,621	$6,160	$16,145,360
		Total =	$23,200,925

*Margins set by and subject to change without notice by CME Clearing.

target of 7.81 years) resulting from an approximately 50.0 bps rise in rates. The futures hedge effectively reduced the portfolio's duration by one year, reducing portfolio losses by $61 million.

How much capital was required to open and maintain the futures adjustment hedge? Exchange operators like CME Group require performance bond or "margins" to secure and maintain open futures positions. (see Table 8)

The total capital needed to open the futures duration adjustment hedge was a little more than $23 million. If rates fell and the hedge positions remained in place additional funds might be required to keep the futures positions in place. The additional funds are the result of variation margin, required as the market moves against the open positions.

As demonstrated, U.S. Treasury futures can be used to effectively adjust a large bond portfolio's duration to align with a benchmark or for tactical trading reasons. CME Group U.S. Treasury futures trade actively 23-hours per trading day giving risk managers access to liquidity even during non-U.S. trading hours. Because market-shaping events can occur at any time of the global 24-hour day, it is important to have access to liquidity around the clock.

Is this the only way to hedge or modify an existing position subject to interest rate risk? No. Let's now consider options on U.S. Treasury futures and two simple strategies to help manage rising interest rate risk.

CASE STUDY #2: HEDGING INTEREST RATE RISK WITH OPTIONS, LONG SINGLE PUT

Let's go back to the same market conditions in Case #1, but instead of utilizing only futures to adjust KRD for the portfolio we will use some options on U.S. Treasury futures available through CME Group.

Options are attractive to both risk managers and traders because unlike futures which respond to changes in price in a linear fashion, options exhibit an asymmetrical risk/reward profile. That is, if one is buying options one's risk is limited to the premium paid but the potential rewards are theoretically endless. Due to the dynamic aspects of how long option positions respond to favorable price movements in the underlying, their value increases at an increasing rate much like convexity in bonds. Price volatility contributes to an option's premium so when market volatility rises it has a favorable impact on a long options position.

For illustrative purposes we will take one tranche of our portfolio and consider the effects of substituting an options position in place of futures. Looking at five to seven year tranche, we previously adjusted the target duration using 10-year futures (Globex symbol ZN). We calculated a hedge ratio of selling 1,251 contracts to adjust the portfolio's KRD lower to help manage the risk of rising interest rates. Now, assume the PM is interested in buying rising rate protection using out-the-money (O-T-M) puts on U.S. Treasury 10-year notes. Our PM targets a rate rise of 50.0 bps from current (Oct. 14) levels as a risk target.

The first step is to identify a futures price level that roughly corresponds with a 50.0 bps move in rates. Understanding how

Options are attractive to both risk managers and traders because unlike futures which respond to changes in price in a linear fashion, options exhibit an asymmetrical risk/reward profile.

Table 9
Single Put Option Analysis

Option	Price	Delta	Gamma	Theta	Vega	Volatility
Z126 Put	3	-0.05	0.0420	-0.0023	0.0436	5.36%

Data: Quikstrike and CME Group

Table 10
Single Put Option Hedge Analysis

Option/Date	Price	Delta	Gamma	Theta	Vega	Volatility
Z126P-10/14	3	-0.05	0.0420	-0.0023	0.0436	5.36%
Z126P-11/23	44	-0.85	0.3787	-0.0371	0.0208	6.75%
Change	41					

Data: Quikstrike and CME Group

CME Group U.S. Treasury futures price is essential to this step. Normally we would consult a pricing model or spreadsheet and input the appropriate changes to solve for the revised price level. There are software and market data providers, like Bloomberg for example, that have analytical tools to provide this function. Using a CME Group model we calculate a December 10-year note futures price of 125-25. The nearest O-T-M strike, also for December expiry (on Nov. 25, 2016) is the 126-00 put.

Looking into the December 10-year note 126 put on Oct. 14, we find the information illustrated in Table 9.

Taking the DEC 126 put delta and our previously identified hedge ratio of futures contracts we can calculate the number of puts to buy.

Put amount = HR-in futures contracts/delta = 1,251/0.05 = 25,020 or buy 25,020 December 126 10-year note puts at .03, or 3-1/64ths.

Each 1/64th is equal to $15.625, therefore the total cost and capital outlay is 25,020 x 3 x 15.625 = $1,172,813. Buying, or going long, an option (put or call) requires full payment at time of execution. It also defines the total risk of the position. For a long option holder the risk is limited to the total premium paid.

CASE STUDY #2 (CONTINUED): MARKET SIMULATION

From Oct. 14 to Nov. 23, 2016, the price of the December 10-year note futures (Globex code ZNZ6) fell from 129-27+ to 125-11+. How did the DEC 126 put perform? Table 10 illustrates the answer to that question.

The price of the ZNZ6 futures fell far enough to place the DEC 126 Puts from O-T-M to in-the-money (I-T-M) and as a result greatly increased their value. As you can see from the Table 10, not only did the premium of the option increase, so did its delta, gamma, theta, and volatility. The only measurement that decreased was the vega. Without going deeply into options pricing theory, what needs highlighting here is the fact that a long options position conveys convexity. In other words, because this was a long put option position and futures prices moved lower, the magnitude of change in the delta increased with each downtick in price, which contributed to the premium moving higher. Futures contracts exhibit a delta of 1.0, which means their prices change in a linear fashion. One of the benefits of a long option position is positive gamma, or convexity. The put position increased in value more than the short futures position.

To determine the profit & loss (P&L) of the option overlay, take the amount (25,020) and multiply the value of each option ($15.625) multiplied by the net change (41-1/64s)

P&L = 25,020 x 15.625 x 41 = $16,028,438

Let's compare the single put overlay to the futures overlay.

Table 11
Single Put Option Versus Futures

	Single Put	Futures
Result	$16,028,438	$5,629,500
Capital outlay	$1,172,813	$1,995,345

While the results heavily favor the single option strategy, it should be noted that had the price of ZNZ6 futures fallen to only 126-01, the put option would have been O-T-M and unless offset or rolled forward, could have expired worthless. Both futures and options on futures have pluses and minuses regarding their usefulness as hedging tools. Let's consider another simple options strategy that could be used in this capacity.

Table 12
Put Option Spread Analysis

Option	Price	Delta	Gamma	Theta	Vega	Volatility
Z127P-10/14	6	-0.09	0.0752	-0.0043	0.0723	5.00%
Z125P-11/23	2	-0.03	0.0258	-0.0022	0.0301	6.03%
Net	**4**	**-0.06**	**0.0494**	**-0.0021**	**0.0422**	

Table 13
Put Option Spread Hedge Analysis

Option	14-Oct	23-Nov	Change
Z127 Put	6	105	99
Z125 Put	2	6	4
Net	**4**	**99**	

Table 14
Options Versus Futures

	Put Spread	Single Put	Futures
Result	$32,252,344	$16,028,438	$5,629,500
Capital outlay*	$1,303,125	$1,172,813	$1,995,345

CASE STUDY #3: HEDGING INTEREST RATE RISK WITH OPTIONS, PUT SPREAD

Another strategy that may provide effective rising rate risk coverage is a long put spread. A spread is a simultaneous purchase and sale of two options with different strikes, different months or different types. The combination of possible spreads is almost endless. We will limit this example to a simple long put spread. Using the same risk target as the previous example (125-25), we want to "bracket" the target by buying a higher strike put and selling a lower strike put in equivalent amounts. Since 125-25 is between 125-00 and 127-00, we will buy the DEC 127 puts and sell the DEC 125 puts. How do we determine how many to buy/sell? (see Table 12)

Since this is a spread position we are concerned with net effects of our initial position. The spread is a net debit, which means we have to pay to buy it. It also means our losses are limited to our net premium paid. The delta is net negative which implies the spread should increase in value if the underlying futures price goes down. It has positive net gamma suggesting it exhibits convexity and that the delta will increase as the underlying's price moves lower. It has a small degree of time decay and a slight degree of positive sensitivity to higher volatility. How many spreads to buy? Same ratio calculation as the single option:

> A spread is a simultaneous purchase and sale of two options with different strikes, different months or different types.

Put spread amount = hr-in futures contracts/net delta = 1,251/0.06 = 20,850, therefore buy 20,850 DEC 127 puts and sell 20,850 DEC 125 puts. Using the same market dates and price data as before, how did the put spread perform? (see Table 13)

CASE STUDY #3 (CONTINUED): MARKET SIMULATION

As you can see from table 13, the nearer O-T-M 127 puts out performed the far O-T-M 125 puts. The futures price level of 125-11+ on Nov. 23 was in between the two strikes creating good profit potential. Let's review the numbers.

P&L = 20,850 x 15.625 x 99 = $32,252,344

Why did the put spread outperform the single put? The gamma on the 127 put was greater than the gamma of the 126 put. Additionally, the short 125 put position contributed by reducing the initial cost and also lowering the net delta. The fact that the price of the underlying futures contract ended above the 125 strike reduced the drag of the short put side of the spread. (see Table 14)

SUMMARY

There are clear differences among these simple strategies and many more that could be considered. We have limited our review to these few to simply illustrate the effectiveness of a KRD adjustment and compare the dynamic aspects of long options positions to an equivalent straight futures hedge. What is important to remember is there is no "silver bullet," or single risk overlay strategy that works perfectly at all times. Futures and options on futures are very efficient risk management tools. Additionally, liquidity in CME Group U.S. Treasury futures and options is deep and bid/offer spreads very tight, even during non U.S. trading hours. In order to apply the best risk management or hedging strategy it is essential to understand and quantify the underlying price risk. It is equally important to understand the pricing mechanism and trading behavior of the derivative products used to offset that risk. Global interest rates are near record low levels, with correspondingly high levels of duration in institutional portfolios and bond index benchmarks, the break-even levels for fixed income risk managers is very close to current market rates. It will only take a small rise in rates to tip annualized investment returns negative. Transaction and capital charges favor the use of exchange traded derivatives (futures) as a duration adjustment tool. Their effective use can help large institutional asset managers manage risk and enhance returns. ■

David Gibbs is director, Market Development for CME Group. He can be contacted at *David.gibbs@cmegroup.com.*

Staff Corner by David Schraub

Volunteers are the true engine of the Society of Actuaries (SOA). In this new column, however, we will shed some light on SOA staff who work in the shadows to support the section; rest assured this is not comparable to the movie "Hidden Figures."

Of French descent (and accent) with a German last name, I am a staff actuary at the SOA and guide the volunteers' efforts in the investment space. I first studied and worked as an actuary in France for a few years before moving to the U.S. where I worked both as a consultant and in-house on risk management in the life/annuity space. I was exposed to investment, as it is the largest risk for a life insurance company. I did some volunteer work for the SOA, which included a term on a section council, prior to working for the SOA five years ago.

Supporting a section means a wide range of activities from peer reviewing newsletter articles, playing the devil's advocate on research projects, suggesting speakers and providing feedback on draft presentations, or liaising with various internal SOA stakeholders and/or with our section's friends to move a project forward. I am deeply involved in the Investment Symposium, our yearly flagship event. Since I am also supporting other sections, I can leverage ideas seen elsewhere and suggest them to the Investment Section Council.

My view of the intersect between investments and actuarial function is multifaceted. Not all investment experts are actuaries. For this sub-group, the education and research performed by the SOA is complemented by education and research done by other organizations, either not-for-profit associations' or for-profit organizations' thought leadership departments. The SOA research and continuing education arms are working to ensure our offering is relevant, unique and of good quality for this target audience; the Investment Symposium is a clear example of this high-quality, relevant, continuing education product. Another role performed by the section is to support the liability side in performing valuation, pricing and analysis work by providing continuing education content in both pension and insurance. A clear example of this is the series of sessions sponsored by the Investment Section for the SOA Annual Meeting and Exhibit.

But the section activities are not limited to work and we also have fun with a few games; including a crossword puzzle in each issue of this newsletter, the yearly asset allocation contest with a cash prize and invaluable bragging rights for the ones best at managing portfolios with cash flows in and out. There are also essay contests offered on a regular basis.

None of us is as smart as all of us, says the Japanese proverb. Please let me know if you have any suggestions that could help us, any idea you'd like to discuss or any interest in volunteering. I look forward to hearing from you.

David Schraub, FSA, CERA, AQ, MAAA, is a staff actuary for the SOA. He can be contacted at *dschraub@soa.org*.

2017 Redington Prize Awarded at 2017 SOA Annual Meeting & Exhibit

By Jim Kosinski

(From Left) Thorsten Moenig, Jim Kosinski, Nan Zhun

Among the highlights of the Investment Section's Breakfast at the 2017 SOA Annual Meeting & Exhibit was the presentation of the 2017 Redington Prize, awarded by the Investment Section in honor of the best research paper published by an actuary on an investment-related topic in 2015–2016. The Redington Prize carries a $10,000 award and is named after F. M. Redington, the British actuary who coined the term "immunization" in a 1952 paper.

The Redington Prize-winning paper is "Lapse-and-Reentry in Variable Annuities," by Thorsten Moenig and Nan Zhu, FSA. Dr. Moenig is an Assistant Professor of Actuarial Science at Temple University and Dr. Zhu is an Assistant Professor of Risk Management at Penn State University. Their paper addresses the impacts of optimal policyholder lapse behavior on the pricing and design of variable annuities. Using the example of a return-of-premium guaranteed minimum death benefit (GMDB), they quantify the costs—first to insurance companies, but ultimately to policyholders through increased fees—of allowing "free" lapse behavior. The paper goes on to discuss and quantify a number of mitigating factors—from the traditional surrender charge, to roll-up and ratchet designs, additional earnings benefits, and a state-dependent guarantee fee—and discusses their impact on product pricing and ultimately policyholder utility. The paper concludes with a discussion of optimal behavior under taxes, and addresses the question of when the beneficial tax treatment of variable annuities justifies the additional fees they incur.

The Redington prize jury considered 16 nominees from prestigious journals, including; *Insurance: Mathematics & Economics*, *Journal of Risk and Insurance*, *Journal of Mathematical Economics*, *Journal of Portfolio Management*, and *Financial Analysts Journal*. One of the benefits of SOA Investment Section membership is the ability to access these and many other journals through the section's EBSCO subscription. See the following link for more information: *https://www.soa.org/sections/investment/investment-ebsco/*

As chair of the Redington Prize committee, I would like to thank the Redington jurors for their diligent work and the hours they spent this summer reading through the many distinguished papers and choosing a winner. I would also like to thank all the researchers for submitting their papers for consideration, and for their contributions to our knowledge of investments. ■

Jim Kosinski, PhD, CFA, FSA, MAAA, is vice president in the Actuarial department at Guggenheim Insurance in Indianapolis. He can be contacted at *Jim.Kosinski@guggenheiminsurance.com.*

Taking Stock: Are Real Returns Truly Real?

By Nino Boezio

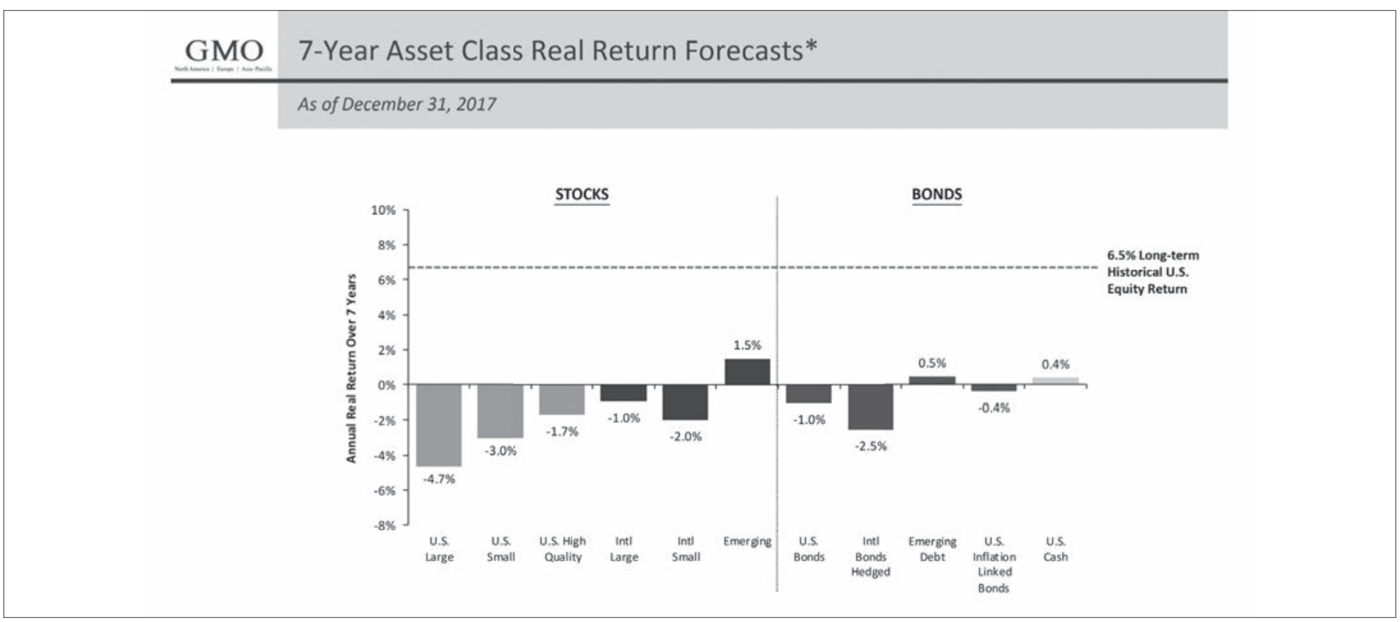
Like many practitioners, I have been grappling with the concept of real rates of return. With the current environment of low interest rates, many fixed income investments, after discounting for inflation, currently provide a negative or very low yield. Retail investors who do settle for that low yield, and hold bonds to maturity, will likely not achieve a rate a return even close to the rate of inflation.

Meanwhile, most other non-bond asset classes have provided attractive returns since the global financial crisis of 2008–2009. Of course, central bank policy (at least in part) can be blamed. The low interest rate "easy money" environment promoted by central banks, has produced "bond refugees" who have fled from short-term cash equivalents and fixed income and have gone elsewhere, hoping to achieve better performance. They seek higher returns in asset classes such as equities, real estate, infrastructure and private equity.

According to Investopedia[1], the definition of real rate of return is "the annual percentage return realized on an investment, which is adjusted for changes in prices due to inflation or other external effects. This method expresses the nominal rate of return in real terms, which keeps the purchasing power of a given level of capital constant over time. Adjusting the nominal return to compensate for factors such as inflation allows you to determine how much of your nominal return is actually real return."

Applying this definition, we have had very good rates of real return for most asset classes over the past several years (in fact, in many cases, rather attractive returns every year since the global financial crisis). Interestingly, we have had good returns even with fixed income, partly arising from the unrealized gains in bond values generated by interest rates drifting lower.

In talking to investment managers, virtually all agree that most, if not all, asset classes are expensive today (some may even claim that certain asset classes appear to be in a bubble). But they may also like to claim that they will deliver returns better than their peers if asset classes do begin to deflate, because they have bought the most attractive securities, have the highest quality research, find the best deals and have the smartest people. They do not want to pare back their portfolios in many cases, since their clients will not want to see that happen, and this behavior of "lightening up" on exposure also smacks of market timing. Also how can they justify charging a certain level of fees if they move to something safer than cash? Granted, I understand the dilemma. Many asset classes



Source: GMO

**The chart represents local, real return forecasts for several asset classes and not for any GMO fund or strategy. These forecasts are forward-looking statements based upon the reasonable beliefs of GMO and are not a guarantee of future performance. Forward-looking statements speak only as of the date they are made, and GMO assumes no duty to and does not undertake to update forward-looking statements. Forward-looking statement are subject to numerous assumptions, risks, and uncertainties, which change over time. Actual results may differ materially from those anticipated in forward-looking statements. U.S. inflation is assumed to mean revert to long-term inflation of 2.2% over 15 years.*

continue to appreciate despite high valuations, and market timing is very difficult. But one thing is for certain, real return expectations are not at levels we used to see.

In the preceding chart, graciously supplied by GMO LLC, we see a negative forecast for real rates of return for a range of U.S. and non-U.S. asset classes, much lower than what the firm views as the long-term historical U.S. equity real return.

The preceding chart is not atypical of what other investment managers may anticipate in terms of average future return over a similar period, even though some sort of decline may not be currently seen as imminent. Another author wrote[2]: "… our long-term valuation models estimate that equities will provide a return of less than 2 percent per annum over the next 10 years, which is less than the expected return of the safe-haven 10-year U.S. Treasury bond. In our view, the historic 4.5 percent risk premium between equities and U.S. Treasuries is now negative because of the $10.5 trillion of financial assets bought by the central banks over the past 8 years."

The general mood in the investment industry, from what I can gauge, seems to be that we may still see additional gains within the next one to two years (despite asset classes being expensive) even though the mathematics suggest that we are already on borrowed time. Such a positive view is being supported by arguing that the fundamentals and the underlying healthy economic environment will preclude the possibility of any major market decline, and history backs up this claim.

RISK PREMIUM

Considering the risk premium adds another twist. Going back to Investopedia[3], "A risk premium is the return in excess of the risk-free rate of return an investment is expected to yield; an asset's risk premium is a form of compensation for investors who tolerate the extra risk, compared to that of a risk-free asset, in a given investment."

In looking at the following table provided in a Canadian Institute of Actuaries presentation in 2016[4], even the risk premium can be called into question.

What happened to the risk premium?

	Length of Period Ending January 1, 2016				
	1 year	5 years	10 years	25 years	50 years
Total Fund Return[1]	5.4%	8.2%	6.2%	8.6%	8.6%
Bond Return[1,2]	4.8%	6.6%	5.9%	9.0%	8.2%
Gap	**0.6%**	**1.6%**	**0.3%**	**-0.4%**	**0.4%**

1. CIA Report on Canadian Economic Statistics
2. Long Canada Bonds

We note from the chart below that the total fund return (keep in mind these are Canadian statistics), but asset classes aside from fixed income, have not truly delivered exceptional added value performance. The risk premium above fixed income is negligible, and the fund performance is highly dependent upon the underlying fixed income performance.

Considering both the chart below and the preceding chart (that showed negative real rate of return expectations for the next seven years), we are now presented with a dilemma that suggests, that if these analyses are correct, we are getting no risk premium compensation for buying risky assets beyond fixed income.

FORECASTS

When presented with negative real return analyses of real return expectations (or a nominal rate of return for that matter), an organization or pension plan sponsor may not be convinced (or worried) and seek to ignore them, and this may be for good reason. A forecast is just a snapshot, often based on a certain set of beliefs after all. These views can differ based on the varied beliefs among forecasters.

But unfortunately there is also pressure to adopt certain beliefs, because of the investment return goals. A pension plan sponsor may opt for a certain discount rate since that is the rate required in order to meet funding needs. An organization may have disbursement requirements that require a certain level of investment return and income. They each need continued exposure to multiple asset classes that can potentially exceed the rate of inflation, even if it entails more risk.

Such goals and beliefs may require new investment ideas and strategies, and necessitate a refreshed view of the world, which may also push one to be more optimistic. All of this inadvertently may then rest on a real rate of return forecast, which is a lot less tangible than investors want to admit (it can land within a wide range where one choice is as good as another). And then unfortunately, the forecast becomes the "target" for investment performance impacting also the asset allocation strategy, and the level of risk exposure becomes secondary and treated as almost immaterial. This whole process can also work in somewhat of a backward fashion, where the target dictates the assumptions and the risk is not taken too seriously.

We like to try and forecast the future, as this can give us some perspective on what investment returns can look like. Forecasts are not factual, but unfortunately the acceptance of a particular forecast and the rejection of another can become a biased decision. Granted, a forecast may be shot down as just an opinion of the future, if it runs contrary to another more accepted and common point of view. Or an organization supporting a pension plan, may argue that the plan has a very long investment horizon (so they are investing for the long-term) and thus can sustain a short-term shock. Such a long-term horizon argument may assume that if equities take a fall, they will eventually catch up and outpace bonds in the long-run anyway, and numerous studies can be cited to support this view. But I still cannot say with confidence that this would always be the case, and it is also going to be time or ending point dependent, but I can see how this argument can become put forward by a wide variety of users.

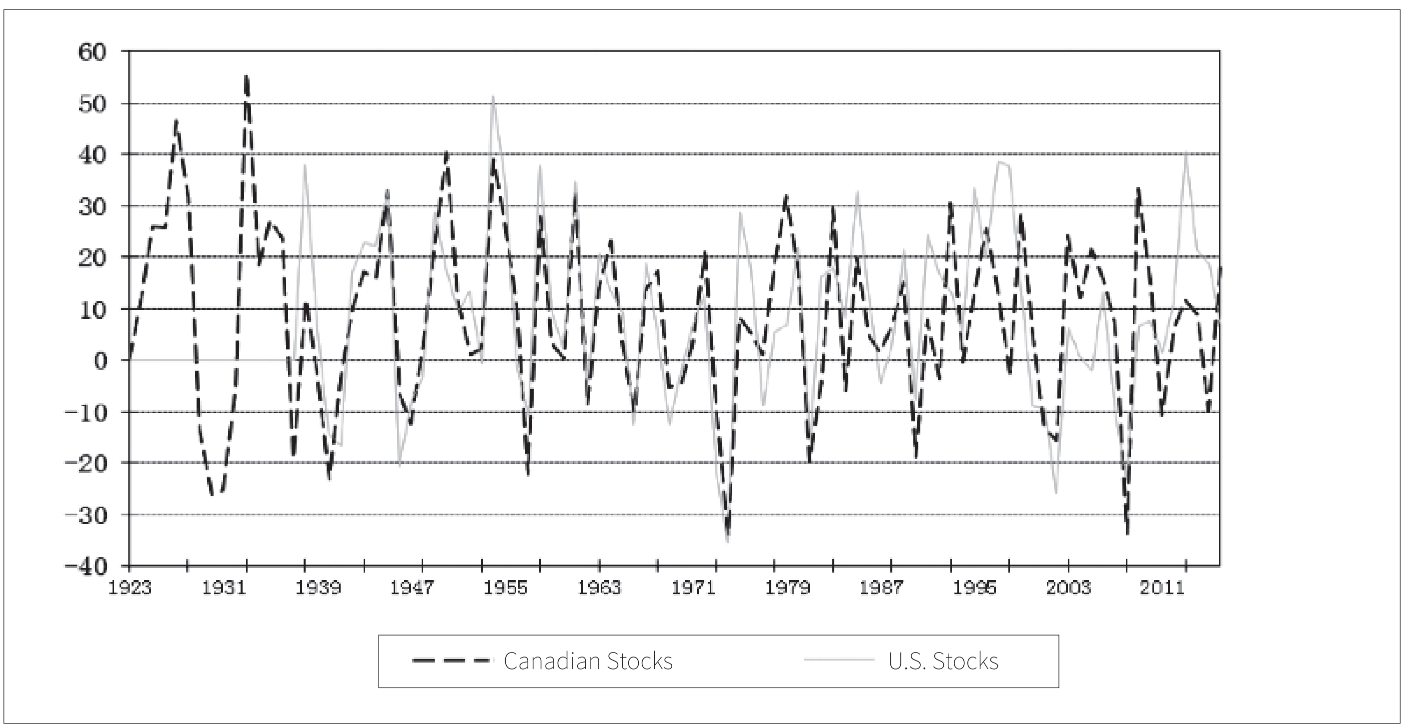
Even if forecasts are not factual, I would still emphasize that nominal returns or real returns are not either. In researching the matter of historical real return expectations and from looking at various studies, I have found quite a bit of dispersion as to where this real rate of return could be, such as for equities. It is also not as simple as subtracting the rate of inflation from a nominal rate (see Figures 1 and 2[5]). We also cannot just take some sort of annual average. It can entail some subjectivity, and we do not necessarily have lots of history on rates of return (at least for my purposes, anyway) even for the longest running asset classes, that would make me feel comfortable.

Fixed income can be considered to provide better information, for at least we know what observed yields are. I have also found it strange how some forecasts may use a long-term real rate of return for fixed income which differs substantially from the observed rate of return, for such a forecast is also assuming a mean reversion is taking place within the expectation. The best expected return for fixed income would arguably be to base it on the current observed yield (less some provision for default)—in fact, the realized returns for bonds will necessarily pull toward this level if held to maturity.

THE INGREDIENTS OF THE REAL RETURN SOUP

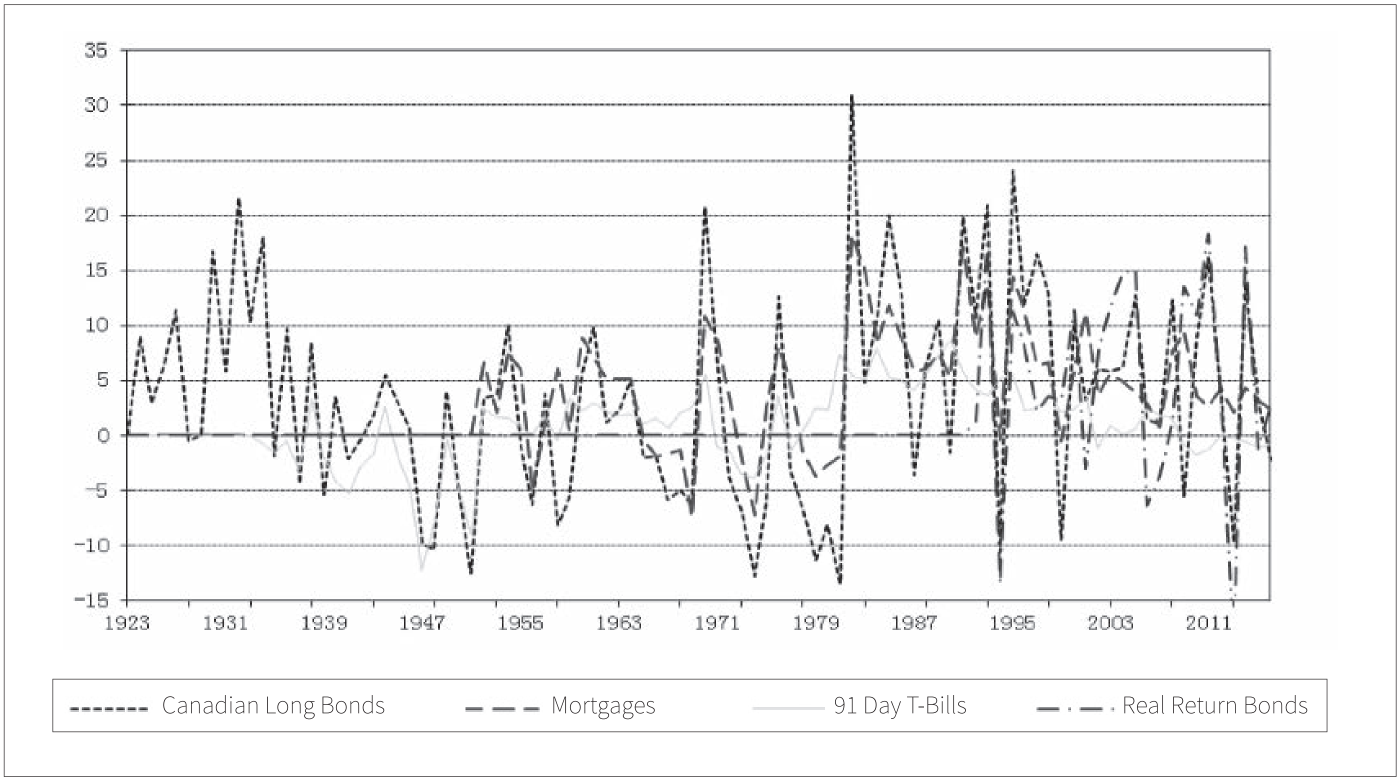
When organizations require a prediction of what their investment portfolio will provide in terms of return (say, in the next three to five years), they may simply create an asset forecast using a reset each year of return expectations, i.e., assume no mean reversion even when recent returns have been exceptionally good or poor. Part of the justification may revolve around recent changes in fundamentals; the low level of interest rates;

Figure 1
Canadian and U.S. Stocks



[5]Source: Statistics Canada CANSIM Series © Copyright 2017. All Rights Reserved.
[5]Source: TSX © Copyright 2017. TSX Inc. All Rights Reserved.
[5]Source: Standard & Poor's, a division of The McGraw-Hill Companies, Inc. © Copyright 2017. All Rights Reserved.

Figure 2
Bonds, Mortgages and T-Bills



'Source: Statistics Canada CANSIM Series © Copyright 2017. All Rights Reserved.

political, taxation or economic changes (GDP); changes in national productivity; investor confidence, etc., so that the real or nominal rates are claimed to not be "lofty" expectations after all. Again, this can be hard to challenge given the wide dispersion of opinion regarding what the real return may be. But on the opposite end, we have negative demographics (which I consider to be a major detractor from the real returns we saw in the past), huge levels of sovereign debt (also a major detractor as it represses fiscal spending), excess capacity in certain industry sectors, increasing regulation (again in certain areas, which is deflationary and economically repressive), rising interest rates, the gradual removal of liquidity, potential geopolitical risk, and so on. The long laundry list above just further emphasizes how forecasting real return is a difficult and complicated task, and history may not also be a useful guide, as the present day is different from the past.

REAL RETURN—MARGIN FOR SAFETY AND PORTFOLIO STRATEGY

Perhaps the best conclusion from the above is that we do need to consider a margin of safety and assess whether the portfolio strategy is truly sound. Given that rates of real return are very debateable, we do need to assess that if assets do not perform as expected, what will be the impact on our portfolio. This may require scenario testing using a range of assumptions, both optimistic and pessimistic. How will an organization be impacted if returns are not as robust as currently assumed? Should a margin of safety be incorporated either in the assumptions, or a toning down of the portfolio strategy be made, just in case?

Too many organizations today (just like on many occasions in the past) are thinking alike. They may feel that many asset classes are expensive, but want to ride things out for further gains, and then somehow expect to be the first to exit a market position before conditions become too "dangerous." The portfolio strategy needs to be continually assessed as to whether it is relying on realistic (not optimistic) assumptions, is it riding on a mood of optimism, and are they getting the full story on the financial environment. We have had good investment returns for far too long, and this has given investors too much "unfounded" confidence. With several central banks now on the road (with more to follow) of raising interest rates and removing liquidity, we may no longer have the tide to lift all boats.

CONCLUDING REMARKS

I believe the use of real return today is a real problem. I have seen it used too often as though it is academically supported to land within a certain (rather tight) range, it will play out over the longer-term to a certain level, and there is no mean reversion (i.e., we will never have to give back the better-than-expected returns of the past).

We need to reflect that there is great uncertainty in estimating what a real return would be under even the best of circumstances. Real return is not as real a measure as we may think it is, or in the way some are communicating it. This uncertainty, therefore, requires us to understand that there should be a margin of safety reflected in our portfolio positioning, or that at least, we need to be prepared for a scenario that is not what is expected but should not be a surprise either. ■

This article is the sole opinion of the author and not of the Society of Actuaries or of the Financial Services Commission of Ontario.

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ENDNOTES

1 The definition of real rate of return is found at http://www.investopedia.com/terms/r/realrateofreturn.asp.

2 Manley Jr., J. Lawrence. "The Financial Asset Bubble Is Ending; Time To Re-Examine Your Risk Allocation." Oct 25, 2017 <https://seekingalpha.com/article/4116560-financial-asset-bubble-ending-time-re-examine-risk-allocation?>

3 The definition of risk premium is found at: https://www.investopedia.com/terms/r/riskpremium.asp The definition of real rate of return is found at http://www.investopedia.com/terms/r/realrateofreturn.asp.

4 Hamilton, Malcolm, Doug Chandler and Faisal Siddiqi, "Low Interest Rates and Retirement Savings," CIA webcast, September 2016, page 25.

5 Report on Canadian Economic Statistics 1924–2016, Canadian Institute of Actuaries, July 2017, Page 5, Figure 1B.

Correspondents' Report

The 2017 SOA Annual Meeting & Exhibit was held at the Hynes Convention Center in Boston. There were more than 180 different sessions, numerous section breakfasts and lunches, boot camps, a mobile scavenger hunt, and plenty of opportunities to network. Every year *Risks & Rewards* seeks to provide our readers with a synopsis of some of the more investment focused sessions for those of you who might not have been able to attend. This year's Correspondent's Report summarizes five sessions.

2017 Annual Meeting & Exhibit Opening General Session

By Kelly Featherstone

"I love data … No, I REALLY love data." Kenneth Cukier, while not an actuary, might well be a kindred spirit to actuaries everywhere in his appreciation of data. The Opening General Session of the 2017 SOA Annual Meeting & Exhibit did not have an investment focus, but throughout the session my mind kept jumping to market and investment implications. In this correspondent's report, I would like to focus on some of the themes of Cukier's presentation and postulate as to possible investment implications.

"It is generally better to have more data than a better algorithm and it is also generally better to use statistic (or actuarial) methods to make decisions than human judgement." The investment world tends to be polarized into camps—passive versus active management and, among active management, quantitative versus fundamental. Neither argument ever seems to win either debate, and the debates rage on. While I agree with Cukier on both his generalizations, I am still a firm believer that there is a place for active management and fundamental research in the investment world—particularly where data history and quality may be limited. But how will investment implementation styles change as data accessibility, quality and machine learning processes improve? (Note: If you are an avid believer in the efficient market hypothesis, please feel free to challenge myself or someone else to a battle of the essays in the Investment Section's 2018 Point-Counterpoint essay contest, "This Time It's Different.")

"In a world where data is becoming increasingly important, in ways and places we never thought possible, incumbent businesses have the data advantage." This is true … to the extent incumbent businesses can leverage their data advantage and evolve to continue to meet future market needs. How can we as investors identify which companies are able to harness their incumbent advantage and differentiate them from companies who fail to embrace change and will be left behind?

"Sometimes causality is important but other times correlation is good enough." The Investment world tends to rely heavily on correlations—the whole premise of mean variance portfolio optimization relies on the "magic" of diversification and stable correlations. This has quite often led to surprises and "black swan events." Where do I/we over-rely on correlations? And when is looking at correlations good enough in the investment and ALM spaces?

Cukier's presentation was engaging, thought provoking and a challenge to actuaries. While actuaries sometimes dismiss correlation in favor of looking for causation, with Big Data—and its emphasis on using correlation—we need to get on board or get left behind. ■

Kelly Featherstone, FSA, CFA, ACIA, is director, Client Relations for Alberta Investment Management Corporation and chair of the Investment Section Council. She can be contacted at *kelly.featherstone@aimco.alberta.ca.*

Annual Meeting Session 25 Panel Discussion: Completing the Hedge

By Jeff Passmore

This panel presentation discussed some of the practical issues associated with hedging pension liabilities. Jeff Passmore of Barrow Hanley moderated the panel and began by quantifying sources of pension liability volatility with particular focus on the importance of credit spread hedging compared to the relative unimportance of hedging key rate durations across the yield curve.

Colyar Pridgen of Standish Mellon discussed some of the subtleties of pension duration and how oversimplifying this topic can undermine a pension hedging approach. He discussed differences between duration measured using the spot vs. par curve and the differing viewpoints of a pension actuary and an investment manager. Colyar also discussed some of the practical issues around credit spread hedging: including the interrelationship between the frequency of rebalancing, the rebalancing target and how certain combinations of these tended to prove superior when spreads mean reverted versus when spreads trended wider.

David Gibbs of CME group discussed using U.S. Treasury Futures in pension hedging. He also discussed advantages of the U.S. Treasuries vis-a-vis the cash markets and other derivatives both for hedging purposes and for repositioning portfolios. These advantages included liquidity, near continuous availability and minimal basis risk.

The panel concluded with a presentation by Kate Tan of PIMCO. Kate discussed using derivatives within both the hedging and return seeking portfolios. She described an approach where a plan sponsor who was not yet ready to fully derisk, could invest all plan assets in a hedging portfolio, but then use a portion of the hedging assets as collateral for a derivatives equity position. She illustrated how this derivative position could be reduced over time, effectively increasing the hedging relationship of assets to liabilities. ■

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Edward Astrachan (center), winner of one of the asset allocation contests, is presented his prize by Jim Kolsinski (left) and Justin Owens.

2017 SOA Annual Meeting—Session 58—Validation of Asset Cash Flows

By Scott Houghton

Moderator: Rebecca Margaret Emily Kovach, FSA
Presenters: Daniel B. Finn, FCAS
Thomas V. Reedy, FSA, FIA, MAAA
Scott D. Houghton, FSA, MAAA

For applications such as PBR, cash flow testing, and economic capital, actuaries often validate and review models that contain projections of both the asset and liability sides of the balance sheet. Actuaries have tried-and-true methods for validating liabilities, but techniques for assets are less developed. In this session, an insurance asset manager (Finn), a consultant (Houghton) and a company investment actuary (Reedy) demonstrated effective and efficient asset model validation techniques.

Finn decomposed a corporate bond model into the components and assumptions needed to replicate cash flow and market value calculations, and provided techniques for duplication and validation of key calculations. He presented a key validation technique of selecting single bonds and projecting yields under a large number of stochastic scenarios. If a model is set up correctly, graphing the yield vs. a scenario-specific representative level of the stochastic interest rate for the term of a Treasury bond should produce a negatively sloped and nearly linear relationship. As the credit risk of a bond increases, the negatively sloped linear relationship decreases, and the plots on the graph move from linear to elliptical shaped.

Reedy covered application of common assumptions for different asset types, and common modeling issues and their prevention. One issue discussed was asset portfolios becoming unrepresentative over time, due to initial scaling or a fixed purchase allocation of short- and long-term bonds. Reedy discussed how implementing a more sophisticated investment strategy like duration matching can correct this issue, and how more sophisticated investment and disinvestment strategies can also prevent distortion of results related to borrowing and arbitrage.

Houghton discussed ways to ensure assets and liabilities interact properly in a model, and expanded on issue prevention and validation techniques. As a complementary validation technique to Finn's method of projecting yields of a single bond under a large number of scenarios, Houghton presented a case study and validation technique where an entire portfolio of bonds were projected under a single scenario. The ratings of the bonds in the portfolio are identified with different colors on a graph of yield vs. maturity date, which makes any assets with data or modeling issues easy to spot as outliers on the graph.

Session slides are available at:
https://www.soa.org/pd/events/2017/annual-meeting/pd-2017-10-annual-session-058.pdf ■

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Coming Soon! Asset Allocation Contest

More information will be posted on the Investment Section's page at: *www.soa.org/sections/investment/investment-landing/*

Session 100: Pension De-Risking Through Glide Paths

By Kathleen Brolly, Brett Dutton, James Gannon and Alex Pekker

Triggered by the Pension Protection Act (2006), the global financial crisis of 2008, and the maturing of the U.S. pension system, the adoption of de-risking glide paths has become commonplace among corporate pension sponsors. Unlike a standard static asset allocation, the glide path is a systematic way to adjust asset allocation by reducing funded status risk as funded status improves.

At low funded status, the glide path recognizes that the sponsor may desire to take on investment risk to close the funding gap.

Conversely, when the plan is fully funded, the sponsor, realizing that there is little benefit to taking additional risk, would want to de-risk and invest primarily in a liability matching portfolio.

Table 1
Simple Illustrative Glide Path De-Risking Schedule

Funded Status Trigger	Return Seeking Allocation	Liability Matching Allocation
<80%	50%	50%
80% to 85%	45%	55%
85% to 90%	40%	60%
90% to 95%	35%	65%
95% to 100%	30%	70%
100% to 105%	25%	75%
>105%	20%	80%

After adopting a glide path, the plan sponsor then must decide on the details of implementation, including:

Governance structure—Whether to de-risk automatically at each trigger or to use the triggers as a chance for deliberation where the committee must approve each de-risking allocation change.

Monitoring frequency—The choice of daily, weekly, monthly, or quarterly creates a trade-off between increased precision and increased costs.

One way vs. two way—A decision whether to allow re-risking of the allocation when funded status declines.

Trading policies—The establishment of tactical ranges, use of derivatives, and the consideration of transaction costs.

Changes *within* the growth and liability-hedging allocations—For example, excluding illiquid growth assets and customizing the liability-matching portfolio as funded status increases.

Before adopting a glide path, the plan sponsor must consider many questions, including:

- Is it appropriate to take risk at all in their pension plan, especially uncompensated risks like interest rate risk?
- Is the time horizon of a glide path long enough for all asset classes to pay off?
- Is it advantageous to wait to buy long bonds and face a crowded marketplace?

- Do shareholders benefit when the sponsor takes equity risk in the pension plan, especially at low funded status and when the plan has high exposure to market downturns?
- Glide paths have become common with an increased regulatory environment, a focus of risk management and a maturing pension system. This can be seen in annual surveys or in the financial statements of a plan sponsor. We do expect the use of glide paths to continue but believe that sponsors need to adopt and implement them in a thoughtful way based on the specifics of their plan and their beliefs as an investor. ■

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Alexander Pekker, ASA, CFA, Ph.D., is a senior investment director and investment actuary at Cambridge Associates in San Francisco. He can be reached at *apekker@cambridgeassociates.com.*

Annual Meeting Session 154 Panel Discussion: The Coming Retirement Financial Crisis and How Actuaries Will be Part of the Solution

By Jeff Passmore

This presentation was adapted from a presentation originally developed for the actuarial student club at the University of California—Santa Barbara. It was adapted to be appropriate to a professional audience of practicing actuaries.

The presentation illustrated the coming retirement financial security crisis in the U.S. and discussed several of the trends driving this crisis. The presentation expressed a positive viewpoint regarding the role that actuaries have played in establishing systems for supporting financial security in retirement and how that role will likely continue, albeit in some adapted way.

There were four primary areas covered:

- Ageing of the U.S. and global population.
- The current and projected funding levels of Social Security and Medicare benefits.
- The current and projected status of corporate pension plans and corporate sponsored retiree medical benefits and the trend towards defined contribution plans.
- The current funded status of public (state and municipal government) pension plans.

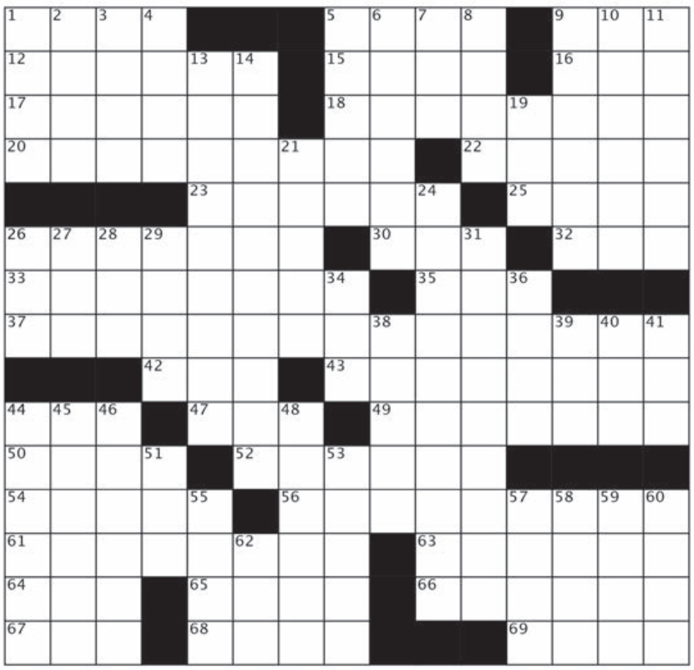
The presentations expressed the conviction that as actuaries, we have the skill set and public trust to address these and present solutions.

I wish to express my gratitude to Ali Zaker-Shahrak who agreed to participate in the panel presentation by sharing his insights from his experience working with public pensions and social insurance programs. On relatively short notice, Zaker-Shahrak replaced another presenter who was unable to participate due to a scheduling conflict. ■

Jeff Passmore, FSA, EA, is director, client portfolio manager and LDI strategist for Barrow, Hanley, Mewhinney & Strauss, LLC. He can be contacted at *jpassmore@barrowhanley.com*.

Crossword Puzzle: You Can Tell a Book by its Cover

By Warren Manners



The solution will be provided in the next issue of *Risks & Rewards* along with the names of those who were able to successfully complete it. Submissions should be made to *enews@soa.org* by May 31, 2018. ■

Warren Manners, FSA, CFA, MAAA, is the controller at Swiss Re in Armonk, N.Y. He can be reached at *warren_manners@swissre.com*.

Across

1 Genuine
5 Not this
9 Scale member
12 Nest chorus
15 Top drawer
16 A credit component of FAS 157
17 Antibody responsible for allergic reactions
18 Favorite stock of life insurers
20 Not melodious
22 Talked bull?
23 Adjusted letter spacing
25 Flightless bird
26 Treat a patient with kidney failure
30 Kia model
32 Record keeper
33 Crucial trial
35 Wall St. operator
37 Favorite song of P&C insurers
42 Make out
43 Turns the hand
44 Jackson and Derek
47 Their, in Nice
49 Consumes
50 Rough waters
52 Erotica pioneer
54 Native of Attu
56 Like some hot wheels
61 Favorite band of variable annuity insurers
63 Argots
64 First follower
65 Ceramic piece
66 Ear of sweet corn
67 Classic Gibsons
68 Flew
69 Stable fare

Down

1 Yellowish brown
2 YouTube co-founder Steve
3 Track event
4 Lizard
5 Never agent
6 Whoop
7 Akkadian god
8 Come down
9 Grouper group
10 City of northern Spain
11 Pekingese or Shih Tzu
13 Favorite appendages of title insurers
14 Tree native to Southern Africa
19 Oil source
21 Eat without restraint
24 The inspiration for Monty Python's Mr. Creosote
26 86,400 seconds
27 Clinch
28 Be indisposed
29 Lipoproteins, for short
31 Favorite drink of health insurers
34 Male sheep
36 Bluff in Banff
38 Tobacco pipe
39 ____ Always Sunny in Philadelphia
40 Snare
41 Part of RSVP
44 Victoria's Secret purchase in Pamplona
45 It's well-positioned
46 Going rates
48 Barley or wheat grass
51 Bird of UCONN fame
53 Islamic honorific title (var.)
55 Blasting agents
57 Venetian farewell
58 Caffeine source
59 Express
60 Nintendo game consoles
62 Driving hazard

Investment Concepts Solution

C	H	O	C		D	I	R	A	C		B	O	D	Y
H	O	M	O		E	B	O	L	A		O	B	O	E
A	T	E	N		C	O	N	T	R	A	R	I	A	N
S	E	N	S	O	R			O	R	B	S			
M	I	S	T	R	E	A	T		Y	A	C	H	T	S
			A	Z	E	R	O		A	S	H	A	R	P
P	L	A	N	O		A	N	G	L	E		L	E	O
L	I	L	T		A	N	G	E	L		C	A	N	T
A	D	O		E	N	D	U	E		D	O	L	T	S
C	O	F	F	E	E		E	S	S	E	N			
E	S	T	E	R	S		S	E	T	A	S	I	D	E
			R	I	T	E			A	L	E	V	E	L
C	O	N	V	E	R	T	A	R	B		R	I	A	L
O	R	S	O		I	C	A	L	L		V	E	R	A
T	B	A	R		C	H	A	S	E		E	D	Y	S

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