

MILLIMAN RESEARCH REPORT

How effective is variable annuity guarantee hedging?

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Introduction

Variable Annuity (VA) writers have implemented hedging programs both to manage risks related to guarantees they offer, and to protect earnings and capital. Over the past several years, hedging has become a core competence of VA writers and a significant contributor to the efficiency and profitability of VA business lines.

This paper examines the effectiveness of the hedging programs for a wide variety of VA writers; among the key findings is that hedging programs are 92% effective in reducing P&L volatility and 96% effective in offsetting losses resulting from market movements.

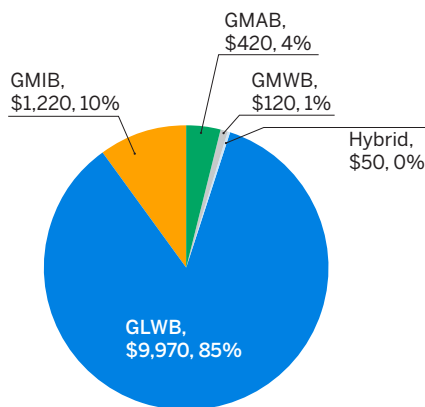
This paper also reviews trends in the development of VA hedging programs and the increasing prevalence of managed risk strategies inside VAs, where hedges are embedded within the funds themselves.

Introduction to VA liabilities

While the vast majority of current U.S. VA products offers basic return-of-premium guaranteed minimum death benefits (GMDB) as a default feature, more sophisticated GMDB designs and living benefits are also available. The guaranteed minimum accumulation benefit (GMAB), guaranteed minimum income benefit (GMIB), or guaranteed minimum (or lifetime) withdrawal benefit (GMWB, GLWB), are very popular with policyholders.

The GLWB has been the dominant choice for the past several years, having been selected by as many as 84% of annuity buyers in 1st Quarter 2016, per LIMRA statistics.

FIGURE 1: GLB DOLLAR AND MARKET SHARE (WHEN ELECTED) \$ IN MILLIONS



These guarantees have proven valuable to policyholders during the years following the global financial crisis because they offer protection for their investments. GMWBs that last for the life of the customer have been the retirement vehicle of choice in many markets around the globe.

Guarantees provided to policyholders can create large liabilities to VA writers when market declines push account balances below the value of the guaranteed benefits.

A VA writer's Net Amount of Risk (NAR), defined as the amount by which the account value falls below the guaranteed amount, is a significant exposure that must be hedged by VA writers. NAR is mitigated in part by two key VA features: (1) guarantees come with withdrawal restrictions, and (2) in-force contracts have long durations. Nevertheless, VA writers still need to protect earnings and capital. As of March 2016, the top seven VA writers together had a NAR of over \$21 billion, according to JP Morgan research reports.

The major drivers for VA guarantee liabilities are movements in the capital markets, including equity levels, interest rates, volatility, and exchange rates. To mitigate the risks from capital market movements, most VA writers have implemented hedging programs.

VA writers generally hedge against the following three kinds of market risks, which are commonly referred to as Greeks:

- Delta: Sensitivity to movements in equity, bond, or foreign exchange markets
- Rho: Sensitivity to movements in interest rates
- Vega: Sensitivity to movements in volatilities

Most VA writers typically implement two kinds of hedging strategies:

- Delta/Rho, which protects against equity, FX, and interest rate movements
- Delta/Vega/Rho, which protects against equity, interest rate, and implied-volatility movements

Depending on a particular company's risk appetite, it may choose to hedge part or all of its exposure as measured by the Greeks. In addition, there are other dimensions of risk due to interactions between the various risk factors, commonly referred to as "cross-Greeks." In practice, however, very few VA writers hedge cross-Greeks because they are usually small in magnitude and expensive to hedge.

Definition of hedge effectiveness

Hedging primarily achieves two objectives for a VA writer:

1. Stabilization of a VA writer's P&L: During periods of market downturns, a hedging program can help stabilize a VA writer's profitability, which is important from an investor standpoint. Hedging reduces P&L volatility because the hedge asset value is designed to offset adverse movements in liability value.

The effectiveness of P&L stabilization can be measured by the reduction of P&L standard deviation.

2. Mitigation of losses resulting from market movement: During a market downturn, a VA writer's liabilities will increase, and increases in hedge asset value should help offset the losses.

The effectiveness of loss recovery can be measured by the ratio of the change in hedge asset value to the change in liability increase during a market downturn.

Study description

Milliman published two research papers in 2008¹ and 2009,² which found that hedging programs averaged a 94% rate of efficacy in mitigating losses. The 2016 study examines again the effectiveness of hedging programs with respect to loss recovery and also expands the scope to include hedge effectiveness in terms of reducing the volatility of P&L.

This study analyzes performance data for a wide range of clients, including those for whom Milliman executes outsourced hedging programs. The study also evaluates other companies' use of Milliman software tools and techniques to hedge their capital market risk exposures. While the overall study is based on actual historical data, extensive measures have been taken to anonymize the results to protect client confidentiality.³

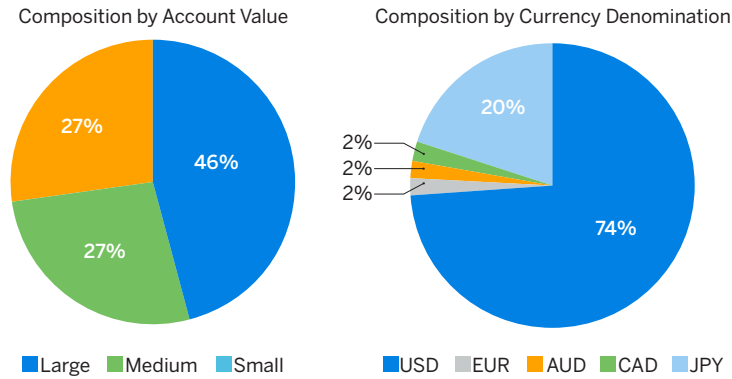
1 See <http://us.milliman.com/uploadedFiles/insight/research/life-rr/performance-insurance-company-hedging-rr12-01-08.pdf>.

2 See <http://us.milliman.com/uploadedFiles/insight/research/life-rr/va-industry-analysis-recent-rr.pdf>.

3 See notes in Appendix I for additional details about the study.

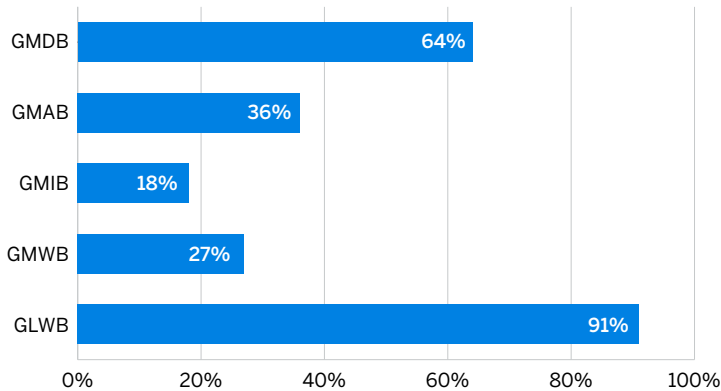
The following charts illustrate the composition across a variety of metrics of the programs being analyzed in this paper. Almost half of the programs had account values of \$1 billion or more and three quarters are denominated in USD:

FIGURE 2: COMPOSITION BY ACCOUNT VALUE AND CURRENCY DENOMINATION



With a usage rate of 91%, GLWBs are the most widely used type of guarantee within VAs:

FIGURE 3: COMPOSITION BY GUARANTEE TYPE

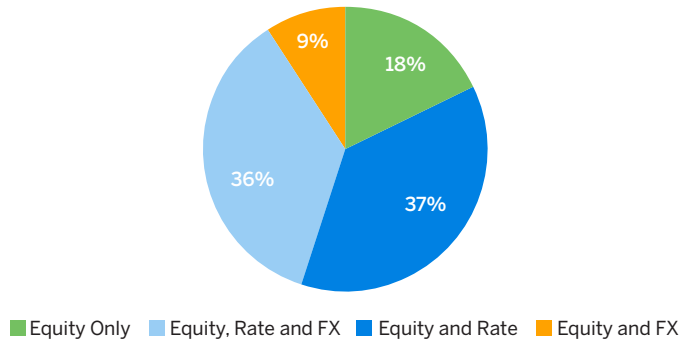


Description of VA hedging programs

The hedge programs included in the analysis vary in terms of the risk factors they aim to hedge. The most common hedge strategy is the so-called “2-Greek” strategy involving the hedging of Delta/Rho, which aims to protect against both equity and interest rate risk factors, with some clients choosing to hedge only selected equity/FX risks, and/or a fixed proportion of interest rate exposure.

To assess the effectiveness of these hedging programs on a comparative and aggregate basis, only the hedged portion of each program’s risk factors was considered in the analysis. The following pie chart illustrates the proportion of programs using each strategy:

FIGURE 4: COMPOSITION BY HEDGE STRATEGY



In addition to prioritizing different risk factors, hedge programs also differ in their approach to:

1. Risk assessment grids and use of cross-Greeks

The computationally intensive nature of valuing large VA blocks of business limits the viability of calculating the risk-factor sensitivities in real time. Most programs calculate trading grids on a daily basis, while some programs also use cross-Greeks intra-day to more accurately estimate the real-time risk factor sensitivities based on movements in equity, FX, and interest rates.

2. Rebalancing tolerance and frequency

Hedging any option-like guarantee, including VAs, generally involves some measure of buying-high and selling-low. Setting the rebalancing frequency and tolerance involves balancing transaction costs and risk of mean-reverting markets against tightness of the hedging and ultimately risk tolerance:



The programs commonly used rebalancing thresholds between 3% and 10% of the risk sensitivity, along with intra-day trading and monitoring. A number of programs also allowed trading in the futures market night sessions.

Methodology

Effectiveness of hedge programs over time can be measured in a number of different ways. Two common approaches are described below:

1. Percentage reduction in the volatility of weekly P&L =

$$1 - \frac{\text{Standard deviation of weekly P\&L with hedge}}{\text{Standard deviation of weekly P\&L without hedge}}$$

This approach measures the hedge program’s reduction of the P&L volatility that is attributable specifically to the risk factors being hedged.

2. Loss recovery comparing P&L of hedged vs. unhedged portfolios for a given period =

$$1 - \frac{\text{P\&L with hedge}}{\text{P\&L without hedge}}$$

This approach measures how effective the hedge program has been in recovering losses, and/or offsetting gains.

A limitation of the first measure is its indifference to the size of the hedged P&L, provided it is stable. For the second method, a limitation is its inability to illustrate a hedge programs' effectiveness in V-shaped markets, which have been common in 2015 and 2016.

With each measure helping to overcome the limitation of the other, both measures are used in conjunction to clearly illustrate the effectiveness of the hedge programs analyzed. As noted earlier, only the hedged portions of each risk factor are included in the results.

Summary of results

FIGURE 5: VOLATILITY REDUCTION AND AND LOSS RECOVERY RATES

ACCOUNT-VALUE WEIGHTED AVERAGE	P&L VOLATILITY REDUCTION: INCEPTION TO 2015	P&L VOLATILITY REDUCTION: CY 2015	LOSS RECOVERY FOR THE WEEK ENDING 8/21/15
EQUITY	92.2%	92.7%	101.8%
RATES	95.9%	97.9%	98.2%
CURRENCY	93.7%	93.8%	101.1%

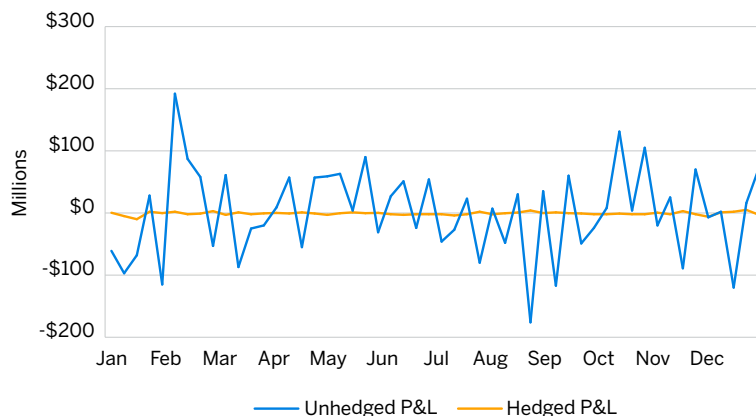
*See Appendix for additional notes

1. REDUCTION OF P&L VOLATILITY

The hedge programs included in this analysis reduced P&L volatility by more than 92% for both the lifetime of the VA hedging and in calendar year 2015. This substantial reduction in P&L volatility was a function of the hedges' effectiveness during the worst drawdown of 2015, when the programs benefited from loss recovery rates in excess of 98%.

Overall, the hedging program greatly stabilized the VA writers' P&L. The chart below illustrates how the hedge asset P&L moved in sync with the liability guarantee value during different market conditions, thus reducing the volatilities of hedged P&L.

FIGURE 6: 2015 WEEKLY NET P&L - HEDGING VERSUS NO HEDGING



2. RECOVERY OF LOSSES

Hedge programs have proven to be very effective in recovering P&L losses during periods of market turmoil. Given the market turmoil and high volatility in August 2015, with a major decline in equity markets, this report analyzes recovery of losses for the week ending August 21, 2015, when the S&P 500 Index dropped sharply by over 6%. The hedge programs in this study recovered the vast majority of the losses (98% to 102%) during that week across equity, interest rates, and FX markets.

In a few instances, hedging programs experienced loss recovery in excess of 100% during the week ending August 21, depending on the rebalancing thresholds and based on the fact that programs can be over- or under-hedged for short periods. Over multiple rebalancing periods, deviations caused by rebalancing thresholds and other program design choices tend to cancel each other out, giving a consistent result that is generally in line with the loss recovery statistics calculated for this week.

FIGURE 7: S&P 500 - 2015



Key factors to effective VA hedging

1. SIMPLICITY AND TRANSPARENCY

Milliman uses simple and highly liquid instruments such as futures, listed options, and swaps as hedging assets. The use of simple and liquid instruments, in conjunction with transparent design and efficient implementation, are key drivers to an effective hedge program. Additionally, managing the risk within a risk management program requires strong internal controls and robust auditing by external reviewers.

2. HEDGING HAS BECOME A CORE COMPETENCY FOR VA WRITERS

In recent years, and especially after the 2008 global financial crisis, VA providers have become increasingly aware that effective hedging and risk management programs are critical to the success of their VA programs. Best-in-class hedge programs can help mitigate losses during market turmoil, while reduction in P&L volatility can save on capital and cash reserve requirements for VA providers.

3. GLOBAL TRADING CAPABILITY

The ability to effectively hedge international risk exposures in VAs relies heavily on global trading capabilities. To continuously monitor risk and respond to market movements on a real-time basis, the trading platform should be built to be able to cover the time zones of all major financial centers. Milliman has three trading desks strategically located in Chicago, Sydney, and London; from these desks, traders monitor risk books, execute trades in a coordinated manner, and share market information gained from local presence. Experience during the global financial crisis and recent events such as Brexit have demonstrated the importance of 24-hour trading, which can help to reduce losses from gap risk and ensure that VA hedges are implemented in a timely and efficient manner.

4. RESEARCH & DEVELOPMENT AND OPERATIONAL EXCELLENCE

Building and enhancing the cutting-edge models used in hedge programs requires research teams focused on continuous improvement; investing in such resources is essential. A good understanding and appreciation of risks is also critical to the success of VA hedging. Close coordination and integration between trading, actuarial, technology, operations, compliance, and legal teams are important for understanding the gambit of risks and maintaining a seamless workflow.

Challenges to efficient hedging

1. BASIS RISK AND TIMING

Managing a Delta hedge with futures contracts requires mapping the underlying funds to the indices that the futures track. A number of approaches can be used to calculate these fund mappings. Here are two common ones:

- Applying regression analysis carried out for each underlying fund against a selected set of indices to determine the fixed weightings to each of these indices
- Using specified benchmark weights provided by the underlying fund managers

Regardless of which approach is used, there will almost always be differences between the fund returns (predicted by the mapping) and the actual fund returns. This difference is referred to as “basis risk” and can be a significant component of hedge inefficiency in VA programs.

Furthermore, futures contracts are derivatives whose value is based on the prices of cash securities. This also introduces some level of basis risk, but to a significantly smaller degree. Often, the futures vs. cash-index basis is dominated by timing mismatches rather than an actual deviation of the futures contract from its fair value.

A common way of addressing basis risk is through restricting the underlying funds to passive index tracking funds.

2. GAP RISK

Gap risk arises when securities prices change significantly before hedge positions can be rebalanced. These price changes can manifest themselves between the close of one session and the opening of the next, or they can happen intra-day.

To minimize and manage this risk, best-in-class VA hedging programs tap into 24-hour trading capabilities, monitoring and rebalancing their hedge positions as necessary, no matter the time of day. By utilizing 24-hour trading capabilities, potential effects from gap risk can be significantly reduced.

3. ESTIMATION OF SECOND-ORDER GREEKS

To effectively run a dynamic hedging program where hedges are monitored and rebalanced in real-time, the Greeks used for hedging need to be accurate and reflect real-time market levels.

However, the models and processes for risk-neutral valuation of VA books are computationally intensive and may not lend themselves to real-time re-valuations. As a solution, many VA hedging programs generate trading grids with risk sensitivities on a daily or weekly basis.

To estimate risk sensitivities in real time, some programs include valuations of cross-sensitives of each risk factor. While this method is reasonably accurate, there can still be some slippage as this method typically assumes that cross-sensitives are constant until the next valuation.

Managed risk fund improves hedging effectiveness

Since the 2008 global financial crisis, VA writers have been pursuing ways of de-risking their products, beyond traditional diversification via asset allocation. In addition to hedging the general accounts, another key advancement and driver in keeping VA products sustainable in a low-rate and high-volatility environment is the introduction and adoption of managed risk funds. The core concept of this approach is to shift some of the hedges associated with VA guarantees to the policyholder.

From a hedging effectiveness perspective, a key benefit of these funds is typically their stable (or targeted) volatility levels. The sensitivity of a VA product to the volatility of its underlying funds is significant and is also a risk sensitivity that is difficult to hedge. By stabilizing the volatility of the underlying funds, this risk sensitivity is effectively removed from the insurer's balance sheet.

The Milliman Managed Risk Strategy combines a volatility target with a capital protection strategy. The two techniques work together to stabilize portfolio volatility, capture a degree of upside participation, and reduce losses during severe sustained market declines. The strategy has been widely adopted in the VA space on over USD \$49 billion in account value.

Conclusions

Robust hedging programs have become critical for insurers who wish to profitably offer variable annuity products in the market place. This study has demonstrated the effectiveness of VA hedging programs both in terms of loss recovery and P&L stabilization.

Over the past several years, the VA marketplace and related hedging and risk management programs have evolved significantly. Managed risk funds that transfer some of the hedge assets into underlying funds represent one of the most significant changes in the marketplace.

Relative to previous years, especially those prior to the global financial crisis, the industry has been on a rapid pace of introducing and adopting meaningful changes and enhancements that are helping manage risk in VA markets more effectively. As the industry continues to evolve, we expect enhancements in both product design and hedging techniques to remain a key driver.

Appendix I

Summary Results Notes:

1. Inception dates range from the earliest in Jan 2010 to the latest in Oct 2014.
2. P&L volatility reduction is calculated to Dec 2015 where possible.
3. Total account value analyzed is over \$28 billion.
4. Results are averages weighted by account value.
5. All the accounts were hedged for equity, 73% of accounts were hedged for rates, and 45% were hedged for currency.

Appendix II: Overview of VA Marketplace

Sales of variable annuities with guaranteed lifetime income benefits continue to represent a large share of annuity sales, though other types of annuities such as Fixed Indexed Annuities (FIA) and Investment-Oriented Variable Annuities (IOVA) are gaining market share. Variable annuity sales totaled \$130.4 billion in 2015, according to the Insured Retirement Institute (IRI). In the first half of 2016, sales declined 13%, according to JP Morgan research estimates.

FIGURE 8: ANNUITY INDUSTRY ASSETS (\$BILLIONS)

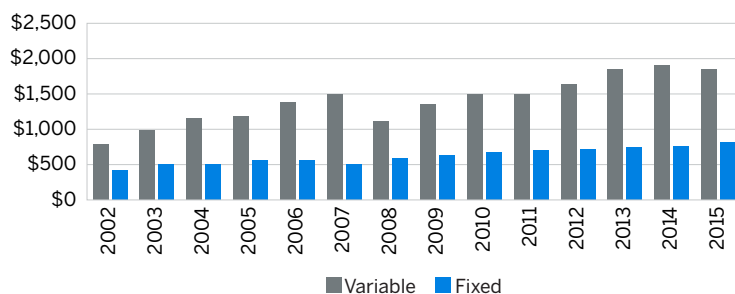
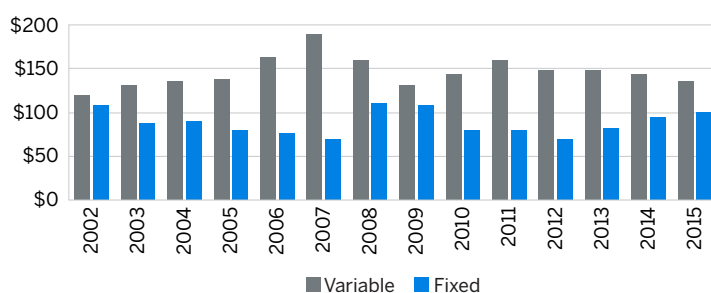


FIGURE 9: ANNUITY INDUSTRY SALES (\$BILLIONS)



Sources: Morningstar, Inc. and IRI Fact Book 2016 (prior to 2014 fixed annuity asset data was provided by LIMRA)

The embedded guarantees in VAs are attractive to consumers because they provide a benefit floor when VA assets decline in value, while still allowing for upside participation when VA assets generate positive returns. VAs with this feature compare favorably to alternatives such as fixed annuities, bank certificates of deposit (CDs), or mutual funds. While fixed annuities and bank CDs are guaranteed, they do not offer participation in the capital markets. Conversely, mutual funds offer participation in the capital markets, but offer no insurance or guarantee against significant losses. As of 1Q '16, approximately 70% of VA assets are estimated to be in equity and balanced funds, 28% in fixed income, and 2% in money market funds according to JP Morgan research reports.

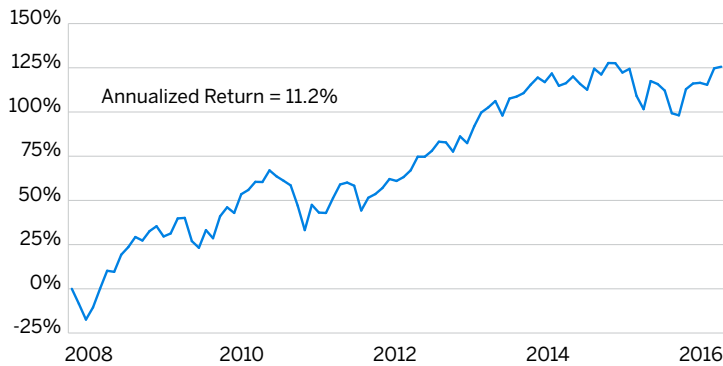
VA sales have declined in recent years due to heightened volatility in equity markets, higher fees, and less generous benefits. Market disruption from the DOL fiduciary rule, which is scheduled to be phased in beginning April 2017 and fully implemented in January 2018, has the potential to further reduce VA sales in the coming years. However, over the longer term, VA sales are expected to grow again as retiring Baby Boomers look for investment solutions that address their retirement income needs and longevity risk.

Appendix III: Capital Market Conditions

Unless otherwise noted, all data in Appendix III is sourced from Bloomberg, as of August 31, 2016.

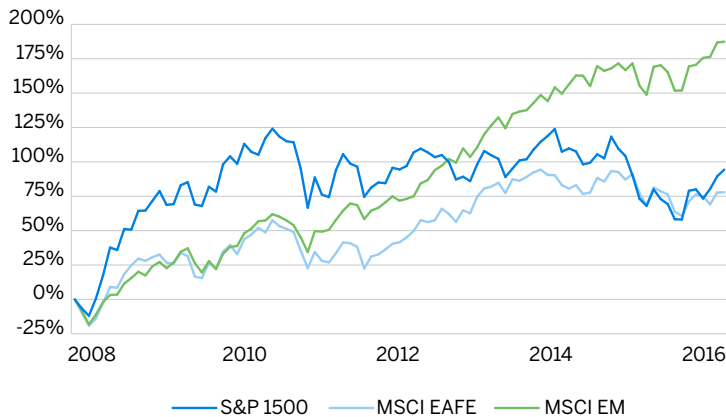
Since the end of 2008, against the backdrop of unprecedented central bank policy accommodation, the global equity market has appreciated significantly:

FIGURE 10: MSCI ALL COUNTRY WORLD INDEX - CUMULATIVE TOTAL RETURN



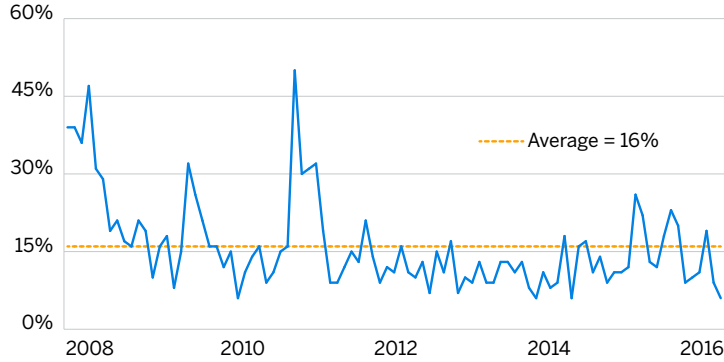
Digging one level deeper reveals that while the broad market segments are all higher, U.S. equities have made gains over the past three years that EM and EAFE stock markets have not kept up with:

FIGURE 11: CUMULATIVE TOTAL RETURNS



Along the way, investors have enjoyed stretches of relatively low market volatility interspersed with bouts of high volatility:

FIGURE 12: S&P 1500 ROLLING 21-DAY REALIZED VOLATILITY (AS OF MONTH-END)



Bond yields around the globe have fallen precipitously as the largest central banks have kept short-term rates near zero, while also executing large-scale asset purchase programs, growing their combined balance sheets to more than \$12 trillion:

FIGURE 13: 10-YEAR U.S. TREASURY YIELD (%)



FIGURE 14: DEVELOPED MARKET SOVEREIGN 10-YEAR YIELDS

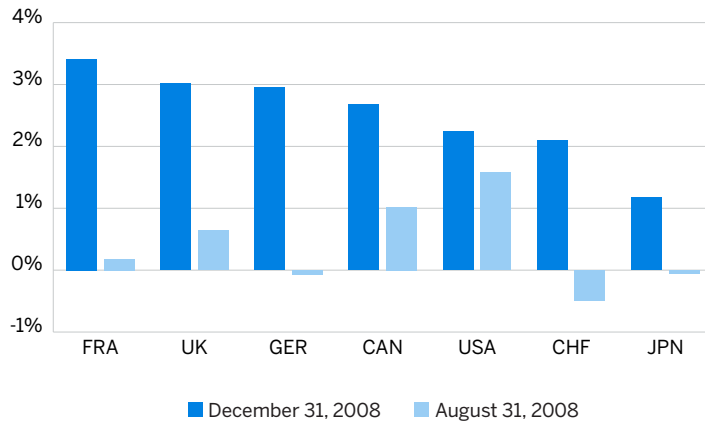
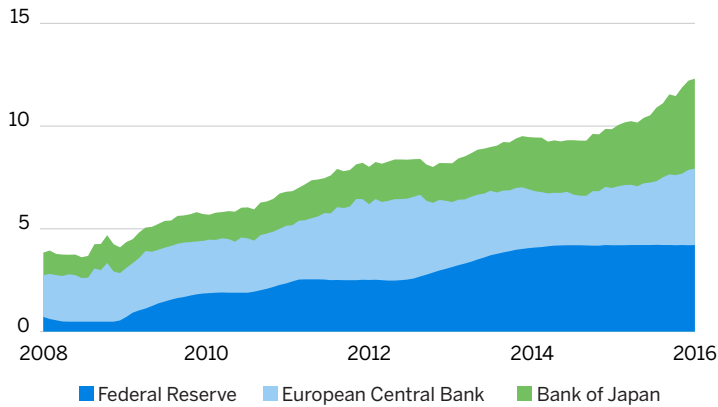


FIGURE 15: CENTRAL BANK ASSETS (\$TRILLION)



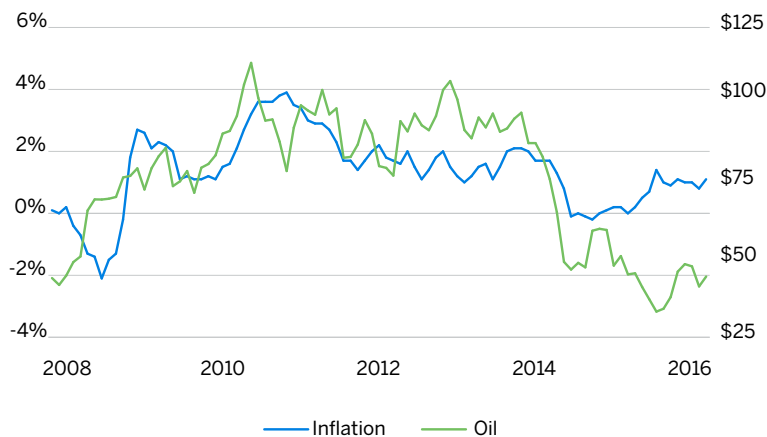
The U.S. dollar was range bound for six years after the financial crisis before breaking sharply higher in 2014, putting significant pressure on international exposures held by VAs:

FIGURE 16: U.S. DOLLAR INDEX



The dollar’s strength and declining energy prices have contributed to low U.S. inflation in recent years:

FIGURE 17: ANNUAL U.S. INFLATION AND SPOT PRICE PER BARREL OF OIL



A reversion to the mean from current conditions would mean higher equity market volatility, rising interest rates, and higher inflation. Each represents a risk that VA writers will do well to actively monitor and hedge as they seek to stabilize P&L and minimize losses.



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