

Variable Annuity Guarantee Hedging Maintains Its Effectiveness

Basis risk accounts for one-third of overall hedge ineffectiveness inclusive of basis

EXECUTIVE SUMMARY

As of Q3 2017, there is about \$1.96 trillion of assets in the variable annuity (VA) industry. Hedging the guarantees embedded in variable annuities has become a core competency for VA carriers for whom an effective hedging program is critical from a standpoint of both solvency and earnings stability. The effectiveness of hedging programs is a closely watched metric for most VA carriers; this paper examines the hedge effectiveness of a wide range of VA carriers.

For this paper, we examine a group of VA carriers from the beginning of 2016 through the end of Q3 2017, and we found that hedging programs were 95.1% effective in reducing earnings volatility during this period. This is a particularly strong result given 2016 and 2017 were marked by frequent and significant V-market scenarios. We also researched periods of significant market drawdowns and observed that the hedging programs were 96.7% effective in one of the largest drawdowns over this period. Overall, our findings from this period are consistent with our previous research and indicate that well designed and prudently managed hedging programs continue to achieve a high level of hedging effectiveness.

We further researched the contribution of basis risks to earnings volatility, and we found that basis risk explains one-third of hedge ineffectiveness. Basis mismatch is a fundamental limiting factor for hedging programs, and as a rule-of thumb, a hedging program's effectiveness in reducing earnings volatility is limited to the square root of the R-squared statistic. Since basis mismatch is not a factor that can be effectively hedged, we explored a few alternatives to reducing basis mismatch. In particular, we believe the recent movement to risk managed funds is a good approach to contain the effects of basis mismatch.

DEFINITIONS OF HEDGE EFFECTIVENESS

Hedge programs aim to achieve two primary goals for VA carriers:

1. Stabilization of a VA carrier's earnings: During periods of market volatility, a hedging program can help stabilize a VA carrier's profitability, which enhances investor confidence. Hedging reduces earnings volatility because the hedge asset value is usually designed to offset movements in liability value.

The effectiveness of earnings stabilization is measured by the reduction of earnings volatility on a fair value basis. In our studies, the earnings volatility reduction is calculated as:

$$1 - \frac{\text{standard deviation of weekly earnings with hedge}}{\text{standard deviation of weekly earnings without hedge}}$$

2. Recovery of losses resulting from adverse market movements: during a market downturn, a VA carrier's liabilities will increase, and increases in hedge asset value should help offset the losses.

The effectiveness of the loss recovery is measured by the ratio of the increase in value of the hedge asset to the increase in value of the liability. The measurement is taken from the week during the study period in which the value of the liability experienced a large increase. In our studies, the effectiveness of loss recovery is calculated as:

$$1 - \frac{\text{earnings with hedge}}{\text{earnings without hedge}}$$

We chose these two definitions because each helps to address the other's limitations. A limitation of the earnings volatility reduction definition is its indifference to the size of the hedged program, provided it is stable. A limitation for the loss recovery definition is its inability to illustrate a hedging program's effectiveness in a volatile and but non-directional market, such as so-called V-shaped markets. We believe the combination of these two metrics provides a good measure of a hedge program's overall effectiveness.

BACKGROUND OF OUR STUDY

This study analyzes performance data for a wide range of clients, including those for whom Milliman executes outsourced hedging programs. This study also evaluates other companies who use 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.

There are a total of 9 companies in our study, covering over \$25 billion of account value. The study period from January 2016 through September 2017.

REDUCTION OF P&L VOLATILITY

As defined above, reducing the volatility of earnings is one of the primary objectives of hedge programs.

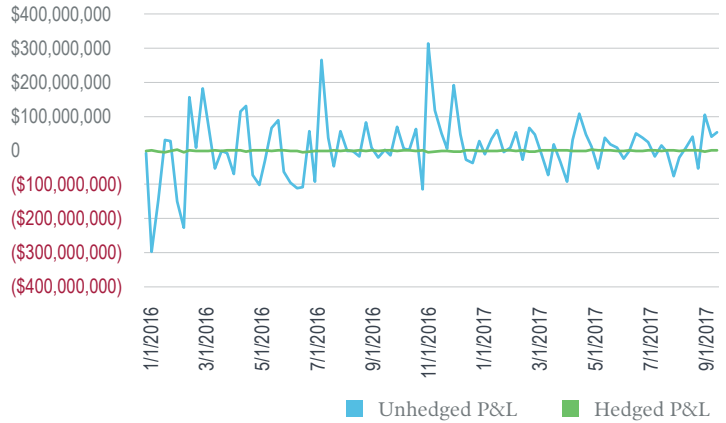
In this study, the calculations show an overall reduction of earnings volatility by 95.1% exclusive of basis risk. Figure 1 shows the break down for this statistic across the various underlying asset classes. Including basis risk reduces overall hedge efficiency to 92.2%. As indicated in the table, the hedge programs effectively stabilized the VA writers' earnings. Previous research results from inception to 2015 and CY 2015 are included as reference.

Figure 1: Reduction of earnings Volatility Results Breakdown

ACCOUNT-VALUE WEIGHTED AVERAGE	EARNINGS VOLATILITY REDUCTION: JAN 2016 TO SEPT 2017
EQUITY	94.3%
RATES	95.9%
CURRENCY	95.4%
OVERALL HEDGE EFFECTIVENESS	95.1%

The above statistics shows that VA guarantee hedging has maintained its effectiveness in stabilizing VA writers' earnings. Figure 2 below also helps to illustrate the hedged earning in comparison to the unhedged earnings.

Figure 2: Weekly net earnings - hedged versus unhedged P&L January 2016 - September 2017



HEDGE PERFORMANCE IN RECOVERING LOSSES IN SIGNIFICANT MARKET DRAWDOWNS

From Jan 2016 through Sept 2017, the S&P 500 index rose 23.26%, but not without setbacks along the way. In fact, there were five notable V-shaped markets during this period, as noted in Figure 3. In Q1 2016, the global market was negatively affected by fears

Figure 3: S&P 500 - Jan 2016 to Sept 2017



of an economic slowdown in China, followed by market-moving political events including Brexit in June and the U.S. presidential election in November. Other major market moves resulted from geopolitical tensions in various locations across the globe, including North Korea in particular, which triggered key market reversals. From February 1st to 11th 2016, the S&P 500 Index saw a drawdown of over 7%. For such sharp market drawdowns, this report examined the loss recovery ratio that measures the mitigation of losses resulting from a major market downturn.

In our previous paper, we examined the loss recovery ratio for the week ending August 21, 2015, where the S&P 500 Index dropped sharply by over 6%. The hedge programs recovered the vast majority of the losses (98% to 102%) during that week across equity, interest rates, and FX markets. In Figure 4, we show that the hedge programs performed well during the 2016 February market turmoil, recovering more than 96% of the liability losses incurred that week.

Figure 3: S&P 500 - Jan 2016 to Sept 2017

ACCOUNT - VALUE WEIGHTED AVERAGE	LOSS RECOVERY WEEK OF FEB 8TH 2016
EQUITY	98.0%
RATES	93.9%
CURRENCY	104.1%
OVERALL HEDGE EFFECTIVENESS	96.7%

As shown in the Table 4, the hedge programs have maintained their effectiveness in a variety of market conditions, including some of the most severe V-market scenarios. In some instances, hedge programs experienced loss recovery of more than 100% as a result of rebalancing thresholds allowing some programs to be over-hedged for short periods of time. However, over longer periods, those deviations tend to cancel out each other, and give results consistent with the statistics calculated on a weekly basis.

FUND MAPPING BASIS AND APPROACHES TO REDUCE BASIS

In this update of our previous paper on VA hedging programs' effectiveness, we are including an additional analysis of the impact of the so-called fund-mapping basis, which can have a negative impact on hedge effectiveness. The previous report had excluded basis risk from this measurement since slippage from fund mapping basis is typically an unhedgeable risk factor with the magnitude being dependent on the choice of underlying funds rather than the hedge strategy itself. This report examined the loss recovery ratio that measures the mitigation of losses resulting from a major market downturn.

Definition of fund mapping basis

Fund mapping is a process that must be carried out as part of

implementing a dynamic hedging program. VA products often allow the policyholders to choose their investment portfolio from a limited selection of funds, some of which are actively managed with no liquid markets for traded derivatives on the underlying assets. Additionally, the embedded guarantees for such policies may not have matching derivative instruments to effectively hedge the risks.

As a general rule, a hedging program's effectiveness in reducing earnings volatility cannot be higher than the square root of the R-squared statistic.

Fund mapping to hedgeable indices allows for a simplified and consistent approach to analyze the risk metrics for a large portfolio of funds. This process maps the funds into a combination of broad indices with liquid hedging instruments using statistical mapping techniques.

The most common measure for evaluating the quality of fund mapping is the R-squared statistic. R-squared of 95% implies that 95% of movements in fund value can be explained by the movement of the combination of hedgeable indices. The remaining unexplained movement in fund values is in essence the "basis mismatch".

We analyzed the "fund basis" for the period from January 2016 through September 2017 for all the hedging programs included in this report. To gauge how the fund basis affects hedge performance, we measure the percentage of hedge programs inefficiency caused by fund basis:

$$\frac{\left(\text{Hedge effectiveness excl. basis} - \text{hedge effectiveness incl. basis} \right)}{\left(1 - \text{hedge effectiveness incl. basis} \right)}$$

The results show that the fund basis accounts for one-third of overall hedge ineffectiveness inclusive of basis, reducing overall hedge efficiency from 95.1% to 92.2%. Reducing basis mismatch can therefore be a very effective next step in enhancing hedging programs to further reduce earnings volatility.

As it turns out, a rule of thumb can be established between the upper limit of a hedging program's effectiveness in reducing earnings volatility and the R-squared of the fund mapping of its underlying funds. As a general rule, a hedging program's effectiveness in reducing earnings volatility cannot be higher than the square root of the R-squared statistic. For example, if the R-squared of a block of VA business is 90%, then the effectiveness of its hedging program is capped at 95%, which is the square root of 90%. This rule of thumb may provide some guidance for VA writers in selecting funds for their programs, and a formulaic derivation of this rule of thumb can be found in the Appendix.

Minimizing fund mapping basis mismatch is important in improving hedging program effectiveness. While this risk is typically left unhedged due to the lack of liquid instruments available, there are steps that can be taken to reduce the effect:

- Increasing the number of indices used for the fund mapping
- Replacing the underlying funds with index/passive funds
- Increasing the number of funds available
- Using managed risk funds

Intuitively, including more and better fitting indices in the fund mapping process is likely to reduce basis risk. This is particularly true if the current fund mapping process is missing indices representing major component markets. For example, adding the EAFE index or deconstructing the EAFE index into its constituent indices can often noticeably improve the R-squared by better reflecting exposure to all the underlying markets.

Utilizing index funds can reduce the many challenges noted above and provide very high R-squared statistics. However, investor preference for actively managed funds over passive

index funds may impact product design choices made by VA writers. In the past, some companies have experimented with offering a large number of funds to VA policyholders in the hope that, due to the law of large numbers, the basis mismatch will cancel out enabling the overall portfolio to be tracked using broad-based indices. While theoretically appealing, this approach was largely abandoned because policyholders began to choose riskier funds to maximize the value of the guarantee benefits offered by the VA writer.

The widespread inclusion of managed risk funds has provided VA carriers a better way to manage their capital market risks while also providing the benefit of reducing basis mismatch. Managed risk strategies are generally applied to funds that have a high R-squared statistic in relation to the underlying mapping indices. For example, for Milliman Managed Risk Strategy funds, the underlying funds have an average R-squared of 93% relative to the underlying mapping indices. As such, choosing managed risk funds may offer the added benefit of reducing the VA writers' fund mapping basis mismatch. The following chart indicates the popularity of managed risk funds within the VA industry

Managed Risk Funds in the VA Industry

PROVIDER	OFFERS ENHANCED BENEFIT VA PRODUCT THAT REQUIRES			MARKET SHARE % AS OF 9/30/2016 (SOURCE: MORNINGSTAR)
	MANAGED RISK INVESTMENT	RESTRICTED ASSET ALLOCATION	NEITHER RESTRICTION	
Brighthouse	✓	✗	✗	10.1%
Jackson National	✗	✗	✓	9.3%
Prudential Financial	✗	✓	✗	8.7%
Lincoln Financial Group	✓	✓	✗	7.3%
AIG	✓	✗	✗	6.5%
AXA Equitable	✓	✓	✗	5.6%
Ameriprise Financial	✓	✗	✗	4.5%
AEGON/Transamerica	✓	✓	✗	4.2%
Nationwide	✓	✓	✗	3.6%
Pacific Life	✓	✓	✗	3.0%

CONCLUSIONS

VA hedging programs have in general maintained their effectiveness both in terms of managing earnings volatility and recovering losses due to adverse market movements. However, fund mapping basis mismatch can contribute to unhedged earnings volatility, which can be mitigated by including managed risk funds in the product offerings.

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APPENDIX – R-SQUARED AND HEDGE EFFECTIVENESS

In this appendix, we show the mathematical approximation that leads to the rule-of-thumb upper limit of hedge effectiveness being the square root of R-squared. We have taken a first order approximation.

Hedge effectiveness for earnings volatility reduction (HE) is defined as:

- $1 - (\text{standard deviation of earnings after hedging}) / (\text{standard deviation of earnings before hedging})$.

One can think of earnings before hedging to be:

- $\text{delta} * \text{unit price movement}$,

This can be expanded to:

- $\text{delta} * (\text{index movement} + \text{error})$,
- where error is index basis match

Conceptually, R-squared is $\text{variance}(\text{error}) / [\text{variance}(\text{index}) + \text{variance}(\text{error})]$.

Assuming hedging can take out 100% of earnings volatility due to index movements, then earnings after hedging = $\text{delta} * \text{index movement}$. This would be the theoretically ideal case.

Therefore,

$$\text{HE} = 1 - (\text{standard deviation of error}) / (\text{standard deviation of } (\text{index movement} + \text{error}))$$

This simplifies to approximately the square root of R-squared.

In other words, the hedge effectiveness of any VA hedging program is capped at the square root of R-squared.

Granted, there are still many other factors contributing to the residual earnings volatility in a real hedge program, such as non-continuous rebalancing and discreet size of hedging instruments. However, we have seen in this paper that basis mismatch appears to be the largest contributor and accounts for more than half of residual earnings volatility. This simple rule-of-thumb sets out the theoretical upper limit of a hedge program's effectiveness, and thus can be helpful in assisting management better understand its periodic earnings.

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