MILLIMAN ANALYSIS: MILLIMAN PENSION FUNDING INDEX ASSET PORTFOLIO WITH MMRS RETURNED 0.9% IN Q1

FIRST QUARTER 2016 REALIZED VOLATILITY WAS 5.7% FOR THE MILLIMAN PFI AND 5.3% FOR THE MILLIMAN PFI WITH MMRS

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INTRODUCTION

A MARKET FILLED WITH BAD PENNIES

Bad pennies, metaphorically, are unpleasant or unwanted things that appear at inopportune times. This past quarter was filled with them. Each time the market calms back down, crisis narrowly averted, the same investor worries return to haunt us. It looked like the energy sector was on the mend with oil prices starting to rise in Q4, but coming into Q1, oil prices dropped again until a gallon of milk was worth two gallons of oil. Another bad penny: the recurring fear of secular stagnation, or an economy seemingly stuck in a low-growth, low-inflation mode with no clear way out. The International Monetary Fund declared that "strains in some large emerging market economies will continue to weigh on growth prospects in 2016-17" (IMF WEO Update).

In reality, bad pennies are counterfeit pennies that people want to get out of their possession before the unsuspecting recipient realizes they are counterfeit. It feels a bit like that is what central banks are all doing as they print and print and put more money into circulation. The past quarter saw Japan's first dip into negative interest rates, joining the European Central Bank (ECB), which showed further willingness to stay negative. It now costs money to loan money. The *Wall Street Journal* quoted Tomohisa Fujiki, head of interest-rate strategy at BNP Paribas Securities Japan, saying that "Every day is like being Alice in Wonderland."

Our surfeit of bad pennies has weighed upon financial markets, causing many plans to miss their expected returns in exchange for heightened volatility. It's not exactly a fair trade-off, and not a new one either. Investors certainly experienced this phenomenon in August through October of last year, when markets dropped then rebounded and interest rates, temporarily on the rise, returned to historic lows. Nimble reactions to changing market dynamics are becoming increasingly important as we wait for the shoe to drop, but few pension plans have the agility to react to portfolio threats as they unfold.

The long-term investment horizon of pension plans is hamstrung by the fact that benefit payments do not go down just because assets do, and contributions are dependent upon short-term market fluctuations. The use of risk management can allow a pension plan with an equity component to maintain its long-term investment policy but decrease its exposure to loss when underlying market risk, or volatility, is above the plan's risk objective. Unlike a plan's investment policy, a risk management overlay is agile and dynamic by nature, parrying the negative effects of risk on a daily basis. This paper discusses the impact of adding the Milliman Managed Risk Strategy™ (MMRS) to the Milliman 100 Pension Funding Index (PFI). Additional information on MMRS and the Milliman PFI is available at the end of this paper.

AGGREGATE PERFORMANCE

MILLIMAN PFI WITH AND WITHOUT MMRS

FIGURE 1: FINAL VALUES OF PFI AS OF MAR-2016 (FIGURES IN $ BILLIONS)

	Portfolio		
	PFI Actual	PFI w/MMRS	Difference
Market Value of Assets	$1,374	$1,709	$335
Projected Benefit Obligation	$1,763	$1,763	$0
Funded Status	-$390	-$55	$335
Funded Percentage	77.9%	96.9%	19.0%
Internal Rate of Return Jan 2000 - Sep 2015	5.4%	6.5%	1.1%

The PFI Actual assets, obligations, and returns are taken from data used to generate monthly Milliman PFI updates. The results shown are for informational purposes only, are not reflective of any investment, and do not guarantee future results.

Weathering much of the equity market correction in January and February with strong offsetting returns on bonds and capturing the large equity gains made in March, the Milliman PFI's assets returned 1.2% for the quarter. The Milliman PFI with MMRS returned 0.9% over the same period, with the 0.3% drag due to the abruptness and significance of the March rebound. By the middle of February, the Milliman PFI with MMRS had increased its cash holdings to around 7% of total account value. That meant slightly lower participation in the large positive gains made during March. However, MMRS was working as designed to position the portfolio in the event that January's shot across the bow preceded a full-fledged market crisis.

In total, the Milliman PFI funded status, both with and without MMRS, fell by approximately $80 billion this quarter. Asset returns, although net positive, were slightly below long-term expectations, but the primary driver of the funded status change was once again falling interest rates used to value pension liabilities.

Figures 1 and 2 show the cumulative statistics of the Milliman PFI with MMRS, ending on the first quarter of 2016. While the risk reduction provided by MMRS was not essential this quarter—largely due to the offsetting effect of strong bond returns—the benefit of a pension risk management strategy like MMRS can be easily seen in the study's outcome. A $335 billion dollar difference in funded status, a 1.1% increase in IRR, and a 19% difference in funded ratios are all the result of retroactively applying MMRS to the Milliman PFI's underlying portfolio movements.

ASSET RETURNS AND ATTRIBUTION

EQUITIES STAR IN A SEQUEL TO AUGUST 2015

The first quarter of 2016 saw the second sputter inside of six months of a staggering stock market. It also saw the second full recovery

from correction-level losses, and despite the wild ride, assets actually ended up for the quarter. The primary drivers of the latest erratic swing—growing in magnitude from August's drop—are the same fears that have antagonized investors for the past nine months.

International markets led equities' dive downward as the new year began. The MSCI ACWI ex. U.S. index returned -7.9% over January and February, with U.S. stocks close behind at -5.67%. Global economic outlook paralleled the lackluster performance of the stock market over those first two months. China's economic growing pains into services and out of manufacturing reverberated far beyond its Pacific border and into the United States. Oil prices were weighed down by a persistent dichotomy between barrels produced—95.47 million per day—and barrels demanded—93.76 million per day (U.S. Energy Information Administration). Investment in long-term projects, the key to robust growth, felt tepid at best and nonexistent at worst, as the economy suffered "from an increasing propensity to save and a decreasing propensity to invest" (Larry Summers). Alternative investments such as hedge funds and private equity realized negative returns as well, returning -4.1% and -0.9%, respectively, as measured by the HFR FOF Composite Index, and Cambridge Associates' U.S. Private Equity Index.

So what changed in March? From its low on February 11 to the end of the quarter, the S&P 500 returned +13%. One obvious factor that shored up stock markets over March is the world economy's very own Atlas: the central banks. On January 29, The Bank of Japan "blindsided global financial markets by adopting negative interest rates for the first time ever" (Chandran, CNBC). This was followed by "further interest rate cuts" by the ECB, spearheaded by Mario Draghi (Jones, *Financial Times*). U.S. central bank rate expectations also drifted downward as the possibility of a 1% Federal Reserve funds rate increase by year-end became less and less likely.

The impact of these changing expectations throughout the quarter is clear in the returns experienced in bonds. Barclay's Aggregate Corporate Bond Index returned a strong 3%, but even more impressively, Barclay's Long Government Credit and Global Treasury Indices returned 7.3% and 8.9%, respectively. This past quarter, diversification between bonds and equities certainly proved to be a boon for pension plans. For the Milliman PFI, bonds absorbed much of the negative impact that equities and alternatives had on portfolio performance.

This is not to say that strong performance was exclusively borne on the back of the central banks. Reason for optimism sprung from low unemployment domestically, now around 5.0%, and modest GDP growth of 1.6% in the Eurozone. This likely lent investors to believe that perhaps the initial reaction to global growth fears might be, as is sometimes the case, overblown. In all, the small positive return the Milliman PFI realized for the quarter betrays little of the turmoil experienced over the period. Like a three-year-old just put to sleep, its present calm says nothing of the struggle just moments ago.

FIGURE 2: MILLIMAN PFI WITH MMRS FUNDED STATUS

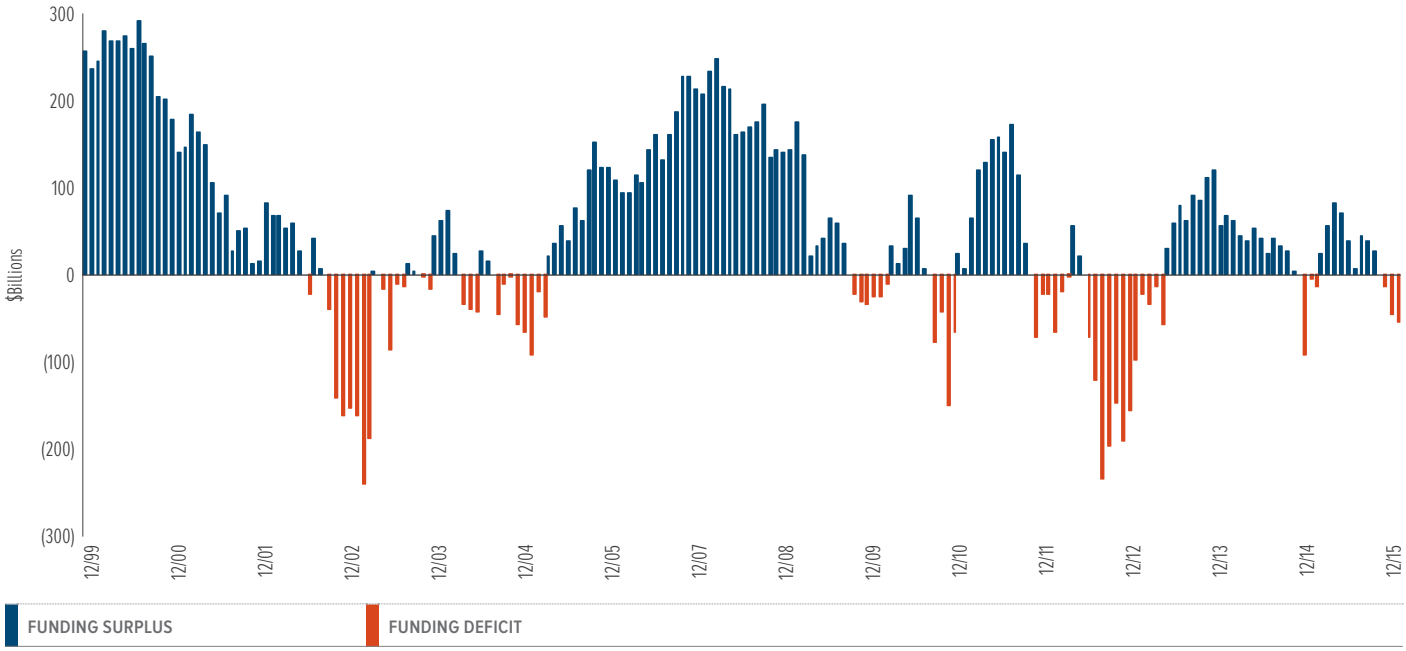

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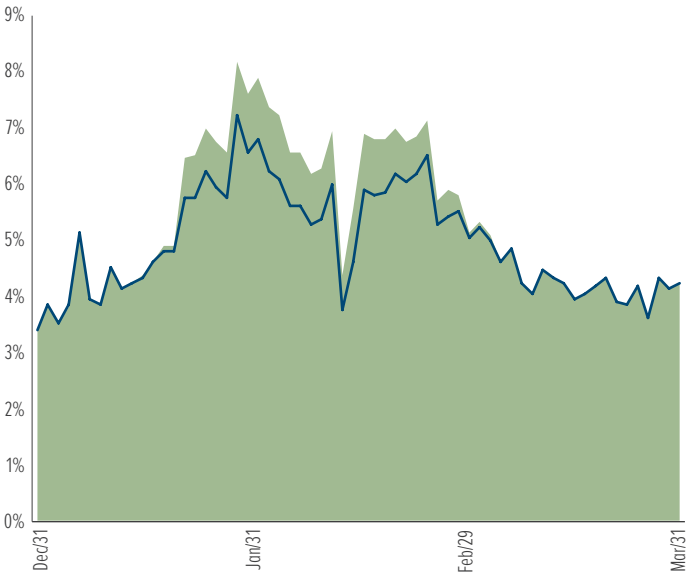
FIGURE 3: VOLATILITY COMPARISON: 2016 Q1



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IMPACT OF MMRS

DAMPENING VOLATILITY WHEN IT COUNTS

MMRS entered into the New Year with no hedge position in place, corresponding to a very low 3.4% 10-day realized volatility on December 31. In the turmoil of Q1, that risk level more than doubled, reaching a peak of 8.2% at the end of January. During the initial drop in equity and alternative asset classes, MMRS remained unmoved. This is because MMRS is meant to be a hedge where traditional diversification fails, but diversification was working well as bonds jumped in the beginning of the quarter, buoyed by falling interest rates. This largely offset the negative impact of other asset classes. However, as the market continued to fall and portfolio volatility increased, MMRS eased the Milliman PFI portfolio out of equities and into cash. The effect of this movement on volatility can be seen in Figure 3. For the quarter, realized volatility for the Milliman PFI without MMRS was 5.7%, and with MMRS it was 5.3%.

The time over which MMRS reduced volatility corresponds with the time over which investors experienced the most concern over the future of their portfolio. Uncertainty personified by volatility has since tapered from its mid-period high, and by the end of the quarter, MMRS was once again allowing the portfolio to be fully allocated to equities.

A BIG RISK IN A SMALL PACKAGE

Skeptics might doubt the effectiveness of MMRS in controlling total portfolio volatility, when equities are only a small portion of a plan sponsor's portfolio. "How can MMRS significantly reduce portfolio volatility when it only adjusts equity allocation?" one might ask. Up until now, this topic has not been addressed in any updates to the Milliman PFI with MMRS, or the original 2015 Q2 whitepaper itself.

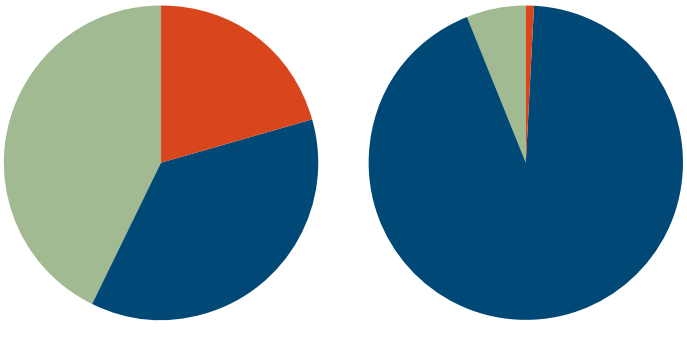
The Milliman PFI is a great example of a portfolio that has heavy allocations to bonds and alternatives allocations. As of December 2015, its estimated aggregate equity/bond/alternative allocations looked like the pie chart in Figure 4. Only 37% of total assets are in the class designated as "equities."

But don't be fooled. In that small portion—little more than a third of the total portfolio value—lies a dormant beast. It is the beast with which MMRS grapples. Using risk attribution, one can measure the contribution of each asset class to total portfolio risk. Risk attribution can reveal that a relatively small portion of a portfolio actually generates large amounts of risk. For the first quarter of 2016, the estimated "risk attribution" of the Milliman PFI can be found in Figure 5.

Ninety-three percent of total volatility is attributable to the Milliman PFI's 37% equity component! MMRS is able to effectively control total portfolio risk through equities because equities remain the largest contributor to risk. The "balanced" dollar portfolio, when separated by risk instead of dollar allocation, can be exposed as misleading. MMRS tackles this issue head on, and by doing so, it can benefit pension plans even with a relatively low exposure to equities. Many times, successfully controlling portfolio risk is as simple as controlling equity risk.

FIGURE 4: $ ALLOCATION BY ASSET CLASS

FIGURE 5: RISK ALLOCATION BY ASSET CLASS



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FED FUNDS RATE INCREASE

THE IMPACT OF FEDERAL RESERVE POLICY ON STOCK MARKETS

We are one quarter into 2016, and some things have not changed in the world of monetary policy. Central banks discovered long ago that they are not just central for countries but also for markets, and they are apparently quite comfortable at the heart of things. After seven years of matrimony between the market and the Fed, investors have seemingly cozied up to them as well.

Then, at the end of 2015 and into January of this year, rumors began circulating that perhaps this shotgun wedding between markets and Federal Reserve policy was not going to last much longer. Expectations of increasing monetary tightening were on the rise, and it was possible to quantify this change using Fed funds futures contracts. "One convenient, market-based way to identify unexpected Fed funds rate changes relies on the prices of Fed funds futures contracts, which embody expectations of the effective Fed funds rate, averaged over the settlement month" (Bernanke & Kuttner, 2003). These contracts are how news venues report the percent probability likelihood for a change in the Fed funds rate, "efficiently incorporating available information on the likely policy actions" (Bernanke & Kuttner, 2003).

According to this method, at the end of December 2015, the market was pricing in an 85% probability that rates would increase by the end of 2016. In fact, the implied probability of a Fed funds rate increase of over 1% by December 2016 was calculated to be 15%. By the end of the quarter, that probability shrunk to 2%. The probability of any increase dropped to a mere 52%. Parallel with this drastic reduction in expected Fed funds rates, domestic equities market rallied.

The extent to which equities are dependent on Federal Reserve policy (or vice versa) is still unknown, yet the relationship between equities and the Federal Reserve is too significant to ignore. In our last quarterly update, we explored how Fed policy might be serving as a source of volatility management for the latest bull market. Just as the drastic reduction in expected rate increases coincided with a market rally this quarter, strong parallels between the Federal Reserve's quantitative easing programs and market volatility were found in other periods.

Using the methodology developed by Kuttner—essentially employing futures contracts as a gauge for market expectation—it is possible to look a bit deeper inside this rabbit hole. Figure 7 plots the cumulative gain or loss on the S&P 500 against the evolving Fed funds expectation at the "next" meeting (for instance, January 25, 2012, is the "next" meeting for the graph's start date of January 3, 2012). During the period marked by QE3, the impact of the fed funds rate is minimal, as expected. Times were good; the Fed gobbled up all the mortgage backed securities it could get its paws on, and the Fed funds rate remained happily unchanged.

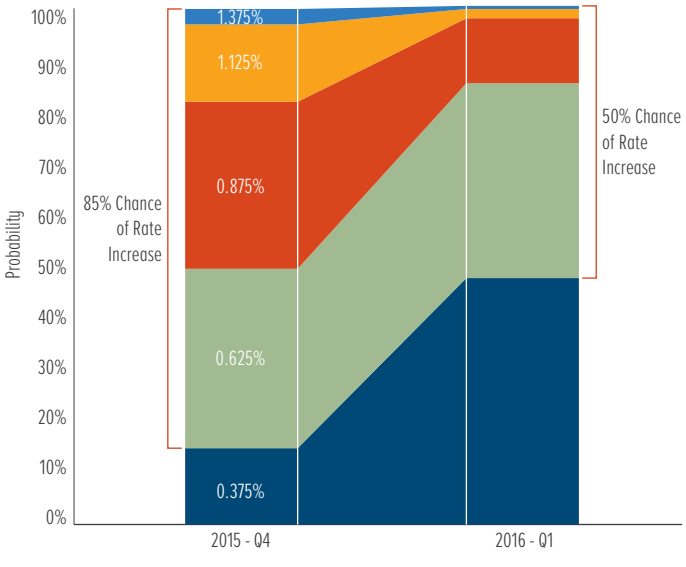
Before and after that period, investors seem to pay very close attention to that magic number and increasingly so, as a rate hike appears imminent at the end of 2015. That is what the black arrows are meant to show in Figure 7. In 2012, before the Federal Reserve announced its intention for a third round of quantitative easing, an inverse relationship is also observable between stocks and the Fed funds rate. In other words, as the Fed funds rate went down, stocks went up. According to this study, that relationship remerged in 2015. One can see how the black arrows cross one another back and forth, one up, the other down, and vice versa. To call it uncanny is to put it mildly.

This analysis also fits well into the phenomena described in the Milliman 100 with MMRS Q4 report. However, in that report the limited applicability of observing market movements within the quantitative easing programs was apparent. The added benefit of observing the Fed funds rate futures level is that it translates the ethereal to the concrete and consolidates market expectation into a single data point.

One question, frustratingly unanswerable as of yet, is if this relationship will continue. In the same paper that discusses the use of Fed funds futures, Bernanke and Kuttner also analyze the effect of a Fed funds rate increase on the equity market. They found that "interest rate reversals—the first rate increase after a series of decreases, or vice versa—may have larger implications for future interest rates than other rate changes, and thus elicit a larger stock market response" (Bernanke & Kuttner, 2003). December 16, 2015, was in fact one of those hallmark days in which Fed policy switched from easing to tightening. Because there has not been another significant change in market expectation since December, there are no observable events after the policy switch.

The conclusion that can be drawn from these graphs is that the Federal Reserve has had a significant impact on equity markets this

FIGURE 6: EXPECTED RATE BY DECEMBER 2016



past quarter. This story, though starting all the way back in 2012, is unfolding as we speak. The Federal Reserve and other central banks do not seem too keen on loosening their grip on the world economy. It is an undiversifiable risk that almost all pension portfolios will face: How will the Federal Reserve unwind its current positions, and how will it affect the stock market?

These questions are not new, but they are important, and they are ones that MMRS aims to address. In 2008, the central banks of the world took on the role of market stabilizer. They saw the market plummet overnight and leapt into action, like Alice watching the rabbit pop down its endless hole, and "in another moment, down went Alice after it, never once considering how in the world she was to get out again."

MILLIMAN PFI WITH MMRS STUDY

At the end of Q2 2015, Milliman conducted a study applying the Milliman Managed Risk Strategy to the Milliman 100 Pension Funding Index returns since inception of the Milliman 100 PFI in 2000. The results of the study are meant to illustrate MMRS's potential to help pension plans achieve their portfolio risk objectives, and in a market plagued with uncertainty, it seems as though it could not have come at a better time.

The cumulative benefit of MMRS is apparent over the 16 years of data analyzed. This update, however, focuses on the first quarter of 2016. For more information on MMRS, we recommend reading our introduction to the Milliman 100 with MMRS, which can be found at: http://www.milliman.com/MMRSPensionQ2. That paper thoroughly describes MMRS, its benefits (as well as potential drawbacks), and its long-term effects on a pension plan's assets.

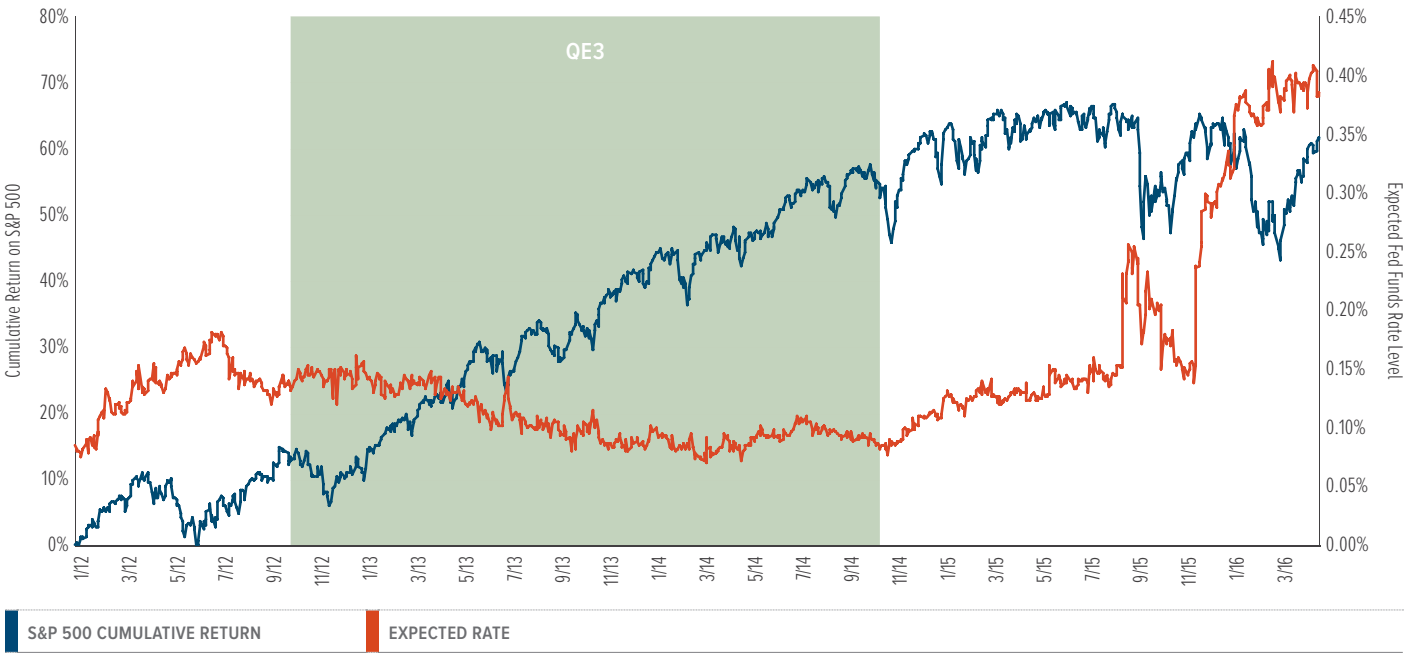
Operationally, both the volatility management and capital protection components of the strategy are implemented with equity futures contracts. Asset allocations for each unique fund in the plan can be represented as a mixture of index exposures. Once that mixture is determined, the Milliman Managed Risk Strategy can be applied to the portfolio by buying and selling futures contracts on that mixture of indices. These futures contracts are inexpensive, transparent, and highly liquid.

OVERVIEW OF THE MLLIMAN 100 PENSION FUNDING INDEX

In order to appreciate the potential effect of MMRS on pension funded ratios as explained in this paper, it is useful to first have a basic understanding of the Milliman 100 Pension Funding Index and how it works. Put simply, the PFI is designed to be a barometer of the funded ratio of the 100 largest pension plans of publicly traded companies in the United States. The funded ratio is a measure of current pension assets, expressed as a percentage of projected pension benefit obligations. A ratio of one or greater implies that the plan's assets are currently sufficient to meet its expected obligations, while a ratio of less than one suggests that the assets fall short of being able to meet future liabilities.

The PFI is calculated by creating a hypothetical portfolio of the pensions' assets. The data used to create the PFI come from Form 10-K annual reports, (which all publicly traded companies are required to file each year), as well as from other publicly available data. In addition to nominal asset and liability amounts, Milliman also uses reported asset allocation data; in the absence of a detailed list of individual plan holdings, asset allocations represent a reasonable proxy for estimating returns. The return estimates are

FIGURE 7: EXPECTED FED FUNDS RATE VS. THE S&P 500 CUMULATIVE RETURN



created by matching the asset classes found in the pension plans with financial market indexes that are believed to best represent the performance of each asset class. Once a year, the asset classes in the PFI are rebalanced to reflect the actual asset class weights in the latest annual reports. In the interim, the PFI is updated monthly based on the returns of the respective underlying market indexes.

Through this simple, rules-based approach, the PFI is able to generate ongoing estimates of pension assets and liabilities and provide a valuable real-time indicator of the health of the largest U.S. corporate pension plans. See the appendix at the end of the Milliman 2015 Pension Funding Study for more details on the methodology.

The PFI uses monthly index returns, but MMRS is implemented on a daily basis. To address this, we generated a series of daily returns using the same underlying indices. Before applying MMRS, the difference between the monthly versus daily return streams was approximately one basis point annually.

CHANGES IN THE VOLATILITY MODEL

The volatility management piece of the Milliman Managed Risk Strategy was recently updated. A new version of Milliman's volatility model has been added and implemented across the majority of Milliman's clients who utilize MMRS.

Previously, Milliman's volatility model calculated volatility based on close-to-close prices. That means each day generated a single data point of new observation: the new market close. The new model is based on intraday prices. That means that it uses intraday tick numbers, along with changes during after-hour trading, to calculate a more accurate volatility measurement.

Since many of Milliman's existing MMRS clients have transitioned over to this new model, it was decided that the Milliman PFI with MMRS should implement it as well.

MILLIMAN 100 METHODOLOGY—TAKEN FROM MILLIMAN 2015 PENSION FUNDING STUDY

The results of the Milliman 2016 Pension Funding Study are based on the pension plan accounting information disclosed in the footnotes to the companies' Form 10-K annual reports for the 2015 fiscal year and for previous fiscal years. These figures represent the GAAP accounting information that public companies are required to report under Financial Accounting Standards Board Accounting Standards Codification Subtopics 715-20, 715-30, and 715-60. In addition to providing the financial information on the funded status of their U.S. qualified pension plans, the footnotes may also include figures for the companies' nonqualified and foreign plans, both of which are often unfunded or subject to different funded standards from those for U.S. qualified pension plans. The information, data, and footnotes do not represent the funded status of the companies' U.S. qualified pension plans under ERISA.

RISK ATTRIBUTION METHODOLOGY

To develop an estimate of the Milliman 100's underlying portfolio "risk attribution", the methodology used was one similar to the method described in MSCI Barra Research Insights *Risk Contribution is Exposure times Volatility times Correlation* by Ben Davis and Jose Menchero. It employs the formula:

$$\sigma(R) = \sum_{m} x_m MCR_m$$

Where: $\sigma(R)$ is the total risk

x_m is the portfolio exposure

$MCR_m = \partial\sigma(R) / \partial x_m$, or the marginal contribution to risk at a given exposure level

First, the exposures of the Milliman 100 were split into its various benchmark indices. Then, at the given exposure level, the incremental change in volatility over 2016 Q1 was observed by scaling that exposure level up and down by a marginal amount. Essentially, it takes the derivative of portfolio risk according to the change in exposure. The change in volatility, given this marginal change in exposure, is the estimated Marginal Contribution to Risk: MCR_m. The estimated MCR observation was then scaled up according to the amount of the exposure: x_m.

As the equation shows, the sum of each $x_m MCR_m$ should equal the total portfolio risk, assuming constant cross-effects between exposures. This equality was checked, and it was found that the model estimated total portfolio volatility for 2016 Q1 of 5.3%, vs. the actual portfolio volatility of 5.7%. The minor difference can be attributed to both cross-effects, and the fact that the measurement taken was not a pure derivative, but rather an estimate of MCR.

To get the percentages in Figure 5's pie chart, the equation $|x_m MCR_m| / \sigma(R)$ was utilized. It should be noted that some of the asset classes had a negative contribution to risk. In other words, it helped lessen portfolio risk. These changes were still included as a positive in the pie chart so the total risk attribution would add to 100%.

MMRS METHODOLOGY

MMRS has two components: volatility management and a capital protection strategy. These two components consist of numerous parameters that must be specified before running a backtested analysis.

The first element of MMRS is volatility management. Volatility management adjusts portfolio exposure between high-risk assets (equities) and low-risk assets (bonds and/or cash) in order to target a defined level of volatility. Given the asset allocation of the hypothetical

portfolio based on the Milliman 100, our expected realized volatility is currently 7%. This number is lower than the volatility target in Figure 7 because it includes the additional effect that the capital protection strategy has on stabilizing portfolio return.

Whereas volatility management aims to maintain a stable level of portfolio risk, the capital protection strategy's main purpose is to hedge against losses. The capital protection strategy is directional and recognizes that the larger the loss the portfolio has experienced, the higher the sensitivity the plan sponsor is to further losses. Therefore, in periods of sustained equity losses, the capital protection strategy decreases a portfolio's exposure to further declines in the market. In periods of high positive returns, MMRS allocates excess cash back into equities.

The capital protection strategy relies on the sale of futures contracts to replicate portfolio holdings. To implement both components of MMRS, the strategy includes a futures overlay (in addition to static allocations to the underlying investment holdings).

In an effort to maximize transparency and reliability, the hypothetical portfolio based on the Milliman 100 with MMRS uses the most liquid exchange-traded hedge assets. Trades are assumed to occur once per day, at end-of-day prices. Futures contracts on the S&P 500, Russell 2000, MSCI Emerging Markets, and MSCI EAFE indices are modeled. The number of futures contracts traded each day in the analysis is based solely on the output of the MMRS algorithm, and pre-specified trading thresholds. The payoffs for each futures contract are calculated based on index returns, interest rates, and the futures multipliers. The analysis assumes that all cash held to support the margin for futures contracts earns interest based on the shortest interest rate input into the model. An additional fee of 25 basis points is taken out of the hypothetical portfolio to simulate the MMRS fee charged by Milliman to implement the strategy.

The results discussed in this paper are based on hypothetical indexes and trading. Hypothetical results have certain inherent limitations. Unlike the results shown in an actual performance record, these results do not represent actual trading. Also, because these trades have not actually been executed, these results may have under- or overcompensated for the impact, if any, of certain market factors, such as lack of liquidity. Simulated or hypothetical trading programs in general are also subject to the fact that they are designed with the benefit of hindsight. No representation is being made that any account will or is likely to achieve profits or losses similar to these being shown.

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