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# Introduction to Predictive Modeling of Fund Manager Behavior for Variable Annuities Riders

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This article is an introduction to how actuaries working with variable annuities (VA) use predictive modeling. The intended audience is for actuaries unfamiliar with daily operation of variable annuity riders, such as Guaranteed Minimum Withdrawal Benefit for Life (GMWBL), and the fund modeling process. This article will explain how predictive modeling is used to model fund manager behavior and its impact on the performance attribution and risk exposure.

The primary goal of an actuary hedging VA is to monitor the behavior of the market, the policyholders, and the fund managers to predict how these will impact the liability and the eventual claims that will be paid. The actual changes to the liability due to market impacts, policyholder behavior, and fund manager behavior are analyzed in the performance attribution. The changes due to market risk exposure are analyzed in the daily risk exposure report. The risk exposure report contains the Greeks which state how the liability will move due to shocks in the underlying risk drivers such as equity, interest rates, and volatility. The underlying account value of each policy is backed by mutual funds selected by the policyholder. Fund modeling is the process of mapping the mutual funds to an array of stock market indices where liquid assets can be purchased to hedge the VA guarantees. The array of stock market indices are used as predictors for the mutual funds' returns. The fund model will produce weights, called betas, which will allocate a certain percentage of the account value to each index. The betas are required to sum to unity. For simplicity, this article will assume that the array of indices used for fund modeling is given. (The indices to use are very company specific. It really depends on the available mutual fund lineup offered by the insurer and the size and type of risk exposures contained in the mutual funds.) Fund modeling is unique in that finding more predictors or different predictors may not help in building a better model if the predictor has no large liquid market to purchase derivatives, not enough exposure in the VA block to warrant hedging, or the block's risk exposure to a predictor is so large that the insurer would dominate the market. Assuming the indices are fixed, the drivers that can change the mapping are the underlying market return, the fund manager's behavior, and the interaction among them.

A great place to get descriptions of mutual funds and their behavior is at Morningstar.com. Morningstar groups the funds by the fund manager's investment strategy, such as U.S. Equity Fund, Allocation Funds, International Equity Funds … Alternative Funds, Commodities, and Sector Equity Funds. These are in order relative to their ease of fund modeling and hedging. (Beyond looking at just the Morningstar group to get a sense of the behavior of a fund, the reader can look at the prospectus to find the amount of cash in the fund and the turnover ratio. The amount of cash in the fund gives an indication of the level of derivatives used. The turnover ratio is the amount of assets that are bought and sold during the year.) The U.S. Equity Funds are the easiest to model because they replicate a major index. The Alternative Funds, Commodities, and Sector Equity Funds consist of a lot of derivatives, have very large turnover ratios, and have high volatility. These characteristics greatly increase the option value of the rider sold and the difficulty in modeling the fund. For these reasons, Alternative Funds, Commodities, and Sector Equity Funds are not rider eligible on VA rider guarantees. The Allocation funds are funds that state in their prospectus they will have a certain proportion of their holdings in equity and the remaining in bonds. Obviously, the aggressiveness of the fund is directly proportional to the amount of equity in the fund. Usually the Allocation funds are fund-of-funds. For proper modeling, the actuary needs to thoroughly investigate the holdings of the fund in its prospectus. For diversification and volatility management reasons, they may contain a certain percentage of their holdings in Alternative Funds, Commodities, and Sector Funds. The higher the percentage to these funds, the more tricky the Allocation fund's behavior can be to model for the reasons already stated.

Even though the Allocation fund has what appears to be an iron clad mandate to its investment strategy, the fund manager does have quite a bit of room to meet the objectives of the fund. The short-term strategy of the fund may be quite a bit different from the long-term strategy, because either the Allocation fund manager or the managers of the underlying funds are trying to take advantage of current trends in the market. If the market is in a straight climb, such as it was for all of 2013 and 2014, then, as time goes on, the fund managers will move more of their holdings to equity so they can beat their benchmark. If there is elevated volatility in the market, such as the fourth quarter of 2011 with the Greek debt crisis or third quarter 2015 with the China equity bubble, then fund managers will allocate more of their holdings to bonds to reduce volatility and minimize losses. These behaviors of the fund manager can greatly affect the decision on what predictive model to use and the behavior of its betas.

Another way to look at fund modeling is to think of it as mapping the individual risk exposures of the mutual funds to equity and

bond indices so that the entire risk of the block can be aggregated and hedged. This implies that the fund modeling has a direct impact on the risk exposure report. How the funds are mapped has a direct result on how closely the Greeks will match the movement of the liability. This in turn affects the amount and the location of the liability's risk exposures. If the risk exposures are poorly mapped, the issue won't be apparent on the risk report, but will instead appear on the attribution report as large unexplained net profit or losses (P&L). The P&L will not be isolated in one location, but bleed throughout the entire report. The fund mapping impacts the performance attribution in the following manner:

1. The fund basis is the difference between actual return and the expected return on the mutual funds. It is essentially the realization of how well the fund model performed over the period. The actual returns come from the underlying fund returns. The expected return is the fund allocation times the index returns. The fund basis line is the difference in the liability valued with expected returns versus the liability valued with the actual returns.
2. The fund modeling update line is the change in the liability due to updating the fund model.
3. Given that the betas are the means by which the account value gets mapped to equity and bond indices, the following are secondary impacts.
    a. The equity and bond exposure is a direct result of the fund mapping, which flows through the equity and interest rate net P&L lines.
    b. The allocation to equity and bond indices determines the amount of volatility exposure in the portfolio. This in turn flows through the volatility P&L line.
    c. The equity, interest rates, and volatility dictate how the velocity of the liability's change and the assets' change due to market forces. This in turn dictates the total market's P&L line.

There is a tug of war between the overall fund basis and the fund modeling update line. In order to reduce fund basis bleed from week to week, a fund model with sensitive weights can be chosen. But during a model update, if the betas significantly shift from equity indices to bond indices or vice versa, this could have a large model update P&L impact because the volatility in the portfolio will change significantly. On the other hand, if the betas are stable during model updates, the model update will have minimal P&L impact, but the fund basis bleed could potentially be large because the model is not responsive enough to the fund manager's short-term behavior.

When managing a VA portfolio, what can be done to deal with the fund manager's dichotomy between short-term incentives and long-term mandates? The easiest thing to do is create two different fund models: one for the short term and one for the long term. In general, the long-term model should have stable betas. This aligns with the principle that the fund manager will meet his fund's stated objectives over the long run. For the short-term model, the prospectus of the fund really needs to be analyzed to determine the proper behavior of the model's weights. In general, the stability of the weights should be inversely related to the turnover ratio, the

amount of cash, and the percentage of Alternative funds, Commodities, and Sector Equity Funds contained in the fund.

How does this enhancement affect the attribution and risk report? It helps relieve the tug of war between the fund basis and fund modeling lines of the attribution and it improves the accuracy of the Greeks. The long-term model has the largest impact on the overall liability value because the long term growth rate has the largest impact on the eventual claims that will be paid. The long-term model has very little impact on the Greeks, because the Greeks are an immediate shock to underlying risk drivers. The opposite is true for the short-term model due to similar logic. The fund basis is affected by both the short-term and long-term fund model because it is a direct realization of how well the fund model maps to the mutual fund returns over the life of the liability. The fund basis should be reduced because the two models will do a better job managing the fund manager's dichotomy.

In the liability model during a valuation run, how should the length of time to use the short-term fund model be defined? In our model, it is defined as the stub period, which is just the end of the policy year following the valuation date. This is done for simplicity of the model rather than accuracy. This is counter intuitive because each policy will be using the short-term fund model for different periods of time during the valuation run. But in reality, the length of time to use the short-term fund model should have almost zero impact on the Greeks and long-term liability value because there is a fund model specifically addressing each of these items. It should only have a marginal impact on the fund basis, which I suspect would not be material.

In conclusion, the VA offers a guarantee backed by mutual funds. VA actuaries need to perform fund modeling to map these mutual funds to indices where they can buy cheap liquid derivatives which can be used to hedge the liability. The major objective of fund modeling is to create predictive models, which will allow the actuary to map the funds to common indices to manage the long term risk exposures and growth rates of the account value. With this, the actuary must realize that the fund manager's incentives to outperform the fund's benchmark in the short-run will cause the fund's short-term allocations to equity and bonds to differ significantly from the long-term allocations. The funds that have a higher turnover ratio and allocation to cash are more likely to possess this behavior. To better manage the fund manager's behavior, it makes sense to have a short-term and long-term fund model for each fund. The performance attribution's net P&L should be improved because, when the fund model is updated, it should have less of a P&L shock and the fund basis bleed should be reduced from week to week. The Greeks should be more accurate because they should better reflect the changes due to market risk and fund managers' behaviors. In the liability model, the method used to transition between the short-term and long-term fund model probably should have minimal impact on the P&L, fund basis, and overall liability value. ■

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