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Risk Aggregation and Risk Magnification

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Economic Capital (EC) framework has been commonly used to quantify risk and capital. As a common practice, the final step in calculating EC is risk aggregation. The presumption is that the EC required for an enterprise is less than the sum of the individual risk exposures due to diversification benefits.

The concept of diversification is well known and used in the financial service industry. It has become an effective investment optimization and risk management tool. Investors or risk managers believe that less than perfect correlated investment instruments or risk factors can mitigate the risks and boost overall returns.

This article will focus on risk management, provide evidence of the opposite of risk diversification (or risk magnification), and discuss a potential change to the way insurance companies quantify and manage the risks.

CURRENT INDUSTRY PRACTICE

In an ideal world, this aggregation process is unnecessary by definition—as long as the distribution of the outcome by all risk factors is obtained, the tail risk measures can be calculated accordingly.

However, to obtain the distribution is difficult or even non-practical because of a lack of the following:

- An integrated stochastic scenarios generator that simulates a series of stochastic scenarios that reflects the joint distribution of multiple risk factors, where the relationships amongst the risk factors are integrated.
- A comprehensive financial projection model that is capable of capturing the true impacts of the risk factors and their interactions. It is capable of taking these scenarios as well as other financial and actuarial assumptions as inputs and calculates the financial impact on the scenario by scenario basis to obtain the distribution of impact by the joint risk drivers.

> One risk is magnified as another risk factor is introduced.

This ideal approach is the so-called integrated approach in EC literatures. It is ideal because stochastic scenarios reflect the natural relationships amongst the risk drivers via scenario file creation process and the resulting financial impact reflects diversification benefits by comprehensive projection model or reflecting the true risk factor interaction mechanism.

However, it is a complicated process, which poses a number of challenges. It not only needs a scenario generator—which requires a deep understanding of the risk factors and their relationships—but also needs a sophisticated actuarial model. The model can project assets, liability and their interaction at enterprise level. The model may also need to reflect the company's day-to-day risk management practice (such as Assets and Liability Management (ALM), or hedging) and discretionary management actions under stress such as adjustment on crediting rate or cost of insurance charge for Universal Life.

Due to the methodological and technical challenges, the integrated approach has not been commonly seen in the industry, especially for large companies with multiple lines of business. Rather, the risk aggregation approach dominates as this paper is written.

There are a few ways of doing that, from simplest to more sophisticated ones.

- Sum of each individual EC—assuming there is no diversification across risk factors.
- Applying predefined diversification benefit factor (or percentage) to the sum—applying the diversification at enterprise level, not at risk factor level.
- Using simple correlation matrix—diversification amongst risk factors is considered, but stays the same across the distribution of risk factors.
- Using correlation matrix with Copula—diversification amongst risk factors is considered and its effect varies by distribution or the degree of stresses.

Amongst these methods, the simple correlation matrix method is most common. Under this method, economic capital is calculated for each individual risk factor at the predefined confidence level, and then aggregated by multiplying the economic capital results through a correlation matrix.

By applying a correlation matrix, the required EC at enterprise level is reduced from less perfect correlation between risks, or the probability of the extreme events occurring simultaneously is lower than the probability of each one occurring individually. In other words, the worst case scenario for all individual risks does not happen at the same time. The diversification benefits are determined by the correlation matrix, which reflects the company's judgements on the relationships amongst the risk factors.

Although commonly used, we will provide a few examples in this article to show that this method may not always work for risk aggregation.

A RISK MAGNIFICATION EXAMPLE

Single Premium Immediate Annuity (SPIA) is a simple, but popular insurance product in U.S. and around the world, designed to address the financial needs for retirement. The SPIA policyholders pay a single premium in exchange for periodic benefit payments starting at issuance of the policies and last for a lifetime. The payment amount is determined at issue and usually fixed, or sometimes with inflation-index attached.

This product has two primary risk elements from insurance carrier's perspective. Namely, interest rate risk and longevity risk. The insurer incurs a more than expected loss either under the prolonged lower interest rate (than pricing) or when people live longer than expected, or both. Lower interest rate puts pressure on investment income, which jeopardizes their ability to make future benefit payments. Longevity risk assumes that policyholders live longer, which requires payments from the insurer. When both happen, the insurer earns less and pays more.

If we take one SPIA policy, and calculate the present value of the annual annuity payment of $1 under four situations, namely best estimate case (or baseline), interest rate stress, longevity stress and interest rate stress, and longevity stress happen simultaneously, we have the results below.

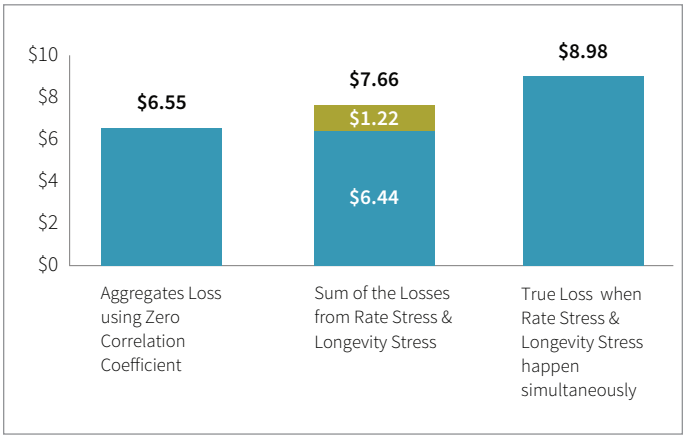
Scenarios	Present Value	Loss under stress from Baseline
Best Estimate Case (baseline)	$14.88	–
Interest Rate Stress	21.32	6.44
Longevity Stress	16.10	1.22
Interest Rate Stress & Longevity stress	23.86	8.98

If we use correlation matrix method, and assume the correlation coefficient between longevity and interest rate is zero as commonly used in the industry, the resulting aggregated loss is

$$\sqrt{6.44^2 + 1.22^2} = \sqrt{42.96} = \$6.55$$

Figure 1 compares the three types of aggregation results.

Figure 1
Three Types of Aggregation Results



The aggregated loss under correlation matrix method is the smallest and the true loss assuming the two stresses occurring simultaneously is the largest. The sum of the losses, which can also be seen as the perfect correlation between the two risk factors rather than no correlation under this correlation matrix method, is in-between.

This indicates that the correlation matrix method underestimates the true loss, even when assuming perfect correlation between the two risk factors.

This result is intuitive because the longevity risk requires the company to pay more and interest rate risk assumes the company earns less. When the two happen simultaneously, not only is there no risk offset between these risks, but also, there is a magnification effect, where one risk is magnified as another risk factor is introduced.

Another way to interpret this is that the longevity extends the benefit payment period, which not only increases the total amount of loss, but also increases the liability duration, which by definition, makes the liability more sensitive to the interest rate risk.

Another example has to do with an interaction between liquidity risk and lapse risk. An insurance company initially was experiencing some liquidity issues on the investment side, and it was downgraded by the rating agencies subsequently; once the news became public, the policyholders—without much knowledge about how to deal with it or being heavily influenced by their agents—became panicked and decided to get their money back by surrendering their policies. This action exaggerates the liquidity wound. The company was forced to sell their assets for liquidity needs. This downward spiral is another example of risk magnification, where the lapse risk becomes more severe as the liquidity risk is introduced.

THE IMPLICATION

Since there are cases where the impact of one risk factor is magnified as another risk factor is present, the correlation matrix method does not always work for risk aggregation purposes. We need to rethink the way we quantify and manage risks.

A company can perform a reality check and see if the existing correlation matrix is valid or reasonable. Although the integrated approach is not achievable at enterprise level, the company can use this approach on a small scale to check the relationship of risk factors on a pair by pair basis, and see if there is a diversification effect or magnification effect to validate the existing correlation matrix.

To quantify the magnification effect, the integrated approach is still preferred. If not possible, applying adjustments to approximate the true effect would be viable alternatives.

To manage risks effectively, managing one risk at a time or on standalone basis may no longer be sufficient. The risks need to be managed at enterprise level, where the interactions amongst risk factors need to be considered and managed as well, especially the other risks that have strong ties to the target risk to be managed.

CONCLUSION

When it comes to risk aggregation, it is not always the case that risks would have an offset effect at the tail. Preferably, risk managers can quantify risks using the integrated modeling. If not possible, explore alternative solutions to capture the impact of multiple risk factors as well as their interactions, such as using deterministic scenario analysis to pick up the compounding effects. This way the company is able to not only to manage the individual risk, but also to understand and manage their interactions. ■

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