# FSA: Enterprise Risk Management – Model Solution for End of Module Exercise

| **How Did You Do?** | |
|---|---|
| | On the following pages you will find a model solution to the exercise you have just completed. Spend about thirty minutes comparing your solution to the model. As you compare the two solutions, consider the criteria listed below. Each criterion is something that should have been done well in your report. Your report meets minimum requirements if most of the items were completed well.<br><br>• Complete all the assigned tasks and submit an Excel file with your solution.<br>**For Task 1:**<br>• Explain why each of the objectives is or is not important to YourCo.<br>• Agree in general with the ranking and reasons given.<br>• It is sufficient to discuss only one risk measure (the model solution discusses two measures and then picks one), but the selected measure must be adequately supported.<br>**For Task 2:**<br>• Match the model solution's numbers for RBC and for the diversification benefit.<br>• Identify key drivers with explanation. Your choices should generally match those in the model solution.<br>• Provide at least two limitations of the framework.<br>**For Task 3:**<br>• Provide a description of each method and then illustrate circumstances in which they are appropriate.<br>• Choose a recommended approach for each risk. Note the model solution indicates some cases where the choice is not clear.<br>**For Tasks 4 and 5:**<br>• Match the model solution for each calculation.<br>**For Task 6:**<br>• Match the calculations for economic capital and the diversification benefit.<br>• Provide two reasons. There are other acceptable reasons beyond the two in the model solution.<br>• Match the calculation needed to determine key drivers.<br>• Identify the key drivers and explain why mortality is not a key driver despite the high stand-alone capital calculation.<br>• Offer a reasonable mitigation strategy for each of the two risks.<br>**For Task 7:**<br>• Summarize the various economic capital values.<br>• Select a single value for YourCo and then support that choice.<br>**For Task 8:**<br>• Write a report that is clear, concise, summarizes your findings and makes a clear recommendation. |

## Model Solution – Task 1 – Recommend Objectives and Risk Measures

*T1.1: Identify which objectives are most important to YourCo and support your conclusions. For those not selected, explain why they are of lesser importance.*

Based on prior discussions with the YourCo team the primary objective is *Capital adequacy*. One of YourCo's major goals is to guard its reputation (and drive sales) by maintaining a high rating from the rating agencies. A key component of most rating systems is having adequate capital. If YourCo's actual capital exceeds required capital determined from its economic capital model, it is then in a better position to justify its financial strength to rating agencies.

Capital adequacy will also be used by regulatory agencies, both in the U.S. and abroad, mostly from a solvency perspective. In the U.S., this is part of the Solvency Modernization Initiative while in Europe, it is part of Solvency II, which will be implemented in the future. Also, since this company is publicly traded, financial markets and analysts pay attention to the level of capital that firms should maintain, both to protect against risks as well as finance growth.

Valuable, but of lesser importance are *Capital and business mix* and *Performance measurement and management*. When companies develop new products, they invest capital. Capital is a scarce resource. So by determining the risks that each product entails and allocating capital accordingly, YourCo will be able to assess performance before and after the cost of bearing embedded risks.

Thus, YourCo will be able to more accurately determine which lines are more profitable on a risk-adjusted basis. Based on this performance analysis, information should flow back into the pricing and decision making as the actuarial control cycle would propose. Although *Risk-based decision making and Risk based pricing* will not be implemented by YourCo in the short-term, the economic capital team should set up future internal processes to make sure that there is consistency in this regard going forward.

An economic capital model will also allow YourCo to *Monitor and control risks* over time by estimating the amount of economic capital required to cover them. Over time, this will help YourCo understand if various strategic initiatives are working along with their embedded risks.

*T1.2: Identify the primary risk measure YourCo should use in determining economic capital and support your choice.*

The two risk measures in common use are VaR and CTE (which has several other names). CTE is more appropriate for YourCo for the following reasons:

- It is a coherent measure of risk.
- VaR is more appropriate for short-term businesses where the magnitude of insolvency is of less importance (for example, shareholders are not responsible beyond the funds they invested).
- CTE is more appropriate for longer-term businesses where the degree of insolvency matters (particularly if others, such as guarantee funds, will have to make up the difference). This more accurately describes YourCo's situation. In fact, the two measures could be operational at the same time. For example, to be able to monitor "normal" risks on a day-to-day basis, VaR is still appropriate and can be implemented risk category by risk category. However, it cannot be added as it is an incoherent measure.
- CTE could also be used for more "extreme" situations, situations that concern regulators.

## Model Solution – Task 2 – Calculate Risk Based Capital and Diversification Benefit and Identify Key Drivers of Risk Based Capital

*T2.1: Calculate the amount of RBC the rating agencies would calculate for YourCo.*

For each risk, the capital requirement is the product of each value times the RBC factor. The totals for the four risks are:

Asset risk – 8.0
Insurance risk – 30.0
Interest risk – 16.4
Business risk – 6.3

The total risk, not accounting for diversification is 60.7

Applying the RBC formula produces

$$\text{RBC} = 6.3 + \sqrt{(8.0 + 16.4)^2 + 30.0^2} = 45.0$$

*T2.2: The difference between the sum of the RBC amounts for the various risks and the total rating agency RBC is known as the diversification benefit (also called the covariance credit). Calculate the diversification benefit.*

The diversification benefit is 60.7 – 45.0 = 15.7.

*T2.3: Within each category, identify the key drivers of RBC for YourCo under this rating agency approach.*

In the RBC formula, the key driver is the item that makes the greatest contribution to the total for that category. Thus a factor could be a key driver because it represents a large proportion of the exposure in that category (large "Value") or because it has a higher RBC factor (large "Factor").

For the Asset risk category, the main driver of the overall RBC of 8 is the Structured Finance category (contributing 5.0 to the total). This is reasonable because the other investment categories, such as treasuries, have historically led to low losses.

For the insurance risk, the RBC of 30 is driven entirely by the high amount of life insurance exposure that YourCo has outstanding.

For the Interest Rate Risk category, the RBC of 16.4 is driven by the underlying guarantees of the variable annuities and the interest rate risk of the fixed annuities. Here the three variable annuity factors have been combined, to contribute 9.0 to the total. Likewise, the fixed deferred and payout annuities combine to contribute 7.3.

For business risk, the RBC is driven equally by the Separate Account and the Life and Health premiums. Basing business risk off of the level of premiums is an indirect approach to recognize the extent of strategic and operational risks present in those lines of business, including the new proposed trading operation.

*T2.4: Identify limitations of using this framework for assessing a company's capital adequacy.*

The RBC framework may not be optimal for assessing a company's capital adequacy for several reasons. First, the factors are developed using a "one size fits all" approach that does not reflect the unique risk profile of a given company. Also, the calibrations for certain risks may not appropriately reflect stressed conditions; especially in light of recent turmoil in financial markets (e.g. credit risk on assets). Further, certain risks that are becoming more prevalent in holistic risk management frameworks are not incorporated in the RBC calculation (e.g. reputational risk). Moving toward an economic, principles-based approach for assessing capital adequacy would address many of these limitations.

## Model Solution – Task 3 – Suggest Quantification Approaches

*T3.1: Briefly describe each approach and indicate, in general, circumstances in which each is appropriate.*

*Stress testing* – "Projecting future cash flow based on a (set of ) scenario(s) that could occur in some extreme environments but for which occurrence probability is not specified." (Milliman, p. 26)

This approach can be appropriate for many types of risk, and often aids user understanding since a defined shock is generally more tangible than a point or range from a probability distribution. It is also generally easier to implement.

*Scenario testing* – Measuring impact of specific scenarios on the loss by simultaneously applying the scenarios to multiple risk drivers. (Milliman, p. 18, paraphrased)

A scenario is usually a combination of predefined stresses developed to be able to assess globally the overall impact of an adverse situation. For example, a scenario could be the estimation of the exit of a European country from the Euro Zone. Then, explicitly, this situation has to be translated into impacts on interest rates, short and long-term, credit spreads, recovery rates, reputation risks, management reactions, etc. Then, the whole scenario is tested at once. Indirectly, extreme correlations are assumed in the scenario itself instead of being done explicitly like in the Stress Testing Approach. The methodology can be done for multiple scenarios at once, like the impact of a pandemic on the economy combined with environmental changes. This approach is useful in cases where risks are independent or loosely correlated within a model and there is interest in the impact of these risk events occurring together.

*Stochastic modeling* – Projection of future cash flow based on multiple scenarios with a probability distribution for the scenarios defined (Milliman, p. 25, paraphrased)

A probabilistic model must be developed and calibrated for each risk that is stochastically modeled (and any deterministically-modeled risks must be adjusted for consistency). The overall approach for each risk is to assume a trend plus normal fluctuations and a jump process for unlikely situations. Although it could be applied to any kind of risk, it is usually implemented for financial risks. In many cases now, these models are modified to account for liquidity considerations in extreme situations, like liquidity-adjusted credit spread models.

*T3.2: For each risk below, recommend which of the three approaches should be used by YourCo and provide a brief justification for each choice.*

Risks that relate to financial markets are best modeled stochastically. They are diversifiable through products such as, interest rate floors and caps, and equity and credit swaps, credit, which should be integrated into the modeling. These risks are often correlated. They can often be produced by a single economic scenario generator that takes into account historical or market-based correlations. For YourCo, these risks are *Credit spread, Interest rate, Currency FX* and *Equity*. Liquidity risk is not diversifiable unless YourCo were a bank that could have access to central bank's funds in case of a liquidity emergency. Some longevity instruments are being developed to diversify this risk beyond the traditional reinsurance options and the modeling could reflect that.

*Credit counterparty* risk could also be modeled stochastically. Unless the counterparties are traded, in which case a credit spread modeling approach could be used. Another option is to model credit

migration explicitly using transition matrices. In addition, it is possible to model actual defaults by counterparty based on probabilities of default and exposures. These may not be included in an economic scenario generator. This may depend on YourCo's particular counterparties.

*Mortality* and *Longevity* risks have two components. The actual number of deaths can be modeled deterministically from a mortality table. As a diversifiable risk, there is no need for more complex modeling. However, the mortality tables themselves are non-diversifiable. Scenario testing under various rates of mortality improvement and/or shocks (such as a pandemic or a cure) is likely to be sufficient.

*Operational/Reputational* risks may be modeled either stochastically using a frequency-severity model or with stress tests. There may be insufficient information available to construct a stochastic model unless an external database of operational risk events is available.

## Model Solution – Task 4 – Calculation of the Total Asset Requirement

*T4.1: Using the projection output determine the total asset requirement (TAR) for this scenario under two different approaches.*

For the *liability runoff* method, the TAR is the current assets (1,000) less the minimum surplus (assets – liabilities) over the thirty years (-33). Thus, TAR is 1000 – (-33) = 1033.

For the *one-year mark to market* method, the TAR is the current assets (1,000) less the surplus on a market-consistent basis as projected one year from now (979 – 970 = 9) for 1,000 – 9 = 991.

*T4.2: For each approach, calculate economic capital using the TAR.*

Under the *liability runoff* method, economic capital is the difference between TAR and current (that is, time 0) liabilities, or 1033 – 950 = 83.

The economic capital by the *one-year mark to market* method is the excess of the TAR over the current market value of liabilities, or 991 – 965 = 26.

## Model Solution – Task 5 – Calculation of Economic Capital Measures for Each Risk

*T5: Based on the simulations, calculate economic capital measures for each risk using VaR(99) and CTE(95).*

The value of VaR(99) can be obtained either by using Excel's Percentile function or by sorting the 1,000 values (sorting each column separately) and then locating the $10^{th}$ largest value. The latter measure was used here (the Percentile function gives a slightly different answer). The risk measures are:

| | |
|---|---|
| Mortality | 25.5 |
| Longevity | 11.7 |
| Credit | 42.0 |
| Interest rate | 34.0 |
| Currency FX | 21.8 |
| Equity | 16.1 |

For CTE(95) it is easiest to sort the values and then average the 50 largest ones. The values are:

| | |
|---|---|
| Mortality | 20.7 |
| Longevity | 10.2 |
| Credit | 31.8 |
| Interest rate | 30.6 |
| Currency FX | 19.5 |
| Equity | 14.4 |

## Model Solution – Task 6 – Calculation of Aggregate Economic Capital

*T6.1: Using these correlations and the individual risk economic capital results from Task 5, determine YourCo's aggregate economic capital. Do this for both the VaR(99) and CTE(95) risk measures.*
*T6.2: Next, for each risk measure calculate the benefit of diversification.*

For VaR(99) the sum of the values for individual risks is 151.1. When the correlations are taken into account the economic capital value becomes 84.6. The diversification benefit is 151.1 – 84.6 = 66.5.

For CTE(95) the sum of the values for individual risks is 127.2. When the correlations are taken into account the economic capital becomes 70.4. The diversification benefit is 127.2 – 70.4 = 56.8.

*T6.3: Provide two reasons why this analysis may not appropriately reflect the interrelationships among the risks and for each suggest an alternative approach that may address your concern.*

A correlation analysis has several shortcomings. Among them are:

- Many risks have relatively small overall correlation but a significant tail correlation. One method of incorporating this type of correlation is to use a copula module (but not the normal copula).
- The square root formula is not exact (it is accurate for standard deviations, but not for other risk measures). A better approach might be to incorporate the various risk relationships into the simulation model, thus simulating the overall loss. Note that in this exercise, the simulation model used produced values for each risk separately, thus did not have correlations built in. The model can also be supplemented wfith deterministic scenarios that combine risk events at various defined levels of severity. Scenario testing is useful when developing a stochastic model of certain risks or their interrelationships is difficult or not practical.

*T6.4: Using only the information in the spreadsheet, determine (under each risk measure) the key drivers of economic capital. Explain why a risk with relatively high stand-alone economic capital values turns out not to be a key driver.*

For each risk, the economic capital measure was set to zero and the change in aggregate economic capital recorded. The results were:

| Risk | Change, using VaR(99) | Change, using CTE(95) |
|---|---|---|
| Mortality | 3.4 | 2.5 |
| Longevity | -1.0 | -0.8 |
| Credit | 30.5 | 22.6 |
| Interest rate | 14.4 | 13.5 |
| Currency FX | 9.3 | 8.6 |
| Equity | 9.5 | 8.2 |

Under either risk measure, credit risk is the key driver, followed by interest rate risk. While the order is reversed under each measure, both Currency FX and Equity have similar effects and are less than the two key drivers. Credit and interest rate risks are the key drivers because they are assumed to be positively correlated with most of the other financial market risks, in addition to requiring the largest stand-alone economic capital. Mortality and Longevity have very little impact. It is interesting to note that mortality is third in the amount of stand-alone economic capital required yet is not a key driver. This is due to the hedge provided to YourCo by having both mortality and longevity risks (represented in the model by a negative correlation between these risks).

*T6.5: The results of the stress tests indicate that these risks can have a significant impact. For each, suggest a way in which YourCo might mitigate the risk (and thus reduce any additions to economic capital related to these risks).*

The consultant identified a potential loss of 135 if a scenario similar to the 1918 influenza epidemic recurs. This may be extreme, but mitigation of this risk is still important. One alternative is to purchase reinsurance against YourCo's mortality risks (also noting that this is a case where its longevity risks may provide an even greater hedge). When evaluating this strategy, it should be noted that there is counterparty risk, particularly in extreme scenarios.

The other stress test performed by the consultant identified a potential loss of 263 due to the operational risks associated with the new longevity swap product segment. The majority (250) of the stressed loss comes from exposure to excess risk taking by the new trading staff. One possible mitigating action would be to revise the compensation structure so the traders have less incentive to take risk. Reviewing trader compensation from the perspective of the economic capital risk appetite may motivate YourCo's management to take this action even if it is unpopular with the new trading staff.

## Model Solution – Task 7 – Analysis of Results

*T7: Based on the key objectives from Task 1, draw conclusions regarding the level of capital currently held and make a recommendation regarding appropriate economic capital for YourCo to hold. Support your statements.*

Four values of economic capital have been calculated. They are:

- The current surplus of 50.
- The rating agency RBC value of 45.
- VaR(99) of 84.6.
- CTE(95) of 70.4.

The most important objective is approval from rating agencies. At the present time YourCo is in a good position as their current capital is 5 more than the RBC formula. However, this is a fairly shaky position to be in. As the stress testing showed, that margin of 5 is not sufficient to assure YourCo's management and stakeholders that a downgrade may not occur in the future. In addition, it is likely that ratings agencies and regulators will be moving toward requirements that are more in line with risk measures such as VaR and CTE.

As noted in Task 1, CTE is a better risk measure for companies like YourCo. My recommendation is that YourCo move to increase its surplus from 50 to 70 to provide more protection against future losses.

## Model Solution – Task 8 – Report to CRO

To: YourCo CRO
From: Actuarial Student
Re: Economic Capital

*Introduction*

At your request, I (with assistance from the economic capital team and a consultant) have built an economic capital model designed to help YourCo meet its primary objective – ensuring that YourCo can demonstrate to rating agencies (and others) that it holds adequate capital. Based on the model, I recommend that YourCo increase its capital from 50 to 70.

In completing this project, we also learned that YourCo's key risks are credit and interest rate. We identified two additional risks via stress testing that can produce significant capital losses and we will suggest mitigation strategies.

*Key decisions*

Economic capital can be used to help achieve a variety of objectives. Because YourCo is committed to maintaining high ratings, capital adequacy is its primary objective. This will become more important as regulatory regimes such as Solvency II and the Solvency Modernization Initiative will place more emphasis on capital levels.

There are a variety of risk measures that can be used when determining economic capital. I have selected CTE because it is more appropriate when assessing long-term risks. It also measures the degree of losses (when they happen), which is of interest to those (such as regulators) who may have to make up any shortfall. Based on conversations with the consultant and our stakeholders, we have selected calculating this measure at the $95^{th}$ percentile.

I used stochastic modeling throughout because the consultant was able to provide an excellent economic scenario generator and we also believe we have good estimates of the correlations between the various risks. Normally, we might use stress or scenario testing for some risks (such as mortality and longevity), particularly when constructing a stochastic model is difficult. We used stress testing for two extreme situations that may affect YourCo.

Aggregate economic capital was calculated using a square root formula that combines the stand-alone values (calculated using CTE) and the correlations. This formula is in common use, but can underestimate economic capital for risks that have relatively low correlation at most levels, but high tail correlation. A copula model could be used to address this issue, but we currently lack the expertise to implement such a model. To account for the tendency of risks to move together in tail scenarios, we could supplement our results by developing deterministic multiple-risk scenarios and calculate their economic capital requirements.

Another option was to use a formula (that does not require correlations or stochastic modeling) that is in use by the rating agencies was considered. This formula is based on a one size fits all approach that does not reflect a company's risk profile. The method we used is based on economic principles and is more likely to provide an accurate assessment of required capital.

*Calculations*

The first step is to calculate the stand-alone capital required (measured by CTE(95)) for each of the six key risks faced by YourCo. The values are:

| | |
|---|---|
| Mortality | 20.7 |
| Longevity | 10.2 |
| Credit | 31.8 |
| Interest rate | 30.6 |
| Currency FX | 19.5 |
| Equity | 14.4 |
| | |
| Total | 127.2 |

The next step is to apply the square root formula to these values (using the correlations) to obtain a value of 70.4. The difference of 56.8 represents the benefits of diversification.

*Recommendations*

Based on the decisions outlined above an economic capital model was constructed. The recommended capital from that model is 70, which I believe is an appropriate target for YourCo. At this value we should be able to maintain our high rating and also be prepared for future regulatory regimes.

Stress testing indicated that significant potential losses could occur if an influenza pandemic similar to that in 1918 were to occur or if we were to suffer operational or reputational losses due to the new longevity swap segment. For the pandemic risk YourCo should consider reinsurance against mortality risks (being aware of counterparty risks as a pandemic will affect all companies and thus may lead to reinsurer failures). For the reputational risk, YourCo should consider revising the compensation structure so that the traders have less incentive to take risks.