

2010 Examinations

SPECIMEN EXAMINATION

Subject ST9 — Enterprise Risk Management

Time allowed: Three hours

INSTRUCTIONS TO THE CANDIDATE

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all six questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

AT THE END OF THE EXAMINATION

Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.

<p><i>In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.</i></p>
--

- 1**
- (i) Define four major risks which can be effectively modelled quantitatively. Explain the reasons for each choice. [4]
 - (ii) Define four major risks which cannot be effectively modelled quantitatively. Explain the reasons for each choice. [4]
- [Total 8]

2 Your answers to the following questions should assume that the firm already employs a Chief Risk Officer.

- (i) Describe eight practices that a firm could introduce to reduce risk without incurring significant additional direct or indirect cost to the firm as a whole. [8]
 - (ii) Describe four practices that a firm could introduce to reduce risk which would predominantly incur an indirect cost rather than a direct cost to the firm as a whole. [4]
 - (iii) Describe four practices that a firm could introduce to reduce risk which would predominantly incur a direct cost rather than an indirect cost to the firm as a whole. [4]
- [Total 16]

3 You have recently completed an ERM model for your employer, a large publicly owned bank. Your manager has asked you to supervise the process of validating that the model is both working as intended and is appropriate for its intended uses. The bank is listed on a major stock exchange and subject to sophisticated government regulation.

- (i) Describe all aspects of the initial model validation process. [10]
 - (ii) Describe the ongoing re-validation process, with reference to the actuarial control cycle. [4]
- [Total 14]

- 4 A bank has decided to launch a new fund. The fund will raise debt and equity at the outset. No distributions will be made during the life of the fund other than interest payments to the debtholder(s). At the end of 5 years the fund's assets will be sold and the proceeds distributed to the stakeholders.

The bank's wealthy private investors will invest a total of £20m in the fund as equity. The remaining £80m raised will be in the form of floating rate debt, with all of the principal to be repaid at the end of year 5. The initial coupon on the debt is expected to be 5% p.a. The bank will not guarantee any future returns to either the equity holders or the debt holders.

The fund will invest solely in BB rated corporate bonds. There are no restrictions on issuer, currency, interest payment type or term to maturity. The sole restrictions are that the investments must be bonds issued by companies and the rating of each bond must be BB at all times during the holding period. That is, a bond must be sold if its rating changes and replaced with another suitable bond. The initial average bond coupon is expected to be 7% p.a.

- (i) Explain four of the most significant risks impacting the equity investors' ultimate return. [4]
- (ii) Explain the most significant risk impacting the bank. [1]

The following table shows the one year rating transition probabilities for BB bonds and the probabilities of default over time for a bond that is rated BB at time zero.

<i>Rating</i>	<i>Rating of BB Bond at Year end %</i>	<i>Year</i>	<i>Probability of Default at the end %</i>
AAA	0.03	1	1.06
AA	0.14	2	3.48
A	0.67	3	6.12
BBB	7.73	4	8.68
BB	80.53	5	10.97
B	8.84		
CCC	1.00		
Default	1.06		

- (iii) Calculate the total expected default losses to be incurred by the fund over the 5 year term. State any assumptions that you make. Your answer should incorporate the anticipated cash flows of the fund. [5]
- (iv) Explain the credit and interest rate spread which is most relevant to the equity investors. [2]
- (v) Describe an appropriate model to simulate future values of the spread identified in (iv). [6]
- (vi) Describe the AIC and BIC model selection criteria that could be used to select the most appropriate model. Your answer should include the model minimizing formulae. [2]

[Total 20]

5 ABC Ltd. is a UK-based general insurance company specialising in underwriting natural catastrophe risks on property.

- Around 90% of its underwritten risks are losses arising from US wind storms.
- Its loss ratio (total losses/total premium net of direct acquisition costs) in each of the last 5 years was: 10%, 140%, 50%, 30%, and 90%.
- Premium income has been constant from year to year for many years.
- ABC maintains underwriting offices in both New York and London.

Pro-Forma Balance Sheet as at 31 December 2008 (GBPm)

Assets:

Cash	100
Government securities	100
Equity investment in US house builders	<u>100</u>
Total Assets	300

Liabilities:

Outstanding claims liabilities	240
--------------------------------	-----

Net Shareholders' Funds:	60
---------------------------------	----

Pro-Forma Profit & Loss Statement for the year ended 31 December 2008 (GBPm)

Gross written premium income	150
Less: direct acquisition costs	<u>30</u>
Net written premium income	120
Investment income (expense)	-30
Claims incurred	108
Operating expenses	<u>24</u>
Profit before tax	-42
Tax at 28%	<u>0</u>
Profit after tax	-42

(i) Describe ABC's key business risks, meaning the risks to which it is specifically exposed due to the business undertaken. For each risk identified your answer should include:

- (a) A description of the risk
- (b) A rough estimate of the size of the risk expressed in GBPm
- (c) A description of any potential interdependencies

[8]

(ii) Explain the construction of a simple model which could be used to perform both sensitivity analysis and scenario analysis on this business.

[6]

- (iii) (a) Explain how sensitivity analysis could help ABC improve its understanding of its business risks. [4]
- (b) Give four examples of a suitable sensitivity analysis. [4]
- (iv) (a) Explain how scenario testing could help ABC improve its understanding of its business risks. [4]
- (b) Give four examples of a suitable scenario test. [4]
- [Total 22]

6 A general insurance company has written three classes of business for many years. In the distant past the actuary for the company used to estimate single point estimates of the loss reserves for each class. These three estimates were invariably adopted by management for the purpose of compiling the company’s annual accounts. In recent years the actuary has included reserve range estimates in his report to management, using a Value at Risk measure to estimate extreme events. The actuary calculates the 97.5% quantile of the overall loss reserves as follows:

- Estimate the best estimate of loss reserves for each class of business using traditional actuarial methods. Assume that these best estimates are equal to the mean of a loss reserve distribution.
- Assume that the loss reserve distributions are lognormal.
- Judgmentally select coefficients of variations for each class based on work published by other actuaries from time to time.
- Judgmentally select correlation coefficients between the three classes based on work published by other actuaries from time to time.
- Use a Monte Carlo simulation model to aggregate the outstanding losses from each of the three classes into one overall loss reserve distribution for the purpose of estimating the 97.5% quantile.

- (i) Discuss the actuary’s approach. [12]
- (ii) Describe the four axioms of a coherent risk measure. [4]
- (iii) Prove that Expected Shortfall satisfies the subadditivity condition of a coherent risk measure for loss distributions. You can use the “law of large numbers for Expected Shortfall Lemma” without needing to prove it. [4]

[Total 20]

END OF PAPER

2010 Examinations

SPECIMEN SOLUTIONS

Subject ST9 — Enterprise Risk Management

- 1** (i) Interest rate risk is the risk arising from changes in interest rates which includes the potential changes in customer behaviour as well as the financial impact. A wealth of historic data are available and a range of forecasting models have proved to be useful predictors of future interest rates meaning that the risk is relatively quantifiable.

Foreign exchange rate risk is the risk arising from movements in foreign exchange rates. A wealth of historic data are available and a range of forecasting models have proved to be useful predictors of future interest rates meaning that the risk is relatively quantifiable.

Credit risk is the risk that a counterparty to an agreement is unable or unwilling to make payment(s) due under an agreement. It can also include changes to the value of an asset due to changes in the perceived creditworthiness of the underlying obligor(s). The inability to pay is relatively quantifiable given the wealth of historic data and the resultant range of credible forecasting models. The unwillingness to pay is not particularly quantifiable depending as it does on socioeconomic behaviour.

Basis risk is the risk arising from differences in the movements of two comparable indices: That is the extent to which a particular position reflects the position required. It is quantitative by its nature because it is the measurement of the potential difference between two other quantified indices.

[Note: other appropriate risk types would be acceptable, such as insurance risk and other forms of market (financial) risk.]

- (ii) Social risk is the risk of a change in society creating a change in demand and/or the opening of new market opportunities and/or the alteration of a business's responsiveness to demand, and as a consequence the characteristics of its workforce. The risk is society's impact on business and not vice versa. This risk cannot be reliably measured because it is behavioural and reliant on people. Changes in society can arise for a myriad of reasons making the past a relatively poor guide and certainly no guide as to the timing of change.

Legal risk is the risk of failing to operate within the law, failure to show evidence of operating within the law and failure to recognise and manage legal threats. This risk cannot be reliably measured because it is behavioural and reliant on people. Effective and strictly observed business processes will of course mitigate the risk. Provided the business processes and observance levels remain up to date then the past may be some guide to the future but at best this will only ever be a very approximate guide.

Political risk is the uncertainty that stems, in whole or part, from the actions of governments and/or non-governmental groups. This risk cannot be reliably measured because it is behavioural and reliant on people. Because people change in government and because economic/social/religious circumstances change over time, the past is an unreliable guide to the future.

Technology risk is the risk of events that would lead to insufficient, inappropriate or mismanagement of investment in technology. The risk cannot be reliably measured because insufficiency, inappropriateness and mismanagement are all qualitative concepts.

[Note: other appropriate risk types would be acceptable, such as regulatory risk, agency risk, reputational risk.]

- 2** (i) Include risk skills as a valuable aspect in future hiring decisions to help to embed risk awareness in the firm's culture.

Form a risk committee made up of management from risk, audit, financial and compliance. Ensure that the committee is for the most part separated from business personnel and that the committee has significant terms of reference, reporting lines and regular access to the chief risk officer.

Inform management and personnel of enterprise risks on a regular basis and encourage feedback.

Incentivise business management to identify risks, report risks to more senior management and to produce risk-adjusted profits, through use of an appropriate reward/bonus system. That is, modify the current remuneration system without adding to the overall cost.

Include promoting ERM, ensuring its effectiveness and implementation of its recommendations in the CEO's own performance evaluation.

Produce simple ERM management reports for both senior management and the board. The reports must include the risks, an estimation of their frequency and severity and recent measures taken to mitigate them.

Introduce a common risk language to the firm including risk rating systems and standard templates for risk reports to improve efficiencies and to improve comprehension.

Include risk discussion as an integral part of staff/management meetings.

Develop and communicate clear organisational responsibilities for the identification and management of risks.

Develop a culture that encourages open and wide communication around the company.

[Note: The solution only requires eight practices for full marks.]

- (ii) Introduce constraints on business practices in order to reduce risk through diversification. For example, set additional portfolio constraints on investments.

Introduce counterparty constraints in order to reduce risks through not trading with more risky counterparties. For example, a bank could introduce lending guidelines which targeted only investment grade companies.

Increase corporate governance within the firm. For example and using available internal resources only, introduce frequent internal audit to all areas of the firm and increase the volume of reporting in the firm. Ban overtime in the firm and require all personnel to take at a continuous period of at least two weeks off each year. People who are less tired may make fewer mistakes and corporate fraud, if existing, is often discovered when the perpetrator is away on leave.

Sell fewer “high risk” products. For example, withdraw from the immediate annuity market (thereby reducing the potential to make profit from it) if it is believed that the company has reached its longevity risk capacity.

- (iii) Transfer risk, e.g. buy insurance and/or buy protection in the financial markets.

Sell risky assets and replace them with less risky assets (or which better match the liabilities).

Close down or reduce in size divisions or product lines which are felt to be particularly risky.

Centralise operations in order to reduce operational risks.

3 (i) The validation process must include:

Quantitative Methods

The use of effective statistical processes to evidence the goodness of fit of key aspects of the model to past data. Goodness of fit techniques will likely include maximum likelihood estimates and method of moments.

The use of sensitivity analysis to changes in key assumptions to test the stability of the model.

The use of back-testing the model to observed experience. Back-testing is important because depending on how volatile past experience has been, it may be possible to test the relative reasonableness across the quantile range of the modelled distributions and not just at, say, extreme results.

Qualitative Methods

The use of scenario analysis and stress testing to assess the apparent reasonableness of the model output to expectations.

Most ERM models will be employed to estimate the potential cost of extreme results. By their nature extreme results don't happen very often (if ever depending on how extreme). Most people accept that appropriate loss distribution models will be monotonically decreasing in the tails; it is the relative weight of the tail over which people will have some differences of opinion. Extreme event stress testing with input from experienced persons is a very useful way of trying to validate the relative weight in the tail of the model.

Internal Validation

The model must be interrogated by appropriately skilled persons at every level of detail from the individual calculations to the overall output being considered by the board.

External Validation

The model will be interrogated at different levels of detail by the auditors, the stock exchange, the credit rating agencies and the regulator. These entities will be expected to compare and contrast the design/input/processes/output of the model with their own internal model ideas and with other ERM models which have been submitted to them by similar firms. As an aside, external parties will not be formally validating the model. They are not in the business of helping firms to build ERM models. They will merely be corresponding with the bank until such time that they are satisfied that the model is sufficient for their own particular oversight purposes.

Data

The model is only as good as the data upon which it is based. The data must be reviewed in order to assess the appropriateness of the population of data employed, the accuracy of the data and the completeness of the data. If model points have been used, the appropriateness of the groupings chosen can be tested by comparison with selective full data runs.

Assumptions

The model assumptions should be presented to all appropriate persons including documentation supporting the derivation/reasonableness of the assumptions. Assumptions made on the basis of nothing more than judgement can be expected to be fully interrogated.

The validation process:

Is iterative

Both internal and external parties will review the model/model output and comment on all aspects of the model. The comments must be addressed and responded to. Agreed model changes should be regularly released to all parties to review and make any further comments.

Requires clear reporting lines and ultimate responsibility

Requires clearly designated responsibilities so that all parties inputting to the validation process know who is responsible for what aspects of the model and who is ultimately responsible for the validation.

Requires Documentation

Of course the model will be fully documented. The validation process must also be fully documented so that any interested party can review the comments made, the responses, the work that was done, the key points of the discussions, the resultant changes to the model and the final agreements from all parties on the acceptability of the model.

Output

Particularly senior management will not wish to review the model itself. Instead they will rely on output from the model. This output must be straight-forward, consistent over time, not too voluminous and sufficient to describe both the key model results and the work undertaken in the validation process.

- (ii) The ongoing re-validation process is in many ways a real time process along the lines of the actuarial control cycle of model specification, parameterisation and construction, testing to new data and unfolding experience, redesign and re-parameterisation. It will involve:
- Testing actual experience to modelled expected experience
 - Re-fitting distributions as new data unfolds
 - Considering introducing new data types/processes to improve the model
 - Corresponding with internal and external parties as necessary over major and minor changes
 - Calculating the impact of the changes
 - Updating the model documentation

- 4 (i) Interest rate risk and more particularly the spread between the average coupon on the bonds and the cost of the debt.

Investment market risk and more particularly the risk of overall capital loss resulting from sales of the corporate bonds in the market at the end of year 5 and during the term as the credit ratings change.

Foreign exchange rate risk which could be significant if the currency of the debt is different from the currency or currencies of the bonds. It could also be significant if the currency of the equity investment is different from the currency or currencies of the bonds.

Default losses risk on the BB corporate bonds, being the risk that default losses are greater than forecast.

- (ii) Assuming that the bank is not the debtholder then the largest risk facing the bank is reputational risk in the case that the fund's returns are significantly less than forecast.

(iii) **Assumptions**

The BB bonds will be sold once their ratings change and new BB bonds bought as immediate replacements.

1.06% of the held bonds will default each year without transitioning.

The fund does not recapitalise for default losses. However it does receive coupons from the bonds and net capital gains from the bond sales.

The fund will pay small commissions to sell the corporate bonds as necessary.

The fund will pay the interest on the debt from time to time.

Assume that capital gains net of selling costs are zero each year.

Assume the fund makes 7% p.a. coupon on the bonds and pays 5% p.a. interest on the debt throughout the investment period.

Assume coupons received at year end and defaults all occur at year end and after receipt of the coupons.

Assume net cash receipts are all reinvested.

Assume no principal is recovered on defaulted bonds.

Calculation

The equity portion of the fund is growing at the rate of $(7 - 1.06) = 5.94\%$ p.a. and incurring 1.06% in default losses each year. The debt portion of the fund

is growing at the rate of $(7-5-1.06=)$ 0.94%p.a. and incurring 1.06% in default losses each year. Hence,

$$\begin{aligned} \text{£}5.68\text{m} &= 20 \times 0.0106 \times 1.07 \times \sum_{n=1}^5 (1.0594)^{n-1} \\ &\quad + 80 \times 0.0106 \times 1.02 \times \sum_{n=1}^5 (1.0094)^{n-1} \end{aligned}$$

- (iv) The investment performance of the fund is largely determined by the spread between the redemption yield on a basket of BB bonds and the interest rate that the debt is tied to e.g. 3 month LIBOR. The positive differential pays for the expected costs of the default and provides the investors with a leveraged return.
- (v) The spread is the difference between two interest rate series. It will likely be best to develop a simulation model which separately models the two different time series and then seeks to allow for auto-correlations between the two time series. The resultant spread can then be calculated for any given iteration. The alternative of developing a single model of the spread volatility using ARCH or GARCH processes should be tested but will probably result in a less stable model.

The forecast period will be 5 years.

The model will be based on time series going back over many years and paying particular regard to the range of BB bonds that the fund manager expects to invest in.

Whilst time series could be fitted directly from the two underlying data sets, the forecasting capability of the model might be improved if other time series were introduced which were correlated with the two required time series. This would only be helpful where the predicting powers of the additional time series were considered to be superior to the predicting powers of the two required time series on their own.

- (vi) Assume that there are m models M_1, \dots, M_m with model j having k_j parameters denoted by $\theta_j = (\theta_{j1}, \dots, \theta_{jk_j})'$ and a likelihood function $L_j(\theta_j; X)$. Let $\hat{\theta}_j$ denote the MLE of θ_j .

The Akaike Information Criterion (AIC) selects the model that minimises:

$$AIC(M_j) = -2 \ln L_j(\hat{\theta}_j; X) + 2k_j.$$

The Bayes Information Criterion (BIC) selects the model that minimises:

$$BIC(M_j) = -2 \ln L_j(\hat{\theta}_j; X) + k_j \ln N$$

where N is the number of observations in the dataset.

- 5** (i) Insurance and underwriting risk, being the risk of unexpected loss arising from the property insurance risks and in this case the risk of natural catastrophes resulting in unexpected losses to ABC. Such losses may be the result of experience fluctuations or of inappropriate selection and pricing of the risks. They write £120m of premium income each year. The average loss has been £77m and the maximum loss has been £168m. The risk of unexpected loss could be about a 20% chance (1 in 5) of a £91m loss.

Financial risk being the risk of loss resulting from the £100m equity holding. The equity holding is likely to have incurred a loss of more than £30m last year because the total investment income was a loss of £30m and the remaining investments were cash and government securities. In rough terms share prices generally collapse by say 30% every 7 years or so before eventually recovering ground. The size of this risk is therefore circa £30m.

Foreign exchange risk could be large if the cash and government securities are not held in US dollars. 90% of the £240m (£216m) outstanding claims liabilities is likely USD denominated and only the £100m in equity is clearly USD denominated. Exchange rate volatility can be dramatic. It is possible that a 20% reduction in GBP relative to the USD could occur. The size of the risks could be the order of say 20% of £116m, i.e. £23m.

There is a possibility that the underwriting risks and the risk of market value loss to the equity holding will be partly negatively correlated. 90% of the underwriting losses are anticipated to arise from US windstorms. US housebuilders should benefit from natural catastrophes as they will be needed to rebuild the homes.

- (ii) The model does not require random variates because its purpose is to perform sensitivity analysis and stress testing. The model will generate future balance sheets (so will need to generate both assets and liabilities) and profit & loss statements. A three year time horizon would likely be sufficient.

Whilst the model itself will not require random variables some analysis of the potential range of each of the key business risks and their interdependencies should be done for the purpose of keeping the sensitivity analysis plausible and for the purpose of testing a range of remotely possible but extreme outcomes during stress testing.

The balance sheets and profit & loss statements will need to be internally consistent over time. For example:

- the balance sheet balancing and consistency between assets and liabilities
- unpaid claims moving to the outstanding claims reserves
- the outstanding claims reserve being run down as old claims are paid
- profits/losses moving across to shareholders' funds
- carried forward tax losses

- (iii) The purpose of sensitivity analysis is to see which of the assumptions are most material on the business. In this case the two key outcomes to track are the net profits and the capital.

Create a base case balance sheet and profit & loss statement which has average expected returns and claims. Test the relative movement in net profits and capital:

- Changing the incurred claims up and down 20% and holding all else constant
- Changing the interest rates on the cash and government securities up and down by 20%
- Changing the value of the equity holdings up and down by 20%
- Changing direct acquisition costs up and down by 20%

Whilst the probabilities of the 20% movements actually happening for the different variables will be different all are reasonably likely to occur and it will give management a feel for the most important contributors to both profit and capital.

- (iv) The purpose of scenario analysis or stress testing is to test different possible states of the world.

Create scenarios showing:

- A base case with average performance of all variables
- A case showing extremely good claims experience for three years with all other variables performing in line with average levels
- A case showing one average year of claims experience (average everything else) followed by two bad years of both claims experience and investment performance
- A case showing one year of “worst foreseeable case” of claims performance followed by two average years. All other variables performing in line with average levels

Testing scenarios such as these would help the company to understand its return on equity in average years, good years and bad years. It would also help the company to estimate the amount of capital it should be holding against the risks it is writing.

6 (i) Potential justifications for the actuary's approach

The approach is simple.

If the 97.5% quantile VaR is only used as a broad guide internally then it may be sufficient for purpose.

Model error, parameter error and changing business mix (data heterogeneity) can make any approach potentially inaccurate and misleading.

The potential shortcoming of VaR

VaR is a simple measure but it does not give any indication of the extent to which losses might potentially exceed the 97.5% quantile.

VaR has poor aggregation properties. Specifically it fails the important subadditive property of a coherent risk measure. This means that the VaR for the overall distribution will not necessarily be less than the sum of the VaR for the three separate loss distributions.

The VaR estimate can be misleading in the sense that it takes no account of model error which in this case could be far larger than normal because of the subjectivity of the assumptions.

Because VaR is a point estimate, at the extreme ends of the distribution it will often be necessary to run the simulation for a relatively long time before the VaR estimate becomes statistically constant.

Other potential shortcomings of the actuary's approach

The initial best estimates of the three classes of business are just that, estimates. They may not be the mean. For example, they could be the median.

The goodness of fit of the lognormal distribution assumption does not appear to have been tested in any way.

The judgmentally selected coefficients of variation could be wrong. This will likely cause the biggest error to the eventual VaR calculation because standard deviations of loss reserves can vary extremely widely.

The adopted coefficients of variation are judgmentally selected. They might be materially wrong. The company has been in business for many years

suggesting that the data should be available to estimate the correlation coefficients directly from the data.

(ii) **Translation invariance**

The Risk Measure should show that the amount of capital required supports the perceived variability of a loss and not its expected amount. Adding or subtracting a fixed amount from a loss leaves the capital (being the amount excess of the expected loss) unchanged.

Subadditivity

Compounding loss distributions should create a diversification benefit. Even if the distributions were 100% correlated the Risk Measure of the compounded distribution should not exceed the sum of the Risk Measures of the individual distributions.

Positive homogeneity

Also known as positive scalability the Risk Measure should show that the capital required to support “ n ” identical losses is equal to “ n ” times the capital need to support one loss.

Monotonicity

The Risk Measure should show that the capital needed to support a smaller loss (with the same distribution) is less than the capital needed to support a larger loss.

- (iii) Let L_1, \dots, L_n be a generic sequence of random variables with associated order statistics $L_{1,n} \geq \dots \geq L_{n,n}$ and note that for arbitrary m satisfying $1 \leq m \leq n$ we have:

$$\sum_{i=1}^m L_{i,n} = \sup\{L_{i_1} + \dots + L_{i_m} : 1 \leq i_1 < \dots < i_m \leq n\}.$$

Consider two random variables L and \tilde{L} with joint distribution function F and a sequence of iid bivariate random vectors $(L_1, \tilde{L}_1), \dots, (L_n, \tilde{L}_n)$ with the same distribution function F . Writing $(L + \tilde{L})_i := L_i + \tilde{L}_i$ and $(L + \tilde{L})_{i,n}$ for an order statistic of $(L + \tilde{L})_1, \dots, (L + \tilde{L})_n$ then we must have:

$$\sum_{i=1}^m (L + \tilde{L})_{i,n} = \sup\{(L + \tilde{L})_{i_1} + \dots + (L + \tilde{L})_{i_m} : 1 \leq i_1 < \dots < i_m \leq n\}$$

$$\begin{aligned} &\leq \sup\{(L_{i_1} + \dots + L_{i_m} : 1 \leq i_1 < \dots < i_m \leq m)\} + \sup\{(\tilde{L}_{i_1} + \dots + \tilde{L}_{i_m} : 1 \leq i_1 < \dots < i_m \leq m)\} \\ &= \sum_{i=1}^m L_{i,n} + \sum_{i=1}^m \tilde{L}_{i,n}. \end{aligned}$$

By setting $m = n(1-p)$ and letting $n \rightarrow \infty$, the “law of large numbers for expected shortfall Lemma” gives us that $ES_p(L + \tilde{L}) \leq ES_p(L) + ES_p(\tilde{L})$.

END OF SOLUTIONS

EXAMINATION

30 April 2010 (am)

Subject ST9 — Enterprise Risk Management Specialist Technical

Time allowed: Three hours

INSTRUCTIONS TO THE CANDIDATE

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all seven questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

AT THE END OF THE EXAMINATION

Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.

In addition to this paper you should have available the 2002 edition of the Formulae and Tables, the ST9 formulae sheet for 2010 and your own electronic calculator from the approved list.

- 1** XYZ plc is a large UK pharmaceuticals firm listed on the London Stock Exchange. Dr John Smith has worked for XYZ plc for 30 years. After starting as a laboratory technician, he was promoted to the main board ten years ago, becoming chief executive five years ago. Last year, the chairman of XYZ plc retired and Dr Smith added this role to his current responsibilities.

Because specialist knowledge is required to understand aspects of the business such as pharmacology and biotechnology Dr Smith insists that all board members be industry specialists. Given the sensitivity surrounding product development, Dr Smith rejects the inclusion of external directors, so all members of the board are either current or retired employees of XYZ plc. Dr Smith assesses the performance of the directors over a one-to-one lunch with each of them over the course of the year. He also agrees the directors' salaries at these meetings. To avoid conflicts of interest, the directors are not allowed to hold stock in XYZ plc.

Discuss ways in which the corporate governance of the firm could be improved. [6]

- 2**
- (i) Explain agency risk in the context of a non-managerial employee of a firm. [2]
 - (ii) Suggest ways in which this agency risk can be substantially reduced or eliminated. [2]
 - (iii) Describe possible constraints that would limit efforts to reduce this agency risk. [2]
- [Total 6]

- 3**
- (i) Explain the terms:
 - (a) Risk appetite
 - (b) Risk profile
 - (c) Risk limits
 - (d) Risk capacity
- [4]

A long established life insurance company has only sold conventional without profits life and health protection insurance to date. The company matches its assets and liabilities as closely as possible. The company is considering diversifying the business into savings by introducing unit-linked products.

- (ii) Describe how the Board might express risk appetite, including examples of key metrics, and how this would be translated into risk tolerances. [8]
 - (iii) Outline how the insurance company would use this to assess alternative strategies, such as whether or not to introduce unit-linked business. [3]
 - (iv) Describe the additional risks to which the insurance company will be exposed by introducing unit-linked business. [4]
- [Total 19]

4 You work for a general insurance company. The pricing actuary believes that the claims arising from the different lines of business might not be independent from one another. He plans to develop a correlation matrix based on Pearson's correlation coefficients. He suggests three possible approaches for adopting correlation coefficients between the various lines of business, namely:

- directly from the data
 - using estimates published by other actuaries for various lines of businesses based on various data sources over the years, and
 - subjecting his claims cost model to a range of possible correlation coefficient matrices
- (i) State with reasons the implicit assumption that the actuary is making about the distributions underlying the claims costs arising from the various lines of business. [3]
- (ii) Describe the pros and cons of the three different approaches suggested by the actuary. [7]

You are concerned that the pricing actuary's suggestions may not be the best way of estimating the dependency structure of the claims arising from the various lines of business. You suggest that the actuary calculates sample rank correlations for the purpose of parameterising a chosen copula.

You should assume that:

1. There are two lines of business, X and Y .
 2. The total claims cost for each line and for each quarter has been calculated over the past ten years to create a vector with 40 rows and two columns.
 3. The individual column vectors have been used to create $f(X)$ and $f(Y)$ continuous probability density functions.
- (iii) Describe Kendall's tau, including formulae, and its properties. [6]
- (iv) State the standard estimator of Kendall's tau parameterised for this particular case. [1]
- (v) Describe, including formulae, the use of the sampled Kendall's tau to calibrate a bivariate Archimedean copula with a single parameter. [3]

[Total 20]

5 ABC is a large insurance company specialising in writing immediate annuity business. To match the long term and regular payment nature of its liabilities ABC invests in fixed interest securities. To maximise the return on its investments and to improve the competitiveness of its pricing in the market ABC invests in corporate bonds as they typically earn a higher yield than government securities.

ABC's credit risk policy is that all bonds must be rated A or higher. If a bond is downgraded below A then it will be sold and the proceeds re-invested in an appropriate bond.

- (i) Comment on the nature of ABC's credit risk exposure and the effectiveness of its credit risk policy to mitigate these risks. [4]

ABC has decided to develop its own internal models to estimate the probability of default for each of the corporate bonds that it holds. It has opted to use the KMV model for this purpose in order to be consistent with the approaches used by the rating agencies.

- (ii) Outline the information needed to estimate the expected default frequency using the KMV model and suggest possible sources for this data. [7]
- (iii) Outline the advantages and disadvantages of using the KMV model for this purpose. [2]

For key individual bond holdings, such as that relating to Company DEF, ABC has decided to enter into a credit default swap (CDS) with Bank GHI.

- (iv) Describe how the cash flow arrangements would typically be structured under this CDS. [3]

It is often claimed that because of the long term nature of their liabilities, life insurance companies are able to extract a "liquidity premium" from their bond holdings that is not available to other investors. A member of ABC's Board has suggested that the extent of this premium could be estimated by deducting the cost of the CDS from the spread available on the bond.

- (v) Comment on the merits of this proposal. [3]

[Total 19]

6 In Country Q all licensed banks are required to develop internal enterprise-wide capital assessment models. These models must be approved by the regulator. The regulator sets each bank's minimum capital requirement to be equal to the capital necessary to give the bank a 99.5% probability of having sufficient capital in the ensuing year. Unfortunately this system appears to have failed as one licensed bank has just declared bankruptcy, and the regulator is under some pressure to change the minimum capital requirement approach.

(i) Discuss whether such a change would be an appropriate reaction. [5]

A politician has suggested that the various banks' internal capital models are far too complex and might easily fail to predict the range of foreseeable future outcomes. He has suggested that instead of setting capital at the 99.5% probability of sufficiency, capital should be set equal to five times the standard deviation estimated by the internal model.

(ii) Discuss this suggestion. [7]

[Total 12]

7 A pension scheme has decided to change the interest rate and inflation rate profile of its asset portfolio. The trustees have received quotes from an investment bank for a series of interest rate and inflation rate swaps with the bank.

(i) Describe the risks that arise for the pension scheme if it enters into this series of transactions. [4]

(ii) Describe the steps that can be taken to mitigate these risks. [6]

The trustees note that the net expected investment performance of the asset portfolio including the series of swap transactions is lower than the net expected investment performance of a hypothetical equivalent asset portfolio with very similar interest rate and inflation rate profiles.

(iii) Suggest reasons why the trustees might choose to trade the series of swaps rather than reposition the physical portfolio. [5]

(iv) Explain an alternative approach that might meet the pension scheme's objectives and which would be less expensive than entering into the entire series of swap transactions as proposed. [3]

[Total 18]

END OF PAPER

**Subject ST9 — Enterprise Risk Management
Specialist Technical**

April 2010 Examinations

EXAMINERS' REPORT

Introduction

The attached subject report has been written by the Principal Examiner with the aim of helping candidates. The questions and comments are based around Core Reading as the interpretation of the syllabus to which the examiners are working. They have however given credit for any alternative approach or interpretation which they consider to be reasonable.

R D Muckart
Chairman of the Board of Examiners

July 2010

- 1** It is good practice for the roles of chief executive and chairman to be held by different people. This is not the case here. This is to avoid too great a concentration of power at the head of a firm. As a temporary measure the board could meet regularly without the CEO and/or appoint an alternate lead director.

It is good practice for the majority of board members to be independent from the firm. This is not the case, due to past employment with the firm. Independence is important as it ensures that the directors act in the interests of shareholders rather than themselves or other members of the board.

It might also be useful for the board to have input and challenge from those who have experience of other industries and who may therefore be better able to see “the bigger picture”.

A significant proportion of directors' remuneration should be in the form of company stock, in order to align the interests of the directors and shareholders. Holding stock would not be a conflict of interests.

Ideally there should be a process in place to at least annually assess the performance of all directors, including the chief executive. No formal process exists here. The performance assessment should include risk based objectives. The performance assessment of the directors including the CEO should be undertaken by a committee of the board called the remuneration committee.

The CEO should not sit on the remuneration committee.

- 2** (i) The broad principle is that an employee will act to benefit his own well being rather than the financial well being of shareholders. A both ways principle statement is fine “each party not acting in concert, each in their own interests”

A specific example would be the use of the internet at work for personal purposes.

- (ii) Agency risk can be limited by:

- increased monitoring of employees
- limiting the opportunities for exploitation of opportunities; and
- using remuneration and benefits to incentivise employees to be productive in a way which is aligned to the shareholders' objectives
- setting known penalties for breaching the rules

In this case, internet sites can be blocked, and/or employees advised that connections are being monitored and personal use could result in dismissal.

- (iii) Any interventions should not breach the employee's legal rights.

The cost of any intervention or prohibition should not exceed the cost of the employee's actions before intervention or prohibition.

Any intervention should not make the employee's position untenable.

The intervention should not be unduly complicated. It will be difficult if not impossible to remove the risk altogether.

The intervention should not overly stifle initiative.

- 3**
- (i)
- (a) Risk appetite: this is the degree of risk that an organisation or individual is willing to accept in order to achieve objectives, both in terms of levels and types of risk. It can be interpreted as reflecting the setting of targets and limits across the organisation as a whole, plus the breakdown of these high level statements into more detailed risk tolerances.
- (b) Risk profile: this is a complete description of the risk exposures of an organisation, including risks that might emerge in the future and that will affect the current business of the organisation.
- (c) Risk limits: this is a group of guidelines that set limits on acceptable actions that might be taken today. If risk limits are adhered to then each individual unit of the business should be deemed to be working within its permitted risk tolerances. Risk limits can be regarded as a component of risk capacity.
- (d) Risk capacity: this is the volume of risk that an organisation can hold as measured by some consistent measure, such as Economic Capital. If there is spare capacity then it might be possible to take positive actions that add economic value to the organisation without breaching existing risk tolerances or risk limits.
- (ii) The Board's expression of its risk appetite need not be complex. Instead, it might be expressed as a short and clear set of statements related to one or more measures of risk.

The Board may wish to express its appetite with reference to metrics such as one or more of:

- the company's solvency level
- its credit rating
- its earnings and ability to pay dividends

In choosing one of the above metrics, the Board might be focusing on the interests of specific stakeholders. Reference to the solvency level will be relevant to one group of stakeholders (e.g. insurance policyholders and regulators), while earnings and dividends will be relevant to others. The Board might state different objectives each with different stakeholders in mind.

In discussions, the Board might initially state that it is unacceptable that quantity X (solvency level, credit rating etc.) falls below level Y over a

specified period (e.g. one year). Normally such breaches cannot be completely prevented, and so the initial statement often needs to be translated into a more probabilistic statement such as:

- The solvency level, X, should stay above the threshold Y with 99.5% probability over the next three years.
- The probability that the company's credit rating is reduced from the current AAA to A, or worse, in the next twelve months should be no more than 1%.
- Earnings volatility over the next year should be no more than Z%.
- The company is prepared to lose \$A with a probability of no more than 0.5% over the next 12 months and \$B with a probability of 0.1% over the next 5 years.

It is important to bear in mind that Boards may express their risk appetite using a combination of statements linked to several metrics.

As a variant, the Board of an insurance company might express the objective to maximise the economic value of a company for shareholders subject to one or more constraints that focus on the policyholders or the regulator, such as keeping the solvency level above a certain threshold with a given probability.

In order to establish the Board's risk appetite statement in the company, the senior risk managers (possibly involving further discussions with the Board, or the risk committee of the Board) would then have the task of translating the higher level statements of risk appetite into a more detailed set of risk tolerances and risk limits across the enterprise. This needs to be carried out in a holistic way to take advantage of synergies and to avoid unanticipated concentrations of risk.

A statement of risk tolerances needs to cover the company's attitude to all risks, both quantifiable and non-quantifiable. Quantifiable categories of risks might have risk tolerance expressed in probabilistic terms, as described above. There should be similar statements related to each category of risk, and a full set of statements might be made for each combination of category of risk and business unit.

Non-quantifiable risks also require a clear statement of what is acceptable or not acceptable. For example, the Board has no tolerance for reputational damage due to risk crystallisation.

Ultimately, these statements of risk tolerance must be expressed in a way that can be easily understood and implemented by all staff within the organisation. In many cases this might manifest itself through statements of risk limits.

- (iii) In order to assess alternative strategies all of the chosen risk metrics, ideally including the balance sheet and profit and loss accounts, will need to be projected over the longer term. The insurance company will need to compare these before and after allowing for the anticipated volume of protection and unit linked business, and will need to ensure that no existing metrics are breached.

However, systems do need to be in place that will allow the company to adjust its risk tolerances and limits if these might inadvertently thwart beneficial alternative strategies.

Further, processes need to be in place regarding how to choose between alternative strategies if more than one falls within the acceptable risk appetite, e.g. maximising risk-adjusted economic value, or the one which closest matches a desired risk profile

The insurance company should also conduct scenario analysis for the status quo and alternative strategies to understand how the switch exposes the insurance company to new risks or increases/decreases exposure to current risks.

- (iv) The additional risks will depend on the exact policy features for the unit-linked business.

Market risks – typically equity price, property price and credit spread risks – relating to the fact that typically charges are deducted as a percentage of the funds under management. Any reduction in the prices of the underlying assets will reduce the funds under management and hence the fund management charge received.

Should the prices of the underlying assets not increase in line with expectations then it may not cover the costs incurred by the insurance company or take much longer for the insurance company to cover the costs associated with writing unit-linked business.

Poor market performance relative to competitors also introduces the risk of lower new business sales and higher lapses.

Operational risks related to the establishment of new processes within the insurance company (particularly unit pricing) and the training of staff to execute these processes.

Related to these operational risks, compliance risks may arise relating to the sale of a new type of product.

Additional product sellers in the market place or competitive action by existing sellers may put pressure on the volume of business sold and the profit margin. Where the volumes of business are less than anticipated then the expected expense allocation will be in error leading to expense risk, particularly the recovery of the product development and launch expenses.

- 4 (i) Pearson's correlation coefficient and the resulting correlation matrix can be calculated for any distributions of any type.

However, it is a linear concept based on moments meaning that it only fully defines the dependency structure when the cumulative distribution is elliptic as with, for example, the multivariate normal distribution and hence when the marginal distributions (post any transforms) are elliptically (e.g. normally) distributed.

The pricing actuary is most likely planning to use the correlation coefficients for forecasting and is therefore assuming that the underlying claim frequency and severity distributions (or total claims cost distributions) post any transforms are normally distributed.

- (ii) Directly from the data

- Provided the datasets are sufficiently large to produce credible estimates this should be the best approach as it reflects its own dependency structure.
- This data will be more recent than the industry data.
- This is likely to be the most time consuming approach.
- The actuary will need to consider the accuracy and completeness of the data.
- The actuary will need to consider the likely homogeneity of the data both over time
- and between the risks allocated to each line of business.
- The claims data will require transforming to take account of past inflation rates.
- If it is not possible to estimate the past levels of claims inflation from the data then the transformation will involve adopting external data.
- Results can be very sensitive to extreme outcomes.
- This is a common problem for heavy tailed distributions if the actuary has wrongly assumed that the claims cost distributions are normally distributed.
- The randomness associated with small data sets could result in the actuary adopting inappropriate correlation coefficients and as a consequence over or under pricing.

Using estimates published by other actuaries for various lines of business using various data sources over the years

- This information may not be produced regularly or recently.
- Nor is it subject to any particular standardisation. It is possible that the various studies may produce results which are not comparable to each other.
- It is even more likely that the various results might not be directly useful to the particular risks written by the insurer.
- Gathering the studies and interpreting them should be relatively straight-forward.
- The adopted correlations can be reviewed and updated as more studies are released in the future.
- The studies are likely to use relatively larger datasets than the insurer's own datasets. The larger datasets may reduce the chance of randomness over-influencing the results.
- The studies do not offer any direct insight into the dependency structure of the insurer's own data. To the extent that the insurer's own experience is different from the published data then it would lead to over or under pricing.

Using scenario testing for a range of possible correlation coefficients

- Assuming that the claims distributions are sufficiently symmetrical (or can be transformed to be so) then subjecting the underlying claims distributions to a range of possible correlation matrices might be quite a useful way of estimating the range of likely capital needed for the underwriting side of the business.
- This approach might give some insight into potential claim costs under extreme conditions.
- Clearly, the ultimate choice from the range of results will be subjective and, to the extent that the choice is wrong, would lead to over or under pricing.
- The method does not offer any direct insight into the dependency structure of the insurer's own data.
- The method should be relatively straight-forward to employ.

$$(iii) \quad \rho_{\tau}(X, Y) = E(\text{sign}((X - \tilde{X})(Y - \tilde{Y})))$$

where (\tilde{X}, \tilde{Y}) is an independent copy of (X, Y) .

- Kendall's tau is a rank correlation measure.
- The numerical difference between the random variables (rvs) is discarded and only the sign of the difference is analysed.
- Kendall's tau works by generating pseudo distributions of the rvs being analysed which have the same distribution but are independent from one another.
- Kendall's tau is equal to the mean of the sign of the calculations of the product of the differences between the actual rvs and the pseudo rvs.
- Kendall's tau is a symmetric dependence measure
- between $[-1, 1]$.
- Independent rvs have a tau of zero
- but a tau of zero does not ensure independence.
- When tau equals 1, X and Y are comonotonic.
- When tau equals -1 , X and Y are countermonotonic.
- For continuous marginal distributions Kendall's tau depends only on the unique copula of the distributions
- and is thus invariant under strictly increasing transformations.

$$(iv) \quad \rho_{\tau}(X, Y) = \binom{40}{2}^{-1} \sum_{1 \leq t < s \leq 40} \text{sign}((X_t - X_s)(Y_t - Y_s))$$

$$(v) \quad \text{Assumed model } F(X, Y) = C_{\theta}(F(X), F(Y))$$

where θ is the single parameter to be estimated.

Let r^{τ} = sample value for Kendall's tau.

Solve $r^{\tau} = f(\hat{\theta})$ for $\hat{\theta}$ to estimate copula parameter θ .

For example Gumbel's copula is calibrated by taking

$$\hat{\theta} = (1 - r^{\tau})^{-1}$$

5 (i) ABC's credit risk exposure falls into three categories:

- The risk that the counterparty for a particular bond defaults on (all or some of) its payments resulting in a shortfall of cash or assets
- The risk that the counterparty for a particular bond is downgraded triggering a widening of spreads and a fall in the value of the asset relative to its liabilities
- Concentration risk: The risk should be considered across all the bond holdings with a particular counterparty rather than on an individual security basis.

The policy described above sets relative risk limits for default risk. It does not directly mitigate against any of these three risks at the point of sale which is when the risks are crystalising.

In fact it may actually make things worse as it would require ABC to sell bonds just after a downgrade when the market in that bond is already depressed triggering further falls.

The approach relies on credit rating agencies rating the bonds accurately and frequently.

(ii)

INFORMATION	SOURCE
Market value of equity (S_0)	Share price \times shares issued
Value of liabilities (B)	Balance sheet
Market value of assets (V_0)	Modelled – using option pricing
Asset volatility (σ_V)	Modelled – using option pricing
Default threshold (\tilde{B})	Liabilities due over the next year, including the “close out” cost of longer term liabilities
Leverage ratio of the firm (d)	Balance Sheet
Average coupon paid (c)	Past Financial Statements
Risk free rate	Market information
Time horizon	Determined by company

(iii) Advantages:

- Reacts quickly to changes in economic prospects of the company– faster than rating agencies
- More sensitive to current macroeconomic conditions than historic default / transition probabilities
- Accommodates complex liability structures

Disadvantages:

- Only applies to firms with publicly traded stock
- Sensitive to any over- or under- valuation in equity markets

(iv)

- ABC pays fees/premiums to bank GHI
- If the defined event does not occur then no other payments are made.
- A payment is made from bank GHI to ABC if a credit default event on the company DEF corporate bond occurs.
- The amount of the payment is the difference between the original price of the DEF bond and the recovery value of that bond.
- Alternatively, the CDS may be settled physically i.e. ABC receives the full agreed value of the bonds from bank GHI and ABC gives the defaulted bond to bank GHI.
- The payment from GHI to ABC is subject also to the risk of GHI defaulting.

(v) The credit spread is made up of four parts:

- The expected probability of default and the expected loss given default
- A risk premium covering unexpected defaults
- A liquidity premium
- A premium for structural/documentation complexity

The CDS only estimates the first of these components. Deducting the cost of the CDS from the spread will not help us distinguish between the remaining parts.

Also reflected in the CDS price will be the profit loadings and credit risk premiums attached to the counterparty GHI causing a further distortion.

The profit loading includes the risk premium for covering unexpected defaults.

A CDS may not be available for a large number of assets in the portfolio.

Different banks will have different profit loadings.

6 (i)

- 99.5% is potentially misleading due to model risk and estimation error.
- The failure could have been due to a 1 in 200 year event or worse, i.e. in excess of the 99.5% confidence interval.
- The cause of the failure should be analysed carefully.
- It might have resulted from an event which was not previously considered to be a risk and so was not being modelled by either the banks or the regulator.
- For example, a court ruling imposing new and unexpected liability on the bank to cease trading a given product type and to repay all losses to customers who had lost moneys but not be entitled to collect profits from customers who had made money.
- The bankrupt bank's model could have been flawed. It could have underestimated one or more risks.
- The bankrupt bank's model variance could have been insufficient.
- The regulator should consider whether there have been other bank failures or near failures in past years.
- Regulation should be proportionate. Consumer protection and confidence in the system doesn't mean that individual banks should not be able to or allowed to fail.
- The regulator could consider augmenting the current approach with additional requirements e.g. governance, reporting requirements etc..

(ii) Politician & Regulator

The politician wants more capital, safer banking and customer protection.

The regulator wants safe banking and customer protection but also appreciates that too high a capital requirement could lead to banks boosting charges to customers and/or banks finding it difficult to attract capital and/or domestic banks being forced out of business by foreign banks with lower capital requirements.

The choice of 99.5% probability of sufficiency in the ensuing year has been made by the regulator. It is subjective and could have been higher or lower. The regulator will not want to make changes unless it is proven to be warranted.

The “five times” suggestion is a simple and relatively practical solution given the subjectivity of measuring the extreme ends of a distribution. Moments are very sensitive to extreme values and hence the extreme end of a distribution can be driven by very few extreme observations. The standard deviation is a more robust calculation than the 99.5% probability of sufficiency statistic.

Model

The suggestion is still internal model dependent and as such the model errors and parameter errors remain.

The capital models will still produce both the standard deviation and the 99.5% probability of sufficiency.

Hence, regardless of how the minimum capital is being calculated, the regulator will be able to continue to compare the minimum capital under both approaches.

Industry

The five times standard deviation suggestion could result in a very high capital charge. For example the 99.5% probability of sufficiency under a normal distribution is circa three times the standard deviation. Assuming that the suggestion results in a dramatic increase in capital then it will inevitably impact the banks' profits and the prices that they charge to customers.

Moving to the “five times” suggestion removes some of the individual nature of the capital requirement. Some banks may spend less time focussing on the extreme end of their enterprise capital model.

This may reduce the accuracy of the banks' capital models at the extreme end. It may also result in the banks taking more risk without first testing the consequence of the risk taking in their models.

The “five times” suggestion may encourage previously less risky banks to become more risky in an effort to utilise the additional capital. Conversely it is unlikely to encourage the historically more risky banks to become less risky. As a consequence the banking industry as a whole might be expected to adopt more risky strategies if the “five times” method was introduced.

If all of the banks operate with very similar risk profiles then the suggestion may be equivalent to setting the probability of sufficiency (currently 99.5%) to be equivalent to five times the standard deviation.

The regulator should consider whether the “five times” approach would have saved the failed bank and if so was it just due to the additional capital or was it due to the 99.5% estimate being flawed in the case of the failed bank.

7 (i)

- Basis risk – the risk that the change in the value of the swaps will not match exactly the change in value of the assets.
- Credit/Counterparty risk – the risk that the investment bank will become insolvent.
- Operational risk – the risk that the payments due under the swaps will not be made, or will not be made at the correct level.
- Longevity/demographic risk – this is the risk that the pensioners will live longer than anticipated by the swap.
- Reinvestment risk – Interest rate / inflation residual risks on the roll forward of swaps if not available for a long enough term.

(ii) Basis risk:

Can be mitigated by ensuring that a sufficiently complex swap overlay is put in place both in terms of the various swap terms and underlying payment types.

Credit/counterparty risk:

- Can be limited through the use of collateralisation.
- Can be mitigated by the right to call for additional collateral should the counterparty's credit rating fall below a stated level.
- Can be mitigated by having the swaps automatically unwind should the counterparty's credit rating fall below a stated level.
- Can be mitigated by ensuring full netting arrangements are in place between the counterparties.
- Can be mitigated by only dealing with banks with a minimum credit rating issued by one or more acceptable credit rating agencies.
- Can be mitigated by using multiple counterparties to limit the exposure to any one counterparty.
- Can be mitigated by buying credit protection from another counterparty.

Operational risk can be limited by ensuring that appropriate systems and controls are put in place. An external assessment of the adequacy of these systems could be sought.

Longevity swaps can also be added to limit demographic risk.

- (iii) The comparison might have excluded the costs of restructuring the physical portfolio (buy/sell costs).

The comparison might have used hypothetical market values (mark to model) for both the current portfolio and the new hypothetical portfolio. These prices and quantities may not be available increasing the time and cost of restructuring the physical portfolio.

It might be that the trustees wish to regularly change the interest rate and inflation rate profiles of the asset portfolio. The transaction costs of trading swaps can be lower than those for trading bonds.

Also the time taken to trade swaps may be much less than the time to buy and sell the physical assets.

It might be felt that the current asset portfolio has relatively greater chance of potential future gains from contracting credit and liquidity spreads as the portfolio duration shortens than would be the case for the hypothetical portfolio.

Trading the physical assets may crystallise taxable gains.

The bank trading the swaps may be able to supply other services at a reduced cost.

The physical assets may not be available in the requisite amounts which affect both the price and time taken to trade the physical assets.

The pension fund might not be allowed by scheme rules or regulation to hold some of the hypothetical assets.

- (iv) One alternative is to sell and repurchase all of the larger holdings in liquid bonds. The transaction costs would be relatively low. The trustees would then need fewer (relatively expensive) swaps.

Whilst the initial cost of moving the portfolio might be relatively high, if the assets are then held to maturity, the pension scheme might benefit from credit and liquidity premiums.

Repositioning the physical portfolio takes time and money and so only makes sense for the part of the portfolio that the pension scheme wants to hold for a long period of time.

The trustees could explore the potential for using other derivatives such as interest rate caps and floors. It may be possible to achieve the required profiles at a lower cost.

END OF EXAMINERS' REPORT

EXAMINATION

12 October 2010 (am)

Subject ST9 — Enterprise Risk Management Specialist Technical

Time allowed: Three hours

INSTRUCTIONS TO THE CANDIDATE

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all seven questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

AT THE END OF THE EXAMINATION

Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.

*In addition to this paper you should have available the 2002 edition of the
Formulae and Tables, the ST9 formulae sheet for 2010 and
your own electronic calculator from the approved list.*

- 1**
- (i) (a) State three risk categories which would be analysed as part of an economic capital assessment undertaken by an insurance company. [3]
 - (b) State three business risk categories which are unlikely to be relevant to the investigation. [3]
 - (ii) Give two examples of risks that are not always categorised consistently. [2]
- [Total 5]

2 Outline the benefits of applying ERM to a mature corporation. [7]

- 3**
- (i) Explain what is meant by:
 - (a) Stress testing
 - (b) Sensitivity analysis
 - (c) Scenario testing
- [3]

A life insurance company specialises in writing term assurance and income protection (health) business. It is concerned about the impact that a pandemic event could have on its business and is developing a series of pandemic scenario tests to evaluate its exposure. A critical factor in developing a pandemic scenario is the recognition that a single event could trigger losses from many different risks.

- (ii) (a) List six different risks that should be included in the tests.
 - (b) Explain how these risks could result in losses from a pandemic.
- [6]

Much of the risk from a pandemic stems from currently unknown viruses and diseases meaning that the additional impact on mortality and morbidity cannot be estimated with any degree of accuracy. As such the usual approach of building a model to forecast losses based on inputs does not work because the inputs are not known. Accordingly the life insurance company has decided to use the model in reverse. It will choose a total loss amount and then analyse the inputs and processes that would produce it.

- (iii) Explain the insights that the insurance company should gain from using the model in this way. [2]
- [Total 11]

- 4** Company A, a large department store chain retailer, has fully implemented ERM. It has recently bought Company B, a much smaller company and one of its major suppliers. Company B manufactures fresh sandwiches, salads and bakery goods. It sells these products to various retailers including Company A. Company A intends to install its own ERM framework, procedures, guidelines, handbooks and reporting requirements at Company B.

Explain why it may not be appropriate for Company A to do this. [10]

- 5** A life insurance company sells immediate annuities. It seeks as far as possible to match its future annuity payments with receipts from a portfolio of corporate bonds and equity release mortgages.

The corporate bonds are purchased with the intention of holding them to maturity. The equity release mortgages are loans taken out on residential property by the homeowners, and are written with a loan to property value ratio of 25%. These loans are repayable on death, transition to long term care, or at the request of the homeowner. Interest rolls up at the agreed interest rate until the mortgage is repaid. The eventual mortgage repayment is equal to the lower of the house value and the principal together with accrued interest, both determined as at the repayment date.

- (i) Define liquidity risk as it applies to this insurance company. [1]
- (ii) Explain whether it is appropriate to hold capital to mitigate liquidity risk. [2]
- (iii) Discuss how the insurance company could investigate and manage its liquidity risk. [10]

[Total 13]

6 The regulator of the banking industry in a specific country notes that:

- (1) Extreme events happen very infrequently meaning that there exists relatively little observed data.
- (2) Notwithstanding (1), the banking industry has had two events in the past three years which were considered to be plausible but extreme.
- (3) The banking industry has had one extreme event ten years ago which had not hitherto been thought possible.
- (4) None of the regulated banks declared bankruptcy as a consequence of these three events although several of them did recapitalise or merge with other banks.
- (5) Overall the protection of customers was maintained in the current system throughout the entire period. Confidence in the banking system was impacted by each of the three events but only for a relatively short period of time.

- (i) Define systemic risk and give a “real world” example. [3]
- (ii)
 - (a) Explain strict stationarity and its importance in forecasting time series.
 - (b) Explain the term covariance stationarity and give one example of a covariance stationary time series. [4]

The regulator’s department has produced a number of GARCH models to predict future investment returns. The recent extreme events have resulted in fitted parameters which imply infinite variance.

- (iii) Explain the concept of infinite variance GARCH models. [2]
- (iv) Explain the consequences to the banks if the regulator were to employ infinite variance GARCH models for the purposes of stress testing each bank’s economic capital model. [2]

The regulator has suggested to the banks that they should hold additional capital because three extreme events in the last ten years suggests that large and volatile market losses are not as infrequent as once thought. In reply, the banks point out that the current levels of capital have proved to be adequate to withstand three large systemic shock losses in the past ten years. On this basis they claim that the current capital requirements are more than adequate.

- (v) Outline other model based approaches that the regulator could use as part of its investigation into whether or not to increase the banks’ minimum capital requirements. [5]
- (vi) Suggest requirements that the regulator might introduce which would reduce the banks’ financial risk in lieu of increasing the minimum capital requirement. [4]

[Total 20]

7 A general insurance company has identified several operational risks and has decided to quantify them as follows:

- (1) Adopt separate frequency and severity distributions for each risk.
 - (2) Combine the various frequency and severity distributions into a single aggregate operational loss distribution using Monte Carlo simulation.
- (i) (a) State, defining all terms, a formula for the simulated aggregate operational loss distribution.
- (b) Outline how the Monte Carlo simulation would be performed. [7]

You have been given the following historical loss data on internal frauds over the five year period since the company was established, being from 2005 to 2009 inclusive. Each represents a single separate incident.

September 2006	£46,500
April 2007	£3,100
December 2008	£1,700

- (ii) Fit a frequency distribution to the historical loss data on internal frauds, explaining your particular choice of distribution. [2]

You have been asked to fit a gamma distribution to the severity data. You should assume that:

- The gamma probability density function is:

$$f(x; k, \theta) = x^{k-1} \frac{e^{-x/\theta}}{\theta^k \Gamma(k)} \text{ for } x > 0 \text{ and } k, \theta > 0.$$

- The likelihood function for the gamma distribution is:

$$L(k, \theta) = \prod_{i=1}^N f(x_i; k, \theta).$$

- The log of the likelihood function is a strictly increasing function.
- The maximum likelihood estimate for k is:

$$k \approx \frac{3 - s + \sqrt{(s-3)^2 + 24s}}{12s}$$

where:

$$s = \ln \left(\frac{1}{N} \sum_{i=1}^N x_i \right) - \frac{1}{N} \sum_{i=1}^N \ln(x_i).$$

- (iii) (a) Show that the maximum likelihood estimate for θ is $\hat{\theta} = \frac{1}{kN} \sum_{i=1}^N x_i$.
- (b) Hence fit the gamma distribution. [7]
- (iv) Outline the advantages and disadvantages of using historical loss data to calibrate the frequency and severity distributions for the simulation model. [6]
- (v) Describe two other sources of data that could be used to help calibrate the frequency and severity distributions for the simulation model. [2]
- (vi) (a) Explain the approaches you would use to collect the data described in your answer to (v).
- (b) Describe the issues that you would expect to encounter and the methods by which they could be mitigated. [10]
- [Total 34]

END OF PAPER

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

September 2010 examinations

Subject ST9 — Enterprise Risk Management Specialist Technical

Introduction

The attached subject report has been written by the Principal Examiner with the aim of helping candidates. The questions and comments are based around Core Reading as the interpretation of the syllabus to which the examiners are working. They have however given credit for any alternative approach or interpretation which they consider to be reasonable.

T J Birse
Chairman of the Board of Examiners

January 2010

- 1**
- (i) (a) Market risk
Credit risk
Insurance risk
- (b) Other categories, such as reputation, strategic, and agency risk, are unlikely to be relevant for capital assessment purposes.
- (ii) A common example of a risk which can be categorised in different ways is the risk of fluctuations in the value of corporate bonds due to changes in the credit spread. Some organisations will categorise this as market risk, some as credit risk.

Another example is the risk associated with an earthquake: a general insurance company might treat this as an insurance risk, whereas a bank would treat this as an external event under operational risk.

[Several candidates stated and gave other risks which were also accepted.]

2 Benefits of ERM implementation

ERM can help an organisation to:

- Formally align its risk appetite and strategy.
- Minimise unpleasant operational surprises.
- Reduce the risk of bankruptcy.
- Protect its reputation or brand.
- Enhance its catalogue of risk response decisions.
- Ensure that it has the appropriate skills to manage all of its risks.
- Improve its organisational effectiveness, particularly the direction and use of senior management time, through co-ordination and integration.
- Improve its risk reporting through careful prioritisation of the level and content of risk information that should go to the board, thus increasing both risk transparency and reporting efficiency.
- Ensure that risks are considered holistically, across all the different types of risk in different business areas, focussing in particular on their interdependencies.
- Gain consistency within the risk management process across different companies within a group and countries of operation.
- Allow better for diversification benefits across business units / entities and therefore avoid over-hedging or excessive insurance coverage.
- Align its performance metrics with the overall business and risk objectives.
- Identify and exploit opportunities to add value from upside risks.
- Expand, through proactively taking on risks that have been thoroughly assessed and understood.
- Improve capital needs assessment and allocation.
- Reduce the costs of external financing.

ERM also:

- Improves third parties' perception of the organisation, e.g. regulators and auditors.
- Reassures shareholders and help to support the share price, e.g. by reducing earnings volatility.
- Supports the organisation's credit rating, since credit rating agencies are putting increased weight on the quality of risk management functions.
- Promotes both financial security and job security, particularly for senior managers.

[Other points were also accepted.]

- 3**
- (i) (a) Stress testing measures loss under extreme values of the chosen variable without necessarily considering the probability of that extreme event.
- (b) The phrase “sensitivity analysis” is often used to describe a similar test but under less extreme variations. It is used to investigate what would happen if individual assumptions shifted slightly.
- (c) Scenario testing usually refers to the process of measuring the impact on the firm as a result of changes to two or more variables under devised “what if” scenarios – again without necessarily considering the probability of that scenario.
- (ii) (a) and (b) together
- Insurance risk: by increasing the number of claims experienced by the firm
 - Insurance risk: by increasing the claims expenses incurred by the firm
 - Insurance risk: by increasing the number of lapses experienced as people seek to access cash balances / reduce outgoings (and these lapses could be selective)
 - Market risk: if people stay home consumption will fall prompting falls in equity values
 - Liquidity risk: a large number of claims may prompt the need to sell assets unexpectedly to cover risks
 - Operational risk: a large number of staff will be off (either sick or looking after sick loved ones) reducing the ability of the firm to carry out its day-to-day functions like processing claims, monitoring investments, etc.
 - Political risk: the government may be prompted to take unusual / emergency actions under the circumstances which could impact on the regulatory environment, interpretation of claims etc.
 - Reputational risk: public sentiment may turn against firms applying strict underwriting or definitions of valid claims related to the pandemic illness.

- Moral hazard: Having insurance in place may make people less likely to take precautions resulting in larger numbers of affected and claims

[Several candidates gave other risks which were also accepted.]

(iii)

- Insurer A would start by working out how much it could afford to lose in the event of a pandemic.
- Combinations of the level of excess deaths and other pandemic impacts would then be considered
- to understand how well positioned the company is to withstand them
- and what mitigating actions (e.g. reinsurance) should potentially be considered.

4 Whilst the ERM framework could be based on the same concepts the actual procedures, guidelines and reporting requirements must be proportionate to the two companies. Companies A and B are very different. Company A is much larger. It is a retailer. Company B is both smaller and a wholesaler.

Prior to the merger Company A might have been transferring risk to Company B. Now the ERM systems of both companies need to reflect the group position.

For ERM to be effective it must be embraced by Company B's board, management and employees. It cannot be imposed by Company A. Therefore Company A may have to adjust its ERM style in order to "sell it" to these new stakeholders.

Companies A and B will likely have different capital structures.

Companies A and B will likely have different risk appetites.

The ERM policies must be built around a company's capital and risk appetite.

The different risks which will require different procedures, guidelines and reporting include:

- Credit risk – Retailer will sell for cash or cash equivalent. Hence very little credit risk. Company B will sell on deferred terms to its customers making it very exposed to a relatively small number of corporate customers.
- Market risks – changing costs of inputs. Company A will likely have a mix of fast and slow turnover items. Company B will be predominantly very fast turnover items.
- Market risks – customers. Company B will have fewer and relatively much larger customers. Company B is more exposed to the loss of customer but can spend more time and care on each individual customer. Company A must develop mass marketing procedures.

- Technology risk – Company A is bigger and much more complex e.g. customers, premises, employees etc. The ERM must be proportionate to the risk.
- Fixed assets risks – Company A is much more dependent on its premises. Company B is more dependent on its plant and machinery and on its logistics given its fast turnaround.
- Health and safety issues and risks – Company A will be employing customer facing people in a relatively safe store environment. Company B is employing factory workers in a factory. Different people with different jobs require different ERM approaches, policies and guidelines.

The companies will have different risk mitigation and transfer options. They will wish to employ different options because of their different risks, capital and risk appetite.

- 5**
- (i) Liquidity risk is the risk of money markets not being able to supply funding to the insurance company when required, or more broadly to the management of short term cash flow requirements.
 - (ii)
 - It could be argued that liquidity risk could be mitigated through holding large quantities of additional capital invested in easily liquidated assets.
 - However, this would not be appropriate because the additional capital will not be appropriately employed in the business resulting in underperformance relative to ones' peers.
 - Other mitigating procedures should be investigated.
 - (iii) At the start, need to build a cashflow projection model of both liability outgo and asset proceeds.

Do this first using best estimate assumptions and then test the ability of the business to meet all claim payments to policyholders and other outgo from income and asset sales in a range of scenarios.

Relevant scenarios include those where cash inflows are decreased or cash outflows are increased as a consequence of the stress.

The insurance company sells immediate annuity business. Once a policy has been sold the policyholder has no ability to transfer or redeem the policy. Hence, the annuity business is an illiquid liability.

The insurance company backs the business using corporate bonds which are held to maturity. These corporate bonds will not be as liquid as the equivalent Gilts. However, excepting for defaults, since the corporate bonds back annuity business and should be cash flow matched there is no need to redeem these corporate bonds. Corporate bond defaults will upset the cashflow matching.

The insurance company also backs the business using equity release mortgages. The repayment date on these mortgages is not known with certainty due to uncertainty regarding the:

- actual mortality rates that will be experienced in the future, which may advance or delay the redemption cashflows;
- actual level of long term care transitions that will be experienced in the future, which may advanced or delay the redemption cashflows; and
- actual level of voluntary redemptions that will be experienced in the future, which may advanced or delay the redemption cashflows.

The cashflow projection model should be used to optimise the proportion of assets held in corporate bonds as against equity release mortgages. Holding more corporate bonds will reduce liquidity risk but may also reduce the portfolio's expected return.

If actual mortality rates are lower than expected then there will be a greater number of annuity payments – mortality risk – whilst the redemption cashflows on the equity release mortgages will be delayed leading to a mismatch. Scenarios should be investigated to ensure that the insurance company can continue to fund the outgo in such a scenario.

Inflation may also need to be investigated if any of the annuities are inflation linked.

Premium income on new annuity business may be a source of liquid assets in such circumstances, although scenarios should be investigated to ensure that the premium income is a reliable source of liquidity.

Liquidity is also required for short term “current liabilities” such as annual tax settlements, and to meet short term expenses.

Manage risks using risk transfer by way of insurance including financial risk insurance (ART)

Establish an emergency overdraft arrangement with a bank for temporary liquidity assistance

- 6** (i) Systemic risk is the risk that problems at a single firm could create a chain reaction resulting in large losses or defaults at other firms.

Financial institutions have become highly inter-dependent. For example, AIG the large American Insurance Group wrote tens of billions of dollars of credit default swaps in the 2000's. If the US government had allowed AIG to fail in 2008 then many banks would have been exposed to losing tens of billions of dollars each. It was rumoured at the time that a major Wall St bank might have failed if AIG had been allowed to fail.

- (ii) A strictly stationary time series is one whose statistical properties such as mean, variance, autocorrelation, etc. are all constant over time. If the fitted model is being used to forecast the future then a strictly stationary time series is both easier to fit and, all other things equal, should produce estimates with less variance.

A weakly stationary process or covariance stationarity only requires that the first and second moment do not vary with respect to time. A white noise process is covariance stationary.

- (iii) A GARCH model is said to have infinite variance if the sum of its coefficients, alpha and beta, are equal to or greater than 1. This situation typically arises when a small number of outlier data points greatly influence the parameter fitting.
- (iv) Infinite variance models can enter a cycle of positive feedback where volatility increases without limit. In this case the regulator would produce a number of results showing extremely high capital requirements. It is likely that the number of these results would cause the regulator to produce far more onerous stress tests resulting in the regulator requiring that the banks maintain higher levels of minimum capital.

A higher capital requirement would force some banks to raise more capital and would either hit bank ROEs or lead to higher charges or a combination of both.

- (v) The regulator could stress test the individual bank's capital models using both the extreme historic events and imaginary extreme events to estimate how many extreme events the banks can withstand.

The regulator could submit the various capital models to scenario testing to see the likely change in each bank's capital from year to year in less extreme circumstances.

The regulator could seek to build one or more models based on extreme value theory (EVT). This theory focuses on the extreme outcomes (the tail) rather than all of the outcomes and may be more appropriate in this context.

The generalised extreme value (GEV) is a family of continuous probability distributions developed for EVT. The regulator could use the GEV distribution to estimate a realistic probability density function of the observed extreme events.

The regulator should run alternate GARCH models which have finite variance to understand how much of the minimum capital requirement was being driven by the infinite variance assumption; the infinite variance assumption being a consequence of fitting the extreme events to the GARCH model.

(vi)

- Limit exposure to short term funding by limiting the ratio of short term funding to the total bank funding.
- Introduce various product limits to emphasise diversity
- Increase liquidity ratios to make the banks better able to withstand short term funding difficulties and unexpected withdrawals.
- Set limits to a bank's leverage i.e. The multiple of loans to equity
- Introduce other risk mitigants for example requiring banks that find themselves in difficulties to raise capital or merge.
- Prohibit certain trading activities that are considered to be unnecessarily risky.
- Adopt more prudent valuation of liabilities/assets
- Require more frequent and more detailed reporting e.g. off balance sheet risk reporting
- Set limits on asset holdings
- Set limits on counterparty exposures
- Extend qualitative reviews/management assessments

7 (i) (a) The aggregate operational loss distribution is as follows:

$$S = \sum_{i=1}^k \sum_{j=1}^{N_i} X_{ij}$$

where:

- k denotes the number of operational risks;
 - N_i denotes the number of crystallisations arising from the i^{th} operational risk over the specified time horizon (i.e. it is the random variable relating to the frequency of loss); and
 - X_{ij} denotes the operational loss arising from the j^{th} loss event arising by the i^{th} operational risk (i.e. it is the random variable relating to the severity of loss).
- (b) Once distributions have been selected for N_i and X_{ij} (as per the first step – for example a Poisson or perhaps Negative Binomial for each N_i) random observations from those distributions are selected so as to enable the statistical sampling of the operational losses for each of the individual operational risks.

The simulations from these distributions might, for example, be generated using a method which maps random variables generated from a $U[0,1]$ distribution onto the cumulative probability functions of the fitted distributions.

The Monte Carlo method produces a simulated aggregate operational loss distribution, combining the random simulations from the N and X distributions for each individual risk, and summing across these risks.

We are likely to model correlations between the frequencies of the k operational risks. These correlations will be reflected in the simulated aggregate operational loss distribution.

The average (mean) of all simulated aggregate losses might be used for a “best estimate” measurement, and the 99.5th percentile might be used to inform the setting of required operational risk capital.

A sufficiently high number of simulations (or “observations”) is required so as to reduce sampling error.

- (ii) Fit a Poisson distribution for frequency as this is the simplest frequency distribution to fit to the limited historical loss data.

The exposure period is five years and three observations have been made over this period giving a sample mean frequency of 0.6. Therefore, fitting a Poisson distribution to the historical loss data on internal fraud yields the following frequency distribution:

$$\text{Poisson}(\hat{\lambda} = 0.6)$$

[The binomial distribution was also accepted.]

- (iii) The likelihood function is:

$$L(k, \theta) = \prod_{i=1}^N x_i^{k-1} \cdot \frac{e^{-x_i/\theta}}{\theta^k \Gamma(k)}.$$

Taking logarithms:

$$\ell(k, \theta) = (k-1) \sum_{i=1}^N \ln(x_i) - \sum_{i=1}^N \frac{x_i}{\theta} - Nk \ln(\theta) - N \ln(\Gamma(k)).$$

Differentiating with respect to θ gives:

$$\frac{\partial(\ell(k, \theta))}{\partial \theta} = \sum_{i=1}^N \frac{x_i}{\theta^2} - \frac{Nk}{\theta}.$$

Setting to zero:

$$\sum_{i=1}^N \frac{x_i}{\theta} = Nk.$$

Hence:

$$\hat{\theta} = \frac{\sum_{i=1}^N x_i}{Nk}$$

Our estimate of s to three decimal places can be derived using the historical loss data as follows:

$$\begin{aligned} s &= \log((46,500 + 3,100 + 1,700) / 3) - (\log(46,500) + \log(3,100) \\ &\quad + \log(1,700)) / 3 \\ &= \log(17,100) - 26.225 / 3 \\ &= 1.005 \end{aligned}$$

Using our estimate for s we can calculate our estimate of k to three decimal places as follows:

$$\begin{aligned} k &\approx [3 - 1.005 + \sqrt{((1.005 - 3)^2 + 24 * 1.005)}] / (12 * 1.005) \\ &= 0.605 \end{aligned}$$

Using our estimate for k we can calculate our estimate of θ to three decimal places as follows:

$$\begin{aligned} \theta &= ((46,500 + 3,100 + 1,700)/3)/0.605 \\ &= 28,272 \end{aligned}$$

Therefore, fitting a Gamma distribution to the historical loss data on internal fraud yields the following severity distribution:

$$\text{Gamma}(k = 0.605, \theta = 28,272)$$

(iv)

- The company can collect internal historical loss data using incident reporting for both actual operational losses and near misses. This should be both easy to collect and readily available.
- The data would also be directly relevant to the company.
- If there were any high frequency risks, such as credit card fraud, it may be possible to use this data directly when calibrating frequency and severity distributions.
- Such an approach provides a straightforward method for estimating the operational risk capital.
- However, for less frequent risks there will be limited internally collected historical loss data available.
- This seems to be the case for this company, which was only established five years ago and has experienced only a small number of actual losses.

- Further teething problems are to be expected since the process for the collection of historical loss data will be in its infancy.
- Under the new solvency 2 regime, regulators will be looking to companies to evidence that they have validated the assumptions to their internal capital models. The collection of historical data should be very helpful for this purpose.

Challenges include:

- the categorisation of risk, which may prove difficult if there is more than one control failure leading to the crystallisation;
- the inconsistent reporting of losses and near misses;
- the failure to report losses and near misses;
- and the fact that internal loss data is retrospective and as such does not allow for any changes to the operating environment including product mix, control environment, et al.
- Finally, it does not engage the business's experts in the process of loss estimation and hence, does not support the integration of risk and capital management.

(v) External loss data

- Historic losses incurred by other insurance companies may be reported into a central loss database administered by a third party such as the ABI's ORIC database (if the company is a UK life insurer).
- In addition, operational losses are sometimes reported in the press. Such information could be collected by an internal team or accessed through subscribing to a collection service provider.

Scenario Loss Data

- Scenario loss data can be created by bringing together experts from around the business to brainstorm how various risks may crystallise
- and the implications having regard to their control environment, insurances, indemnities, et al.

[Answers based on two separate sources of external data were also accepted.]

(vi) External loss data

The insurance company could subscribe to a consortium collecting external loss data in the short term to address gaps in their internal loss data.

However, most databases have only recently been established and hence, are subject to the same issues previously detailed in respect of internally collected historic loss data.

There are further issues as follows:

- There is an issue regarding the timeframe over which the loss data has been collected; what is an appropriate exposure measure?
- There is a related issue regarding scalability of the externally collected historical loss data; what is an appropriate scaling factor?
- There is a question of applicability; could a reported loss actually happen to our insurance company?
- The classification and granularity of the losses reported; how do we allow for any truncation of the externally collected loss data?
- The externally collected historical loss data is likely to be incomplete – e.g. other insurance companies are likely to be unwilling to record unique losses.
- The heterogeneity within the data in terms of the different features of the contributors. For example, different contributors will have different operational risk control/mitigation
- And again the data is retrospective.

Depending on the information available from the consortium, consider filtering the externally collected historical loss data for those that are applicable and then scale those that are applicable to allow for the difference in size of the contributing member and the size of our insurance company.

Then use Bayesian techniques to combine this with the insurance company's internal loss data.

Scenario loss data

- Obtaining scenario data loss for all operational risks is a significant undertaking, especially on a process by process basis.
- Therefore, many insurance companies firstly obtain self assessment data to prioritise those operational risks for which further consideration is required and to understand the cause and effect for operational risks.
- Such cause and effect analysis can feed directly into the setting of correlations.
- Scenario loss data can be collected in a number of ways, although workshop based sessions with all the relevant business experts present are very popular. These sessions need to be run sufficiently frequently so as to ensure that the scenarios are up to date, but not so often so as to risk the exercise becoming a tick-box exercise.

Issues that arise with the collection of scenario loss data include:

- the lack of statistical understanding of the participants requiring careful framing of the questions;
- gaming by some of the participants so as to paint their own department in a positive or negative light;
- and biases such as for example, hindsight bias whereby participants views are biased to those events that have recently occurred.

- Facilitation by the insurance company's central risk team should be employed so as to identify and eliminate gaming by participants.
- Sourcing estimates from all participants and then reaching a consensus can reduce the tendency for the scenario loss data to be focused on the views of the more vocal participants and help to eliminate biases.
- As before, use Bayesian techniques to combine the scenario loss data with the historical loss data.

END OF EXAMINERS' REPORT

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINATION

28 April 2011 (pm)

Subject ST9 — Enterprise Risk Management Specialist Technical

Time allowed: Three hours

INSTRUCTIONS TO THE CANDIDATE

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all nine questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

AT THE END OF THE EXAMINATION

Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.

In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.

1 BigBank plc primarily offers loans and mortgages. Its front office focuses on revenue maximisation, while the risk management function focuses on loss minimisation.

(i) Outline the advantages and disadvantages of organising the functions of the bank in this way. [3]

(ii) Discuss two alternative ways of organising the functions of the bank, including the advantages and disadvantages of each. [11]

[Total 14]

2 XYZ Limited is an international conglomerate.

(i) Describe the advantages to a group such as XYZ of actively managing its portfolio of risks. [4]

XYZ's risk management framework includes the following components:

- (a) risk capacity
- (b) risk profile
- (c) risk tolerance
- (d) risk limits
- (e) risk appetite

(ii) Discuss aspects of each of the above components that will be relatively more difficult to manage as a consequence of XYZ being an international conglomerate. [6]

[Total 10]

3 A model has been developed for a financial time series.

(i) Describe the construction of a QQ plot to judge the goodness of fit of the model. [3]

(ii) Explain how to interpret a QQ plot. [3]

(iii) State two other graphical diagnostic tests that could be used to judge the goodness of fit of the model. [1]

The diagnostic tests reveal that there are two data point outliers in the twenty sampled data points used to fit the model. It has been suggested that the model would be improved if it were to be re-parameterised after excluding the two outliers from the data.

(iv) Discuss this suggested approach. [2]

[Total 9]

- 4** ABC is a fund that invests entirely in corporate bonds. For many years the fund manager has included a default loss probability distribution for the fund in its quarterly financial statement. The fund manager produces the distribution from the estimated probability of default and estimated loss given that a default has occurred (loss given default) underlying each bond's credit rating. The credit ratings, probability of default table and loss given default table are all provided by rating agencies from time to time.

Each bond's probability of default is assumed to be independent from that of the others.

- (i) Describe the shortcomings of this approach. [3]

A corporate bond is likely to default when the share price falls to zero or perhaps near to zero.

- (ii) Discuss how this insight could be used to develop an alternative approach based on share price movements. [4]
[Total 7]

- 5** DEF Insurance is a long established multinational general insurance company selling a range of personal lines products in a number of developed and emerging markets across the world. The company's well known brand is a key competitive advantage. In each territory a wholly owned subsidiary is used to write and administer the business. Each subsidiary is separately capitalised and regulated.

DEF targets a strong ERM classification from Standard & Poor's.

- (i) Outline the requirements that this imposes on management. [2]

DEF has a target level of group economic capital.

- (ii) Describe the main implications of the group structure for this economic capital calculation. [4]

The Board recognises that damage to the DEF brand in one territory could damage the brand in other territories.

- (iii) Outline the ways in which this risk could be incorporated into the economic capital setting process. [4]
[Total 10]

6 Country X is a large free market economy with a sophisticated financial system. More than 3,000 stocks are listed on the main stock exchange. For the past several years the main stock exchange has required that all listed companies publish risk reports as a part of their quarterly financial statements.

(i) Describe the likely content of such a risk report. [6]

An equity analyst plans to construct a new risk measure using the information contained in the risk reports and financial statements. Its purpose is to produce risk-adjusted returns for all of the companies listed on the main stock exchange on a quarterly basis.

(ii) Explain how this risk measure could be constructed, including the information that would be used. [9]

[Total 15]

7 You are modelling the returns on a portfolio of ten high-yield corporate bonds. Your definition of default is that the return in any one year is less than minus 60%. The probability that a single bond will default is 10%. You believe that the returns on the bonds are linked by a Gumbel copula, with a single parameter $\alpha = 2$.

The generator function for the Gumbel copula is $(-\ln F(x))^\alpha$.

(i) Calculate the probability that all ten bonds will have defaulted in one year's time. [3]

(ii) Explain the relevance of the correlation coefficient and the choice of copula when considering the relationship between two or more variables. [2]

(iii) Discuss the choice of the Gumbel copula in this case. [4]

[Total 9]

8 A life insurance company that will be subject to Solvency II is considering the following proposals for controlling excessive mortality risk within its term assurance portfolio:

- an excess of loss reinsurance treaty
- a mortality catastrophe bond

The excess of loss reinsurance involves payment of a premium. In return, the insurance company will receive payments if aggregate death claims in a single year exceed a certain level.

The mortality catastrophe bond would be structured as a collateralised debt obligation (CDO), with aggregate losses up to a specified limit being covered by the structure.

(i) Explain how such a CDO might be structured. [6]

(ii) Discuss the advantages and disadvantages of the two approaches. [8]

[Total 14]

- 9** Scilly Sandals plc makes sandals, flip flops and other seasonal footwear. It is experiencing severe liquidity pressures.

Discuss the options available to the company that may be utilised to help ease these pressures. [12]

END OF PAPER

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

April 2011 examinations

Subject ST9 — Enterprise Risk Management Specialist Technical

Introduction

The attached subject report has been written by the Principal Examiner with the aim of helping candidates. The questions and comments are based around Core Reading as the interpretation of the syllabus to which the examiners are working. They have however given credit for any alternative approach or interpretation which they consider to be reasonable.

T J Birse
Chairman of the Board of Examiners

July 2011

- 1** (i) The current approach is simple to understand and helps to maintain the independence of the risk management function.

However, the current approach may engender a confrontational relationship between the front office and risk management function.

The current approach is focussed on the extremes, being profit maximisation and loss minimisation. This is likely to result in the bank taking a combination of large risks and virtually no risks. This is highly unlikely to produce an optimal return for a given level of risk. In other words this approach is virtually certain to be detrimental to the performance of the bank overall.

Effective enterprise risk management requires a holistic approach taking account of the bank's objectives, return requirements and risk limits. This approach is not holistic. It seeks to maximise profits without regard to risk and alternatively to remove all risks without regard for the cost to profit of doing so.

- (ii) Instead of using an "offense and defence" approach to organising the front office and risk management function, the bank could switch to a "policy and policing" or "partnership" approach.

The policy and policing approach involves the risk management function establishing policies that set out the parameters within which the front office must operate. The front office's activities are then monitored by the risk management function for compliance with the policy.

The advantage of this approach versus the offense and defence approach is that it is less confrontational instead mirroring the roles of policeman and citizen.

However, there are numerous disadvantages with the approach. These include the following:

- The risk management function is not engaged in the day to day operations, since the front office are free to proceed as they wish provided they remain compliant with the policies.
- As a result, the risk management function may become less knowledgeable on the front office's activities as these evolve.
- Consequently, the risk policies may become out of date with new policies not established in a timely fashion.
- Similarly, the front office may become less knowledgeable on the latest risk management techniques.

- The front office may be tempted to hide an infringement of the risk policies, deliberate or otherwise, particularly where there is uncertainty as to whether a risk policy has been breached.
- The separation of the policy and policing may cause delays in the identification of and quantification of new risks as they emerge in the front office.

The partnership approach involves the front office and risk management function working collaboratively to resolve risk management issues with shared objectives.

There are numerous advantages with the approach. These include the following:

- The advantage of this approach versus the offense and defence and policy and policing approaches is that the front office and risk management function work in partnership with shared performance objectives.
- Application of risk management is more timely executed as soon as risks crystallise and in the day to day decision making process – e.g. in loan and mortgage pricing.
- Working collaboratively should result in the front office having a better appreciation of the latest risk management techniques, whilst the risk management function will be more knowledgeable on the front office's activities.

The main disadvantage is the loss of independence of the risk management function.

This may be remedied through blending the approaches described above as these are not mutually exclusive.

[It is axiomatic that an advantage of one approach would be a disadvantage in another approach. To gain full marks the advantages and disadvantages need be described with reference to the given approach.]

2 (i) Unbundling risk origination, retention and transfer...

By unbundling companies can identify their core competencies and decide where in the value chain they wish to compete

Providing a risk aggregation function across the company...

Helps clarify which risks are managed through the corporate and strategic management process...and which are managed centrally for the group

Setting risk limits and asset allocation targets...to provide complimentary targets for balancing risk and return in the business

Influencing transfer pricing, capital allocation and investment decisions...

Effectively creating an internal capital market to allocate capital and decisions accordingly.

May permit greater analysis of how risks interact with each other / reduce concentration risk

Keeping up to date with emerging risks / avoiding crisis management

Greater respect from regulators/credit rating agencies/analysts

More effective risk mitigation/transfer strategies

- (ii) Risk Capacity – An international conglomerate will have different types of businesses, of different sizes, operating in different countries with different languages, legislation and potentially regulation. This will create communication problems, difficulties in consistently identifying and quantifying risks, reporting delays and inaccuracies.

Furthermore, the group's overall risk capacity will likely be difficult to set. Actual capital will of course be known but the economic capital will depend on the accumulation of risks across company, industry, country, currency etc.. The diversification benefits in the group economic capital will then make it difficult and in part subjective to allocate the capital and hence risk capacity to individual companies.

Risk Profile – The risk exposures will be changing over time. It is important that all of the companies take a consistent, diligent and timely approach to the maintenance of the risk profile. This will be difficult as the approach to risk management often varies by size of company, industry, country.

Risk Tolerance – To be effective, each company should set its own risk tolerance (statements). These statements may well be incompatible at the group level. The group will need to overlay a central set of risk tolerance statements to manage these inconsistencies.

Risk Limits – Risk limits are relatively straightforward to set for a standalone company. In this case each company's risk limits need to be set having regard to the group's diversification benefits. This is both complicated and partly subjective.

Risk Appetite – Risk appetite will be set at the group level and will essentially state the variation in profit that the group is willing to accept in return for its target profit. In this case it will be more difficult to monitor actual to budget profit across the group due to currency fluctuations, reporting delays and changing risk profiles across the group companies.

[This question was generally well answered. A small number of candidates showed that they were slightly confused as to the differences between risk tolerance, risk

limits and risk appetite. Put simply, risk appetite is the risk that someone wants to take (i.e. target), risk tolerance is typically a set of risks that one recognises will need to be taken at least to some degree in order to maintain the targeted risk appetite and risk limits are maximum acceptable levels of identified risks.]

- 3** (i) A QQ (quantile-quantile) plot is a plot of the quantiles of two distributions against each other. In this case there is sample data. The number of quantiles might be set to be equal to the number of data points or something similar. The quantiles are non-decreasing and there is an equal probability of being in any given quantile. Normally the sample data quantiles on the y-axis are plotted against the theoretical reference distribution quantiles on the x-axis. Of course, one first needs to decide on an appropriate theoretical distribution.

For a time series the time dependency of the sample data is removed by measuring the variation in the observed to modelled trend. This variation is then plotted against modelled variability.

- (ii) Always non-decreasing when viewed left to right.

If the two distributions are identical then the QQ plot will follow the $y = x$ line.

If the two distributions agree after linear transformation then the line will be straight but not $y = x$.

If the QQ plot is relatively flatter than $y = x$ line then the distribution plotted on the horizontal is more dispersed. Conversely, if the QQ plot is steeper than the $y = x$ line then the distribution plotted on the vertical is more dispersed.

An S shaped QQ plot indicates that one distribution is more skew than another and/or fatter tailed.

The fit is often good for the bulk of the distribution and less good at the extremes.

Interpreting a completely messy and seemingly awful fit might be due to the poor choice of the underlying theoretical distribution.

- (iii) Histograms with superimposed fitted density functions
Empirical cumulative distribution functions (CDFs) with superimposed fitted CDFs
Plotting the residuals i.e. actual minus fitted.

- (iv) Two data points represents 10% of the total sample from which the model is being built. It is difficult to argue that 10% of the data are outliers.

Removing the two most extreme values will likely reduce the volatility estimates and quite possibly overly so. The model may underestimate future volatility.

The model may underestimate both the frequency and severity of the relatively more extreme outcomes.

The parameter error will increase if the outliers are removed.

The data for the outliers should be checked to ensure they are accurate.

[Most candidates were not able to demonstrate that they could interpret a QQ plot in detail. Several candidates failed to be concerned that removing 10% of the data would create several problems with the fitting exercise.]

- 4** (i) Corporate bonds are not re-rated very often. The rating may be out of date. This could be due to company specific changes over time or due to systemic changes such as economic changes.

The rating agencies may not publish estimated probabilities of default and losses given default very often, meaning that they too may be out of date.

Also, different rating agencies will have different views meaning that the fund manager will need to choose one rating agency over another in some cases.

Whilst some bonds' probability of default may be independent of some others it is unlikely that all of the bonds are independent from one another. Empirical data shows that companies' returns and share prices are often positively correlated and particularly so in adverse times when they would be more likely to default on their debt.

The independence assumption for the losses given default is also unlikely to be true and particularly in times of large numbers of default.

The rating is a single best estimate and doesn't include variation.

- (ii) As stated in the question, a corporate bond is likely to default when the share price falls to zero or perhaps near to zero.

The more volatile a company's share price the greater the chance it has of reducing to zero. The probability of default of a corporate bond is largely driven by both its current price and the volatility in the share price.

The share price model would seek to forecast future share prices based on the current share price, past observed volatility and the dependence structure between the various companies' share prices.

The volatility estimates and dependence structures are key assumptions. Market volatility changes over time. Sometimes these changes can be both large and rapid. Hence the share price model will need to be stress tested for changing volatility and dependence.

The dependence structure is best estimated using a copula as empirical data suggests that share price probability distributions are not normally distributed.

[Many candidates handled the question well. Those that did not failed to develop a model that estimated the probability of a company's share price falling to near zero in a given time horizon.]

- 5** (i) The strong ERM classification requires that DEF can evidence that it has strong capabilities to consistently identify, measure, and manage risk exposures and losses within the enterprise's predetermined tolerance guidelines.

DEF will be able to evidence that it has processes in place seeking to optimise risk-adjusted returns.

Risk and risk management will usually be important considerations in DEF's corporate decision making.

- (ii) Each subsidiary will have to meet local regulatory capital requirements.

This makes it preferable to first calculate capital for each subsidiary before aggregating it for the group.

It is unlikely that capital can be transferred between entities quickly in response to a risk event.

This lack of fungibility must also be incorporated in the aggregation calculation.

Nevertheless, the group is still likely to be able to benefit from diversification. The overall diversification credit will be capable of being estimated.

However, it will be difficult, partially subjective and sometimes not possible to pass this diversification credit down to the individual companies.

This is because each regulator is likely to require that the capital in the regulated entity be estimated on a stand alone basis.

In order to aggregate the various subsidiaries' capital requirements into a group economic capital model it will be necessary to allow for fungibility and diversification credits.

It will also be necessary to allow for currency fluctuations.

This complexity is likely to mean that a simulation model will be needed.

It is difficult to ensure consistent calibration (to the specified confidence level) between entities since, for example, they will have different risk volatilities from country to country.

Also some territories will be better than others with respect to data collection and modelling expertise.

- (iii) One option would be to recalculate the capital required at group level. Most likely a stochastic model would be used.

This could be done by reflecting the dependencies in the diversification structure.

These reputational group risks effect the correlations between entities (in fact, these concentrations can be thought of as the opposite of diversification benefits).

It would be necessary to model both the frequency and severity distributions.

The results may then be allocated to each subsidiary and capital held at local level.

Alternatively the capital required could be calculated directly at subsidiary level.

These reputational group risks could be considered as a special case of operational risk and included in the operational risk capital.

Alternatively, at group level scenario analysis could be carried out to estimate the adequacy of capital held in each subsidiary

And the capital could be topped up as necessary.

[There were a number of different and acceptable answers to parts (ii) and (iii).]

- 6** (i) The risk report should be in keeping with the content and depth of the financial statements. In other words it should produce information at a group level.

It should include:

- A risk appetite statement
- A statement describing the risk management process of the company noting any key changes to the process over the reporting period. The statement should include the methods for identifying, monitoring, quantifying, transferring, mitigating and reporting risks.
- A table of risk categorisations.
- Top 5 risks ordered by reasonably foreseeable economic impact. The table should include a description of the risk, its relative chance of occurring and the estimated range of net cost to the group should it occur.

- Top 5 risks ordered by likelihood of occurrence over the next 12 months (for risks which are deemed to have a large potential economic impact). The table should include a description of the risk, its relative chance of occurring and the estimated range of net cost to the group should it occur.
- Commentary on any changes to the risk lists since the last report.
- A statement comparing large risk exposures to stated risk tolerances
- A statement describing the risk modelling (quantification) process including the validation process.
- A statement describing the main operational risks and the systems in place to mitigate or transfer them. Corporate governance, HR rules, Compliance Dept, management structure and oversight, internal reporting to mitigate risks and insurance and outsourcing to transfer them. This statement could reference the risk mitigation strategies in place for the top 5 risks mentioned if any.
- A statement of risk crystallisations / risk events which happened over the past period.

(ii) Information From Risk Reports

- Frequency and severity estimates for the major risks.
- The risk description in the risk list can be compared across companies (same industry, same size).
- The description of mitigation strategies for operational risks will help to decide on the company's exposure to operational risks.

Information from the Financial Statements

- The net profit
- Any components in the net profit which arise from risk costs. These should be added back to estimate the return before risk costs.
- Average shareholders' equity during the period (adjusted for rights issues, bonus issues etc..)

Would also need to use the average risk free rate of return (say 3 month government debt return) for the purpose of calculating the risk adjusted ROE

The risk reports will be different between companies and over time.

Adjust all of the risk reports to cover the same time horizon (probably one year)

A perusal of all of the risk reports may give insight into typical risks of companies, by industry, by market cap, overall.

The risk report will provide frequency and severity information for the largest risks. Use this information to estimate a risk cost distribution for the company. Judgmentally, gross up this risk cost distribution. The gross up factor would depend on the extent of the risk list in the given company's risk report and the comparable risk lists of other companies in the same industry.

Overlay a (judgmental) risk factor to allow for operational risk.

The percentile chosen of the risk cost distribution will depend on the purpose of the risk adjusted return table. For example, use the mean risk cost to estimate each company's expected risk adjusted ROE in the upcoming 12 months. Alternatively use the 75th percentile to estimate the sensitivity of each company's net profit to a changing risk outcome.

Risk adjusted ROE = (Pre-dividend net of tax profits adjusted for risk based losses minus mean risk cost minus risk free rate of return) divided by shareholders' equity during the period adjusted for any rights issues or bonus issues.

[This question was intended to be difficult. Many candidates noted that the risk report should include some sort of quantification of the company's key risks at the time of each report. A smaller number of candidates realised that these key risks would likely change over time and hence could be compared over time for a given company and across different companies in the same or different industries.]

- 7** (i) The generator function for this Gumbel copula is $(-\ln F(x))^2$.

We are interested here in $x = -0.6$, for which $F(x) = 0.1$.

So the generated result for a single loss is $(-\ln(0.1))^2 = 5.3019$.

Multiply this by 10 to allow for the number of bonds in the portfolio, giving 53.019.

Apply the pseudo inverse of the generator function (square root, take the negative, take the exponential) to obtain 0.000688 or 0.0688%.

- (ii) The correlation coefficients indicate the overall level of dependence.

A copula describes the shape of this relationship.

Both are important in describing the relationship between variables.

- (iii) The Gumbel copula has upper tail dependence. This is appropriate if you think that extreme positive returns are likely to be more closely related than extreme negative ones. For a high-yield bond portfolio, the opposite is more

likely to be the case. This suggests that a copula such as the Clayton copula is more likely to be appropriate. However, as single-parameter Archimedean copulas, the Gumbel and Clayton copulas can be parameterised only with a single variable. This means that there is an implicit assumption that the shape and degree of correlation between each bond is assumed to be identical, which might not be the case. A wider range of relationships could be described by an elliptical copula. In particular, a t-copula could also be used to describe data with fat tails.

[This question required candidates to be relatively familiar with the calculation of a copula.]

- 8** (i) A CDO is formed by setting up an investment entity known as a special purpose vehicle (SPV). This is used to purchase a portfolio of bonds, mortgages, credit derivatives or, in this case, mortality-related cash flows.

The money used to purchase these cash flows comes from external investors. The money from the investors is used by the SPV to make payments to the life insurance company, which then pays any claims on the term assurance policies it has written. This means that the greater the number of deaths, the greater the level of payments from the SPV to the insurance company and the smaller the funds left for the investors.

These investors can purchase different classes of share in the SPV, each of which receives returns from the SPV. The riskiest tranche of shares – known as the equity tranche – suffers the full impact if the mortality rate is higher than expected. In other words, for the first term assurance claims, only holders of the equity tranche suffer a reduction in their income stream. However, to compensate for this increased risk these investors have the highest expected returns relative to their initial investment. At the other end of the scale the safest tranche of shares does not suffer the impact of any term assurance claims until all of the funds allocated to lower tranches have been exhausted through prior claims. The high level of security means that investors in this tranche have the lowest expected return. For this reason, it is known as the senior or super-senior tranche. In the middle, with a moderate level of both risk and return, is the mezzanine tranche.

The aggregate loss at which the payments on a particular tranche start to reduce are often defined by attachment points. The returns for investors in a particular tranche can therefore be defined as follows:

- if the loss for the portfolio as a whole is less than the attachment point for this tranche, then the investor will receive the maximum possible investment;
- if the loss is greater than the attachment point for the next most senior tranche – which can also be regarded as the detachment point for the investor's own tranche – then the investor suffers a total loss; and

- if the loss is between these two points, then the return to the investor is the fund value less the detachment point.

Other methods to share loss include coupon reduction or default and different approaches to allocating partial capital losses of the various tranches.

The return received for each tranche is in return for an initial investment. The total investment over all tranches must equal the total initial value of the fund, but the greater the investment required for investment in a particular tranche the lower the potential return for that tranche. The return for each tranche therefore depends on both the attachment points and the initial investment required from investors in each tranche.

The attachment points and levels of investment are determined using quantitative models that are frequently agreed with credit rating agencies. This means that the tranches themselves get credit ratings.

- (ii) Both will provide protection against extreme losses.

The CDO is described as only covering losses up to a certain limit; the reinsurance may not have a limit. The ultimate payout will depend on the specific terms and conditions of the contracts.

This will reduce the amount of capital required to write business if the protection reduces the amount of capital required under Solvency II – in other words, if it reduces the SCR and/or the ORSA.

However, depending on the premiums paid, the protection may reduce the expected level of profit.

The extent to which this is true will depend on whether the cost of the reinsurance or the profit foregone with the catastrophe bond exceeds the additional profit that can be generated from the increase in the volume of business written.

With the reinsurance, there is credit risk from the possibility of reinsurer failure. This can be managed by ensuring that the reinsurer has a sufficiently high credit rating. This risk does not exist with the catastrophe bond as the capital is set aside in an SPV for the term of the bond.

However, in this instance there is instead the risk that too high an expected return might need to be embedded in the bond to make it attractive to investors. Such a bond might not be particularly liquid, so a higher premium might be needed as compensation. Investors might also be concerned about asymmetry of information, since the insurer would know more about the lives being placed in the bond. This is also potentially true with reinsurance, but the reinsurer is more likely to have seen past claim data so will be more confident on the pricing.

The CDO structure could make the product more attractive to a wider range of investors.

Market capacity is more likely to be known and stable for the reinsurance deal, but the market for catastrophe bonds may be less well developed and there may or may not be appetite for this particular issue.

There may not be a sufficiently great economy of scale to enter into the CDO arrangement.

There may be different levels of administrative burden. The reinsurance deal is likely to be relatively straightforward to enter into and broker, but will require regular information feeds to/from the reinsurer thereafter. The CDO is likely to take more effort initially with the design and getting it to market, but there may be less ongoing administrative burden.

There may be potential tax differences in the jurisdiction involved.

There may be differences relating to the flexibility regarding adaptation to writing new business, so that the company can continue to manage its mortality risk on an open book, rather than just on the existing portfolio. For example, with the reinsurance it may be possible to keep the treaty open to new business.

The reinsurer may provide extra benefits such as data, pricing advice and underwriting expertise.

[This question was intended to have difficult components. Part (i) was generally well answered. Many candidates' answers to part (ii) appeared to be a little rushed. They were quite superficial. For example, many candidates failed to reflect on the likely differences in terms and conditions between the two contracts.]

- 9** A number of options are available to Scilly Sandals plc to help ease the severe liquidity pressures.

Whatever the company does to address the short term issue it should endeavour at the same time to reduce the chance of the liquidity strain recurring in the future.

A cash buffer may have been set aside on the balance sheet so as to help the company manage through liquidity pressures. However, the cash buffer may have been utilised already, since the liquidity pressures now facing the company are described as severe. Therefore, further more severe actions to ease the liquidity pressures may now need to be considered.

Actions relating to the company's working capital may be undertaken so as to maximise short term cashflow.

- The company could sell surplus stock, although the value achieved for the surplus stock may depend on the season due to the seasonal nature of the products. In

addition, there may be longer term pricing and brand implications where aggressive pricing is required to shift the surplus stock. Finally, the sale of surplus stock may take some time, particularly where this has not been undertaken previously so that established channels for the sale of surplus stock are not readily available.

- The company could monetise receivables, although there will be cost implications due to the third party's interest charges and other costs. As with the sale of surplus stock, the monetising of receivables may take some time, particularly where this has not been undertaken previously so that established channels for monetising of receivables are not readily available. It might be simplest for the company to first chase debtors to see if any will pay.
- The company may delay payments to suppliers, although this may negatively impact upon the relationship of the company with its suppliers. Worse still, the delaying of payments to suppliers may lead to alarm spreading amongst the company's suppliers regarding the company's financial health. This may in turn result in suppliers becoming unwilling to ship goods.
- The company could sell assets. This might generate cash quickly but some of the assets might need to be repurchased in the future at possibly higher cost.
- The company could reduce expenditure eg. Raw materials and/or staff costs. This action may reduce the quality of the company's goods and lower staff morale.

Actions relating to the company's capital expenditure may be undertaken so as to maximise short term cashflow.

- The company may temporarily reduce the planned maintenance expenditure – e.g. spending on refurbishing the head office could be delayed. However, reduced maintenance spending may not be possible or may take time to implement where contractual agreements have been entered into or where there are regulatory requirements.
- The company may temporarily reduce investment in new products from planned levels. However, reduced investment in new products may not be possible where the company has entered into contractual agreements – e.g. official flip flop supplier to the 2012 Olympic Games.

Actions relating to the capital markets and the company's bank credit may be undertaken so as to access further or at least preserve capital.

- The company may defer dividends or pay scrip dividends. However, such measures may send a distress signal to the capital markets with possible implications for the company's ability to access further capital. Similar comments apply where dividends on preference shares are deferred with such deferrals potentially creating a liability on the company's balance sheet.
- The company may tap capital markets for further capital utilising the debt or equity markets. However, with the severe liquidity pressures being experienced

the company may already be experiencing rolling over commercial paper let alone accessing further capital.

- The company may be able to negotiate credit facilities with its bank. However, unless there are committed lines of credit the company may find the door closed where the bank is not confident in the ability of management to negotiate the severe liquidity pressures.

Finally, where the company has a defined benefit pension scheme the company may be able to negotiate the delay of payments into the scheme with the trustees. This is most likely to be successful where the scheme is in surplus and where the trustees are confident in the ability of management to negotiate the severe liquidity pressures.

[The key point of this question was that Scilly Sandals had an immediate issue that needed immediate or at least near term solutions. Several candidates focussed on relatively long term solutions which would not have worked in time to save the company.]

END OF EXAMINERS' REPORT

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINATION

6 October 2011 (pm)

Subject ST9 — Enterprise Risk Management

Time allowed: Three hours

INSTRUCTIONS TO THE CANDIDATE

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all eight questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

AT THE END OF THE EXAMINATION

Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.

In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.

- 1** The central risk team of a global insurance company is preparing for the introduction of a new risk based regulatory regime. The Chief Risk Officer for the insurance company has responsibility for preparing a set of new risk policies.

Outline the areas that should be covered in each risk policy. [4]

- 2** Investment Bank A is listed on the national stock exchange. It has grown rapidly in recent years and has operations around the world. It uses outsourcing arrangements to provide a large part of its services.

It has just appointed a new external director, who has commented that although the bank has implemented a risk management framework, it does not appear to have a very strong risk management culture.

(i) Discuss this comment. [4]

(ii) Propose ways in which the management of the bank could seek to improve the risk management culture. [5]

Life Insurer B is a domestic, unlisted life insurance company that sells retirement savings products. Investment Bank A is looking to acquire Life Insurer B in order to boost the scale of its investment management operations.

(iii) Outline how Lam’s seven “key lessons learned” can assist the Board when integrating the risk management frameworks of the two businesses. [7]

[Total 16]

- 3** A large bank’s trading book comprises hundreds of thousands of interest rate and foreign exchange rate swaps with a wide range of counterparties.

(i) Describe the main risks to the bank arising from its trading book. [3]

Historically such risks have been measured by estimating the daily volatility on interest rates for the interest rate swaps and by estimating the daily volatility on both interest rates and foreign exchange rates for the foreign exchange rate swaps. The Pearson’s correlation coefficients between the various foreign currencies are also estimated and used in the risk calculations.

The bank is now developing a model to measure the amount of risk in the trading book, based on these daily volatility estimates and a correlation coefficient matrix for the various foreign currencies.

(ii) Describe the additional inputs that would be required in order to construct this risk model. [6]

(iii) Describe the outputs that should be produced by this risk model. [3]

(iv) Discuss the extent to which this risk model is likely to produce reasonable results. [5]

[Total 17]

4 Over the last few years the price of aviation fuel has generally been increasing, as has the volatility of the price. In response, UK based Snooze Air plc purchased futures contracts listed on the New York Mercantile Exchange relating to the company's forecasted usage of aviation fuel over the following 18 months.

(i) Describe why the company has purchased futures contracts. [2]

(ii) Describe the issues that might arise in relation to this mitigation strategy. [4]

[Total 6]

5 Let S_t and B_t be the value at time t of a firm's equity and debt respectively and V_t be the firm's value at time t . Then Merton's model at time t for the value of a firm, assuming frictionless markets, states that $V_t = S_t + B_t$.

If V_t is assumed to follow a diffusion model of the form

$$dV_t = \mu_V V_t dt + \sigma_V V_t dW_t$$

where μ_V is real and is the mean value of the firm, σ_V is greater than 0 and is the standard deviation of the value of the firm and W_t is a standard Brownian motion, then the default probability of the firm can be calculated as:

$$P(V_T \leq B) = P(\ln V_T \leq \ln B) = \Phi \left(\frac{\ln(B/V_0) - (\mu_V - \frac{1}{2}\sigma_V^2)T}{\sigma_V \sqrt{T}} \right).$$

where T is the term to maturity of the debt.

(i) Justify the above formula using economic intuition. [4]

The above form of the Merton model can be extended to include credit migration thresholds. It can be shown that the firm belongs to rating class j at time horizon T if and only if $d_j < X_T \leq d_{j+1}$ where:

$$X_T := \frac{\ln V_T - \ln V_0 - (\mu_V - \frac{1}{2}\sigma_V^2)T}{\sigma_V \sqrt{T}},$$

$$d_j := \frac{\ln \tilde{d}_j - \ln V_0 - (\mu_V - \frac{1}{2}\sigma_V^2)T}{\sigma_V \sqrt{T}},$$

where \tilde{d}_j is a ratings threshold (for example \tilde{d}_1 is the default threshold, e.g. the value of the firm's liabilities).

(ii) Explain how the firm's management and external credit analysts could use this threshold model for decision making purposes. [6]

[Total 10]

- 6** ABC is a life insurance company. It sells two product types, namely immediate annuities and term assurances, both of which are backed by portfolios of government bonds.

The two products are sold through different distribution channels. Recognising that the key risk exposures are quite different for each product (longevity and mortality respectively), ABC also has separate administration and back office functions for each product.

ABC has recently begun developing an economic capital model. It believes that these two products to some extent provide a natural hedge and it would like to reflect this in the model.

- (i) Explain the role of diversification in measuring economic capital requirements. [2]

ABC has calculated the economic capital requirement for annuities and term assurances on a standalone basis to be £5.5 million and £2.25 million respectively. ABC has estimated that the correlation between the two blocks of business is 0.25.

- (ii) Estimate the combined capital requirement and diversification benefit for the business, using a simple correlation matrix approach. [4]
- (iii) Suggest an alternative modelling approach that could be used to recognise the natural hedge between the two product lines. [1]

The Business Development Manager has suggested that a third product line would help to increase the relative size of the diversification benefit available and has suggested selling a savings product with a guaranteed investment return.

- (iv) Discuss this proposal. [5]
- [Total 12]

- 7** Traditionally, most companies state that their primary objective is to increase profits from year to year. A well-known economist has recently said that, in most cases, a company's stakeholders would be better served if the company's primary objective was to operate at the limit of its stated risk tolerance.

Discuss this comment. [12]

- 8 (i) State the formulae that define Value at Risk (VaR) and Tail Value at Risk (TVaR). [3]
- (ii) Outline the four axioms of a coherent risk measure. [4]

The Argyle Assurance Society currently uses a VaR approach when setting its risk based capital, assessing the 97.5% quantile over a one year time horizon.

The investment manager for the society is considering a portfolio of 20 independent corporate bond issues. The estimated probability of default on each of the bonds is 2% over the following year. The current price of each bond is £100,000. If there is no default on a particular bond then that bond pays £105,000 in one year's time. If there is a default on a particular bond then there is no payment in one year's time.

The investment manager has proposed two alternative strategies:

- Investment strategy A involves investing £2m in a single corporate bond issue from the portfolio.
- Investment strategy B involves investing £100,000 in each of the 20 corporate bond issues from the portfolio.

The following is a schedule of the cumulative distribution function for the binomial distribution with $n = 20$ and $p = 0.02$:

x	$F(x)$
0	0.6676
1	0.9401
2	0.9929
3	0.9994
4	1.0000

- (iii) Calculate the VaR and TVaR for each investment strategy, using the given schedule. [8]
- (iv) Discuss the suitability of using VaR and TVaR when setting the risk based capital for the society. [6]
- (v) Explain which investment strategy should be recommended to the Board for approval. [2]

[Total 23]

END OF PAPER

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

September 2011 examinations

Subject ST9 — Enterprise Risk Management Specialist Technical

Purpose of Examiners' Reports

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and who are using past papers as a revision aid, and also those who have previously failed the subject. The Examiners are charged by Council with examining the published syllabus. Although Examiners have access to the Core Reading, which is designed to interpret the syllabus, the Examiners are not required to examine the content of Core Reading. Notwithstanding that, the questions set, and the following comments, will generally be based on Core Reading.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report. Other valid approaches are always given appropriate credit; where there is a commonly used alternative approach, this is also noted in the report. For essay-style questions, and particularly the open-ended questions in the later subjects, this report contains all the points for which the Examiners awarded marks. This is much more than a model solution – it would be impossible to write down all the points in the report in the time allowed for the question.

T J Birse
Chairman of the Board of Examiners

December 2011

General comments on Subject ST9

The ST9 exam generally requires bullet point form or short form essay style answers that apply general principles to directly address specific circumstances. The answers given below are just one possible set of acceptable answers. Candidates are awarded marks for all reasonable answers including different but still reasonable numerical solutions. Marks are awarded for working in the case of numerical answers.

Comments on the September 2011 paper

Well-prepared candidates scored acceptably well across the whole paper. The comments that follow the questions concentrate on areas where candidates could have improved their performance.

1 Administrative points need to be included such as:

- policy owner;
- sign off;
- date of sign off and next review; and
- applicability to business units, activities and products.
- Approved risk taxonomy

The risk policy should also include the risk appetite, risk tolerances and risk limits.

The risk policy should provide guidance on the identification, measurement, selection and management of risk.

The risk policy should cover risk governance including roles and responsibilities. In particular, the escalation processes should be outlined.

The question was handled well by most. Many candidates failed to note the administrative points.

2 (i) The director may be correct in that the bank has implemented risk management *processes*, but has not recognised that culture is an important part of the overall ERM framework.

It may be that the bank has perceived ERM implementation as a “box ticking” exercise. For example to keep credit rating agencies, regulators or other stakeholders happy.

However, if the risk management culture is not strong then the rest of the framework is unlikely to be successful, and this will not impress such observers.

It may be that it is recognised as being important, but a strong culture has been more difficult to achieve due to the bank’s fairly fragmented structure, both internationally and through the use of outsourcing arrangements.

Its rapid recent growth rate might mean that there has been temporary management distraction.

Or it might be taking time for positive actions to be implemented across all of the business.

The director’s fresh external perspective is likely to be quite helpful but may include some expectations that are unreasonable, perhaps based on his experiences with previous organisations that have a very different size or structure.

Being new he may be basing his judgement on initial impressions, which should be validated before further action.

- (ii) The overall aim should be to enable everyone throughout the bank to participate in risk management to some extent. If not already implemented, the following actions should be taken to achieve this:
- The Board should ensure that it is leading by example, prioritising risk management issues as a matter of course.
 - All line managers should have defined responsibility for managing the risks within their areas of accountability.
 - Line managers should be required to report on the more important risks to a central point.
 - The bank should communicate regularly and openly about risk management matters to all staff, e.g. via regular e-bulletins.
 - The bank's intranet could be used to highlight the importance of risk management buy-in.
 - There should be clear processes in place that enable all staff – not just managers – to be involved in the identification of new and enhanced risks.
 - Easy reporting mechanisms should be implemented for other aspects, e.g. ideas for increasing opportunities, mitigation suggestions, procedure failures.
 - The bank could offer regular prizes to staff for the best risk management related suggestions.
 - Performance management for all staff could be introduced that are clearly related to risk management objectives.
 - Performance based remuneration for all staff could be introduced that are clearly related to risk management objectives.
 - The bank should ensure that there are risk management champions throughout each part of its international operations, and that there is strong liaison between them.
 - It should also engage with its outsourcing suppliers to ensure that there is consistency in terms of risk management culture, to avoid dilution of the messages.
 - The bank should ensure that there are adequate checks and validations within the risk management framework to minimise the risk of bias.

- Train all staff in the importance/role of risk management.

(iii) **Know your business**

- The bank must not seek to impose its own framework on the insurer
- The bank must recognise the importance of understanding the different specific risks of the insurance company, particularly those that relate to activities not undertaken by the bank (e.g. insurance risks)

Set limits and boundaries

- Risk limits and metrics should be specific to each of the businesses, taking into account different products, target markets, geographical areas of operation, possibly sizes, capital structures, risk types.
- However, the bank should also aim for consistency within the combined risk management framework

Use the right yardstick

- These limits and metrics should influence the choice of performance objectives and measures set for managers and staff
- These should be consistent for similar roles across the two organisations, allowing where appropriate for specific issues

Pay for the performance that you want

- Compensation policies should be aligned to these risk measures and the objectives of the company.
- To avoid staff dissatisfaction, they should be consistent between the two organisations for roles of similar levels and responsibilities.

Establish checks and balances

- Care should be taken not to create excessive concentrations of risk – for example by it may be useful to incorporate restrictions such as additional checks and balances if the investment assets of both businesses are combined and therefore exposed to the same operational risks.
- The bank should also avoid creating increased concentration of power or authority of specific individuals as a result of the integration.

Keep your eye on the cash

- This applies equally to ensure that the management of cash flow for both entities remains appropriate to their requirements after the combination

- The bank should assess the quality of the insurer's financial authorisation and control processes, and might either adopt them itself or introduce its own internal processes, depending on their relative strengths.

Balance the yin and the yang

- Management should not overlook the “softer side” of risk management and the development of a combined culture for the firms.
- Given the earlier suggestions about the quality of risk management culture within the bank, it is possible that it can learn something from the approach taken by the insurer.

The question was handled well by most.

Part (iii) says “when integrating the risk management frameworks of the businesses.” Hence the answer should be specific to the businesses and not just a restatement of the generic description in Lam.

- 3**
- (i) The bank is exposed to the risk of the market value of the net trading book being less than expected. The three main sources of risk are:
- Movements in interest rates underlying the swaps. This is made up of the delta, gamma and vega of the interest rate curves being essentially vertical changes in the curve, changes in shape and the rate of change in the slope respectively.
 - Movements in foreign exchange rates relative to the Bank's reporting currency. This risk will be on the net trade position gross of any collateral.
 - Counterparty risk remaining after trades are netted and collateral is taken into account.
- (ii) A summary of the mark to market value of the net trades produced at different points in the past (say monthly).

The summary would be separated into interest rate swaps and foreign exchange swaps.

The interest rate swap summary would be broken down into interest rate reset term and the remaining term of the swap.

The foreign exchange swap summary would be broken down into foreign currencies being swapped and the remaining term.

The summaries are needed at different points in order to estimate the likely range of potential growth in the book over the forecast period.

Alternatively one could assume a range of hypothetical growth rates.

Daily volatility estimates for interest rates provides an estimate of delta.

It will be necessary to input estimates of gamma and vega or least the observed impact to the historical trading book of historical changes in gamma and vega.

A list of net (of both trades and collateral) counterparty exposures by counterparty and by rating.

Time horizon

Choice of probability distribution for volatilities, if assumed variable

Default probabilities by counterparty rating

- (iii) The risk model should produce a probability distribution of the future mark to market value of the net trading book.

The risk model could estimate the distribution of the net book at different points in the future and so produce a number of different distributions.

The risk model should produce a number of key statistics including expected value, modal value, 90th percentile (probability that the value of the book will not be less than X in 90% of modelled scenarios), 95th percentile and 99th percentile.

The risk model should produce relative estimates of the major sources of variability e.g. exposure to one or more particular currencies and/or counterparties.

- (iv) The model is based on volatility estimates and the linear correlation coefficient. This is reasonable if the underlying interest rate change/ exchange rate change distributions are normally distributed or at least elliptically distributed.

However, past observations of financial data suggest that the underlying distributions are not normal and are more likely to be relatively fat tailed, which would lead to underestimation of the risk to the bank.

The model is based on daily volatility estimates. Extrapolating the daily volatility estimates into weekly, monthly, annual forecasts may be expected to be increasingly inaccurate, since volatilities can change rapidly. Other things equal, the model should produce reasonable estimates for short forecast periods.

The volatility estimates are likely to be the major reason for variation around the mean when forecasting results which are not extreme e.g. say between 10th

and 90th percentile. Other things equal the model should produce reasonable results for the bulk of the distribution but possibly not the tail.

Past observation of financial data also suggests that the correlations between financial instruments can increase greatly in times of stress and under relatively extreme events, which will again underestimate the risk to the bank in these conditions.

The question was in the main not well answered by many. Questions (ii) and (iv) were found to be particularly difficult.

For part (iv) some candidates gave the alternative and more generic answer about model specification, parameter error etc. Marks were given for this answer if the points were valid and if they addressed the specific circumstances.

- 4**
- (i) Snooze Air plc has purchased futures contracts so as to lock into the aviation fuel prices that are currently priced into the futures contracts. In particular, it is protecting itself against increases in the price of aviation fuel above this level over the next 18 months. Assuming the company's forecasted usage of aviation fuel is accurate, the use of futures contracts may help the company to manage its earnings volatility.
 - (ii) A worsening economic environment would likely lead to lower passenger volumes and possibly reduced schedules. Where this is the case the company will have purchased futures contracts for fuel that is no longer needed leading to a mismatch.

On the other hand, the company may have under-estimated its fuel consumption needs (e.g. by over-estimating the fall in demand), and would remain exposed to fuel prices in relation to this shortfall.

A worsening economic environment would also likely lead to lower fuel prices resulting in losses on the purchased futures contracts, including those futures contracts relating to any mismatch.

The protection afforded is only available in the short term. Once the futures contracts mature, the company will once again be exposed to fluctuations in the price of aviation fuel, which may mean paying far higher prices than those that are priced into the futures contracts.

The futures contracts are listed on the New York Mercantile Exchange with likely delivery in the American Northeast. Therefore, the company is exposed to local factors that lead to differences in the price of aviation fuel in the America Northeast and the UK.

This approach may need cash to pre-fund some of the future fuel costs because if the future contracts go out of the money then Snooze Air will have to meet margin payments.

Snooze Air may not have the requisite expertise to buy and administer the contracts.

It is possible that the currency for the contracts is different from the currency in which Snooze Air usually buys its fuel. This gives rise to different if not additional currency risk which will need managing.

The question was handled well by most.

- 5** (i) T is the term to maturity of the debt. This is the logical point in time to test whether the value of the firm is more than or less than the debt repayment.

The probability of default increases as the ratio of B/V_0 (the value of the debt to the original value of the firm) increases. This makes sense as the firm is more leveraged and closer to $V_t \leq B_t$.

The higher the mean value of the firm μ_V , the lower the probability of default makes sense, particularly if μ_V is large relative to the volatility in the firm value σ_V .

As volatility in the firm value σ_V increases the probability of default should increase, since there is more chance for V_t to slip below B_t in any given scenario.

The denominator being $\sigma_V \sqrt{T} : \sqrt{T}$ is the standard way to adjust volatility for time.

Marks were also given for showing how the formula fits the Black Scholes formula as it's a call option.

- (ii) It is only a one period, single firm model and so not useful for portfolio management purposes.

Key factors in the model are B , V_0 , μ_V , σ_V and T . \tilde{d}_j are asset value levels that mark the boundaries of higher rating categories.

The firm's management would gain insight into its business once it saw that σ_V and \tilde{d}_j are not within their direct control. T is simply the time horizon. V_0 and μ_V are potentially changeable by management if it were to raise new equity or distribute some back. The level of debt B is probably the easiest and most direct thing for management to control.

The firm's management could use the model to judge the extent to which they would need to change their debt and equity structure to change their rating.

Alternatively the firm's management could estimate the probability of a rating change (including default) over the single period of time T .

External credit analysts could use the model to estimate the immediate impact on the firm's debt rating of significant changes in the firm's outstanding debt and/or share price. This can help the analysts' clients to decide on potential trades. Actual changes in credit ratings can take some weeks.

Alternatively external credit analysts could estimate the probability of a rating change (including default) over the single period of time T . They could then advise their clients of the relative proximity of the firm's debt to upgrade or downgrade and the probability of default over time horizon T .

Marks were given for alternate answers such as it might trigger a full rating review by the external analyst or that the model could be used to help gauge reactions to market movements.

- 6** (i) 100% positively correlated risks will have no diversification benefits. Conversely 100% negatively correlated risks will effectively cancel each other out

In relation to economic capital calculations, diversification benefits arise where the risks being assessed are less than fully correlated.

The probability that such risks will crystallise at the same time is likely to be less than the confidence level at which the economic capital is determined.

Consequently the amount of overall capital that needs to be held for the combined risk events is less than the sum of the capital amounts that would need to be held for each risk separately.

The diversification credit will increase as the correlation changes from 100% positively correlated to 100% negatively correlated. The increase in the diversification credit is not linear as the correlation coefficient decreases between 1 and minus 1.

- (ii) Undiversified = $5.5 + 2.25 = 7.75$

Diversified = square root $\{5.5^2 + 2.25^2 + 2 \times 0.25 \times 2.25 \times 5.5\} = 6.44$

Diversification benefit = $7.75 - 6.44 = 1.31$

Several candidates misread the correlation matrix.

- (iii) Calculate the economic capital using a single mortality deterioration or longevity improvement stress test covering both products at the same time. In this way the loss on one block is automatically offset against the gain on the other in the components of the calculation. However, the 100% correlation assumption would need to be interrogated.

Marks were also given answers involving a simulation model with joint probability distributions etc.

- (iv) The new contract is primarily exposed to market risk. This will introduce potential diversification benefits but will also introduce new risks to the company.

This will provide a new dimension to the risk profile that will allow for more diversification benefit.

Will need to consider the levels of correlation between the new and existing products.

The correlation will not be zero, i.e. not completely independent, but it is likely to be relatively small given the different nature of the main underlying risks.

It should also be noted that volumes of business written may have to be significant before the increased diversification benefit is tangible. It may take time therefore before there is any impact on capital requirements.

The new contract requires different core competencies and expertise to the existing business. These may not be available in the business. This therefore increases the operational risk exposure of the business while the expertise builds up.

If additional operational risk capital is required it will (partially) offset any benefit of the increased diversification credit.

An additional mark was awarded for candidates who noted that product changes could help to reduce the risk e.g. removing the minimum investment return guarantee.

7 Risk Tolerance Statement

A company's risk tolerance statement is a relatively detailed set of statements, many of which will be quantitative or statistical in nature. The statements will likely include targets and limits to specific categories of risk and/or units of business.

Risk tolerance often includes the Board's appetite for reductions in its profit and/or the ability to pay dividends. This concept incorporates the idea of wishing to increase or at least maintain profitability but recognising that there are risks and sometimes profit will be lower than desired.

Importantly the profit objective may not be an equal priority for all stakeholders. The risk tolerance statement will include other metrics which together should comprise a more balanced set of objectives to meet the group of stakeholders.

Operating at the Limit of the Stated Risk Tolerance

In order for a company to operate at the limit of its stated risk tolerance it will need to:

- Implement and embrace ERM at a level of sophistication which is at least equal to the detail contained in the risk tolerance statement.
- Regularly publish the risk tolerance statement. It will incentivise both the board and management to make the risk tolerance statement clear, comprehensive and up to date.
- Regularly publish information describing whether the company believes it is operating at/below/above its stated risk tolerance. This level of information will be very useful to stakeholders wishing to analyse the company.
- Have the capital in order to have the capacity to operate at its chosen risk appetite threshold.

Targeting Profit

Most companies are required to report annually or more frequently. This time horizon may be too short for measuring profit.

Profit is measured. It is the result of a large number of processes, many of which may be outside of the control of the management. Hence targeting profit is targeting something that is at least in part fortuitous.

This said, because profit is both a measured outcome and a very important key performance indicator for the company, it is often used for staff performance appraisal and bonuses. In other words, management may still be focusing on profit even when the Board's stated primary objective is to operate at the limit of its stated risk tolerance.

Targeting profit may make management more inclined to act contrary to the other stakeholders' wishes, for example, taking unnecessary risk or taking short term measures which may increase short term profits but are likely to reduce aggregate profits over the long term.

Targeting Risk Measures

Risk is estimated. It can be continually monitored. In this sense it is not subject to either the time horizon issue or to fortuitous results. Fortuitous results are just the consequence of different actual observations across the risk spectrum.

Profit is likely to be much more volatile than risk tolerance.

By setting the objective to operate at the limit of the risk tolerance the company is implying that expected profit will be maximised providing that the company is able to operate on the efficiency frontier. This is useful as it allows the stakeholders to focus on monitoring things which are within the control of the management, namely, the risk it is taking and the efficiency with which it is managing the business. Targeting risk tolerance is more useful for the board and the corporate governance policy as it represents control and management and not just outcome.

Stakeholders

Investors can diversify risk. Modern portfolio theory suggests that investors demand additional expected profit for taking additional risk. All too often it is not possible for investors to assess the risk a company is taking to achieve its returns. It will therefore be very useful to investors to have companies publish and monitor their adherence to stated risk tolerance and to make their objective to operate continually at the stated level. Traditional risk measures based on share price volatility and or profit volatility are very poor measures of the underlying risk that a company believes it is taking.

Bondholders, credit rating agencies and regulators will all be much more concerned with risk and the comparable capital of the company than a profit objective.

Many stakeholders will be concerned to try to estimate the extent to which two or more company's share price are correlated. More particularly they will likely be concerned to try to estimate correlation in extreme events. Providing the companies have similar or at least stable primary objectives then the correlation estimations can be reasonably derived from the historic share price movements. However, for the purpose of estimating correlation under extreme events the detail in the risk tolerance statements and the resulting history of profits should prove to be a very useful differentiator. (need to explain).

Suitability to All Companies

Targeting the limit of the risk tolerance statement is likely to be suitable for the majority of medium sized and larger companies. It may not be appropriate for small companies, sole traders, privately held companies, publically owned companies. Companies with relatively few stakeholders and /or particularly well informed stakeholders may believe that the risk position is relatively stable from year to year in any case and that the profit objective is both more tangible, more focused and more appropriate. Alternatively the company may have been formed with a particular alternative set of objectives in mind e.g. a charity.

This question was not well answered by many candidates. Marks were given for a range of different approaches. Several candidates failed to address the standard investment tenet that additional expected return is generally associated with taking more risk. Hence, other things held equal, maximising profit could easily involve taking more risk than is stated in the company's risk appetite statement.

8 (i) $\text{VaR}_\alpha = \inf\{y \in \mathfrak{R} : F(y) \geq \alpha\}$

$$\text{TVaR}_\alpha = 1 / (1 - \alpha) \int_\alpha^1 \text{VaR}_p(L) dp$$

where:

α is the confidence level

$F(\cdot)$ is the cumulative distribution function of loss L

L is a random variable representing the loss on a portfolio of assets and liabilities

TVAR(alpha) = E[L/L > Var(alpha)] is an acceptable alternative answer.

(ii) **Translation invariance**

The Risk Measure should show that the amount of capital required supports the perceived variability of a loss and not its expected amount. Adding or subtracting a fixed amount from a loss leaves the capital (being the amount excess of the expected loss) unchanged.

Subadditivity

Compounding loss distributions should create a diversification benefit. Even if the distributions were 100% correlated the Risk Measure of the compounded distribution should not exceed the sum of the Risk Measures of the individual distributions.

Positive homogeneity

Also known as positive scalability the Risk Measure should show that the capital required to support “ n ” identical losses is equal to “ n ” times the capital need to support one loss.

Monotonicity

The Risk Measure should show that the capital needed to support a smaller loss (with the same distribution) is less than the capital needed to support a larger loss.

Marks were given for correct formulas instead of descriptions.

(iii) VaR calculations

For investment strategy A we have:

$$\text{VaR}_{97.5A} = -20 \times 5,000 + 0 \times 100,000 = -100,000$$

(since zero defaults represents the 97.5th percentile for this strategy).

For investment strategy B we have:

$$\text{VaR}_{97.5B} = -18 \times 5,000 + 2 \times 100,000 = 110,000$$

(since $P(\text{Bin}(20, 2\%) \leq 1) = 0.9401$ and $P(\text{Bin}(20, 2\%) \leq 2) = 0.9929$ so that two defaults represents the 97.5th percentile for this strategy).

Marks were given for an interpolation approach.

TVaR calculations

For investment strategy A we have:

$$\text{TVaR}_{97.5A} = (-20 \times 0.5\% \times 5,000 + 20 \times 2\% \times 100,000) / 2.5\% = 1,580,000.$$

For investment strategy B we have:

$$\begin{aligned} \text{TVaR}_{97.5B} &= ((99.29\% - 97.5\%) \times (-18 \times 5,000 + 2 \times 100,000) \\ &+ (99.94\% - 99.29\%) \times (-17 \times 5,000 + 3 \times 100,000) \\ &+ (100.00\% - 99.94\%) \times (-16 \times 5,000 + 4 \times 100,000)) / 2.5\% = 142,000 \end{aligned}$$

(ignoring the probability of five or more corporate bonds defaulting since this is less than 0.01% according to the probabilities extracted from the Binomial distribution schedule).

- (iv) The VaR approach provides a simple method of setting the society's risk capital. The VaR approach is also widely used to set risk capital under regulatory regimes – e.g. Basel II and Solvency II – and by rating agencies – e.g. Standard & Poor's and Moody's.

However, the VaR approach does not give any indication of the extent to which losses might potentially exceed the 97.5% quantile. The TVaR approach addresses this issue since it is defined as the expected loss given that the loss exceeds the VaR at the same confidence level.

In addition, the VaR approach has poor aggregation properties. Specifically it fails the important subadditive property of a coherent risk measure. This means that the VaR for aggregate losses will not necessarily be less than the sum of the VaR for the individual loss distributions. This can be seen by comparing $\text{VaR}_{97.5A}$ and $\text{VaR}_{97.5B}$ for investment strategy A and investment strategy B respectively. The TVaR satisfies all the properties of a coherent

risk measure including the subadditive property. This can be seen by comparing $\text{TVaR}_{97.5A}$ and $\text{TVaR}_{97.5B}$ for investment strategy A and investment strategy B respectively.

Because the VaR approach provides a point estimate, at the extreme ends of the distribution it will often be necessary to run many simulations before the VaR estimate becomes statistically credible. The binomial approach used above is overly simplistic and would not be used in practice.

Marks were given for other valid answers.

- (v) Investment strategy B should be recommended to the Board.

The $\text{VaR}_{97.5A}$ is less than $\text{VaR}_{97.5B}$. Therefore, using a VaR approach to setting risk capital would indicate that investment strategy A, which is the less diversified of the two portfolios, would be the best option. However, we arrive at this unintuitive result because the VaR approach fails the subadditive property of a coherent risk measure.

The $\text{TVaR}_{97.5A}$ is more than $\text{TVaR}_{97.5B}$. Therefore, using a TVaR approach to setting risk capital would indicate that investment strategy B, which is the more diversified of the two portfolios, would be the best option. This is the more intuitive result that should therefore be recommended to the board.

END OF EXAMINERS' REPORT

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINATION

27 April 2012 (am)

Subject ST9 – Enterprise Risk Management

Time allowed: Three hours

INSTRUCTIONS TO THE CANDIDATE

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all eight questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

AT THE END OF THE EXAMINATION

Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.

In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.

1 Discuss when it would be helpful to distinguish between upside and downside risk, and when it would not. [5]

2 (i) Outline how different types of supervisory body carry out their controlling functions. [5]

The government of a small democratic country is concerned that a number of multinational banks have recently become insolvent. Some of its citizens may have lost moneys on deposit, and the government does not guarantee bank deposits.

The government is considering introducing legislation which will require all banks operating in the country to do so with a separately capitalised entity which may only hold domestic assets and domestic liabilities.

(ii) Discuss the likely impact and potential shortcomings of this proposed new legislation. [4]
[Total 9]

3 (i) List four Archimedean copulas. [2]

(ii) Explain different situations in which it would be appropriate to use each of these copulas. [5]
[Total 7]

4 Endeavour is a European insurance company providing all forms of marine insurance. It has decided to develop an internal model and apply for approval of this model under Solvency II.

- (i) Explain why the management of Endeavour might believe that an internal model would be more appropriate for its business than the standard formula. [2]
 - (ii) Outline the process which Endeavour should undertake to develop its internal model. [6]
 - (iii) Explain how expert judgment could be used to augment or refine the model development process. [2]
- [Total 10]

5 (i) Define the following terms:

- (a) economic capital
- (b) Value at Risk

[2]

GHI Insurance is a medium-sized proprietary life insurance company. It believes that its existing regulatory liabilities – on an economic basis and over a one year time horizon – are distributed normally with a mean of 3,000 and a standard deviation of 200. GHI Insurance is required to hold regulatory capital at the 99.5th percentile.

- (ii) Calculate how much regulatory capital GHI Insurance needs to hold. Your calculation can ignore potential changes in the value of assets. [2]

Insurance companies need to meet regulatory solvency requirements at all times and not just at valuation or reporting dates.

- (iii) Suggest a simple approach that GHI Insurance can take to address the risk that it may breach its regulatory capital requirement between normal calculation dates. [1]

A non-executive board member has heard that Value at Risk (VaR) has a number of shortcomings and that Tail Value at Risk (TVaR) is a more appropriate measure of how much capital to hold should an extreme event occur.

- (iv) Estimate the TVaR for GHI Insurance at the 99.5th percentile, stating any assumptions that you make. [2]
- (v) Describe the factors that GHI Insurance needs to consider in determining how much capital, if any, it should hold in excess of the regulatory capital requirement. [3]

[Total 10]

- 6** A leading economist has said that when it comes to modelling changes in future foreign exchange rates or interest rates, it is more important that the model predicts the direction of the change than the amount of the change.

Discuss this comment. [5]

- 7** Rockfort Bank is a long-established family-owned bank based in a high rated European country. Historically it has focussed on lending to and advising companies in its home country. Recently it has been losing business to larger banks that are able to offer a wider range of services to companies.

Approximately three years ago the current generation of Rockfort's management commenced lending on retail mortgages and accepting personal customers' deposits. A summary of key elements of the bank's recent financial reports has been provided. (See the tables at the end of this examination paper.)

- (i) Estimate the bank's tier 1 capital ratio under Basel I as at 31 December 2009, 2010 and 2011. State any assumptions that you make. [4]
- (ii) Discuss the financial risks facing the bank that would be expected to be highlighted in the bank's economic capital model, including figures where appropriate. [8]
- (iii) Outline the financial metrics that would be expected to be monitored in the monthly ERM committee reports. [5]
- (iv) Discuss the financial risks facing the bank that would increase if the bank were situated in a poorly rated European country. [3]
- (v) Suggest changes that the bank could make to reduce its liquidity risk. [4]
- (vi) Analyse the financial impact on the bank over the next three years of:
 - (a) a threefold increase in residential mortgage defaults
 - (b) a dramatic fall in investment yields

You should assess each event independently of the other. [6]

- (vii) Explain the main operational risk facing the bank. [2]

[Total 32]

8 Several years ago an entrepreneur noticed that the dairy goods industry was virtually unregulated, very fragmented and the majority of small transactions were conducted in cash. With financial backing he started the Happy Cow Company. Through acquisition the Happy Cow Company grew rapidly. It became one of the largest 100 companies by market value on the country's main stock exchange and raised substantial amounts of debt in the international capital markets.

Consumers were delighted with Happy Cow, which offered a wide range of dairy products at extremely competitive prices.

Dairy farmers and producers were also delighted with Happy Cow. They were either able to sell their produce at relatively high prices to Happy Cow or sell their entire business to Happy Cow for a high price.

The equity and debt investors were happy because Happy Cow maintained an unbroken track record of sales growth, increasing profit and increasing net asset value.

However, not all share market analysts were happy. Happy Cow was very secretive and published the minimum amount of information. The analysts were concerned that:

1. The majority of shares were held in trusts making it not possible to trace the owners of Happy Cow.
2. Happy Cow received very large dividends from unconsolidated associated companies. Little was known about these companies.
3. Happy Cow paid and lent large sums of money to both third parties and associated companies.
4. Based on market share estimates, Happy Cow apparently made very high profit margins although it was not possible to confirm this with Happy Cow data.
5. Happy Cow received a very significant part of its income from cash based door-to-door milk sales. This was a reversal of a dairy industry trend towards store sales prior to the emergence of Happy Cow.
6. Happy Cow employed a very small firm of external auditors to prepare its audited accounts.
7. Happy Cow refused to disclose any detail of its management, its management practices and the members of its board.

(i) Explain why these seven issues would have concerned the analysts. [7]

Happy Cow's management refused to address the analysts' concerns, simply saying that they were a large and well-run company. Their market share allowed them to make good profit margins and to grow from year to year.

Time has passed. Three months ago, the police arrested the founding entrepreneur and several members of the senior management team for a number of offences. The stock exchange has suspended trading in the shares and the court has placed the company into administration.

- (ii) Describe what might have prompted the police to investigate the company and its personnel. [2]
- (iii) Discuss the offences that the company's personnel are most likely to have committed. [3]
- (iv) Outline the legislation, regulations and codes of practice that are typically employed to try to prevent these offences from being possible. [6]

The government is considering passing new laws to try to reduce further the possibility of these types of offence being committed in the future.

- (v) Suggest with reasons two laws that the government might reasonably consider, but which would likely have an unduly onerous impact on the economy. [4]
- [Total 22]

Tables for use in question 7

Balance Sheet in EUR millions	Dec 31, 2011	Dec 31, 2010	Dec 31, 2009
FINANCIAL ASSETS AT AMORTISED COST			
Cash and balances with central bank	5200	4200	2000
Due from other banks	3400	4000	4500
Loans	14000	13700	12100
Securitised loans	1200	1200	1000
FINANCIAL ASSETS AVAILABLE FOR SALE			
Debt investments	2300	2200	2100
FINANCIAL ASSETS HELD AT FAIR VALUE			
Loans	2000	1800	1700
Residential mortgages own book	6600	3000	1400
Securitised residential mortgages	11400	5300	3000
Debt investments	600	500	500
Derivative financial assets held for trading	5000	4900	4700
Derivative financial assets used for hedging	400	400	450
OTHER			
Investments in associates	60	50	50
Intangible assets	400	390	390
Property, plant and equipment	200	180	170
Other assets	320	300	270
TOTAL ASSETS	53080	42120	34330
FINANCIAL LIABILITIES AT AMORTISED COST			
Due to other banks	2300	2200	2000
Deposits from customers	12000	7600	2500
Own debt securities in issue	26400	19200	17100
Debt securities in issue related to securitised mortgages	1000	1000	1000
FINANCIAL LIABILITIES HELD AT FAIR VALUE			
Structured debt securities in issue	3400	3100	3000
Derivative financial liabilities held for trading	5200	5200	4500
Derivative financial liabilities used for hedging	80	100	130
OTHER			
Employee benefits	20	41	57
Subordinated liabilities	800	620	570
Other liabilities	400	320	360
TOTAL LIABILITIES	51600	39381	31217
TOTAL SHAREHOLDERS EQUITY	1480	2739	3113

Profit & Loss Statement in EUR millions	Dec 31, 2011	Dec 31, 2010	Dec 31, 2009
Net interest income	160	150	145
Net fee and commission income	32	30	20
Dividend income	2	1	1
Net trading income	30	28	5
Net gains from financial assets	50	40	10
Share in result of associates	4	2	1
Other operating income	80	100	110
OPERATING INCOME	358	351	292
Personnel expenses	140	110	90
Other operating expenses	80	70	65
Depreciation and amortisation	22	20	15
OPERATING EXPENSES	242	200	170
Impairments of financial assets	18	26	17
TOTAL EXPENSES	260	226	187
PROFIT BEFORE TAX	98	125	105
Tax	16	20	17
PROFIT AFTER TAX	82	105	88

Securitised Residential Mortgage Exposure By Implied Rating			
AAA	0%	0%	0%
AA	10%	10%	10%
A	10%	10%	10%
BB	60%	60%	60%
Not rated	20%	20%	20%

Securitised and Own Book Residential Mortgage Exposure By Region			
Home country	95%	95%	95%
Germany	5%	5%	5%

END OF PAPER

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

April 2012 examinations

Subject ST9 – Enterprise Risk Management Specialist Technical

Purpose of Examiners' Reports

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and who are using past papers as a revision aid, and also those who have previously failed the subject. The Examiners are charged by Council with examining the published syllabus. Although Examiners have access to the Core Reading, which is designed to interpret the syllabus, the Examiners are not required to examine the content of Core Reading. Notwithstanding that, the questions set, and the following comments, will generally be based on Core Reading.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report. Other valid approaches are always given appropriate credit; where there is a commonly used alternative approach, this is also noted in the report. For essay-style questions, and particularly the open-ended questions in the later subjects, this report contains all the points for which the Examiners awarded marks. This is much more than a model solution – it would be impossible to write down all the points in the report in the time allowed for the question.

T J Birse
Chairman of the Board of Examiners

July 2012

General comments on Subject ST9

The ST9 exam generally requires bullet point form or short form essay style answers that apply general principles to directly address specific circumstances. The answers given below are just one possible set of acceptable answers. Candidates are awarded marks for all reasonable answers including different but still reasonable numerical solutions. Marks are awarded for working in the case of numerical answers.

Comments on the April 2012 paper

The April paper included, relative to past papers, more mini case studies. Candidates found question 7 quite difficult because it required them to interpret historic balance sheets and income statements. Future papers may well contain questions of a similar vein. Question 8 was also a mini case study question and involved fraud and money laundering. Candidates found this question to be more straight-forward even though they were equally weighted between knowledge and application.

Well-prepared candidates scored acceptably well across the whole paper. The comments that follow the questions concentrate on areas where candidates could have improved their performance.

- 1** Many companies are relatively risk averse and so will be more willing to commit limited time and resource to identifying, estimating, mitigating and transferring the risks of not making the expected returns or other financial objectives. They will be interested to know that there are scenarios that result in higher than expected returns but they won’t spend much time analysing them and seeking to optimise them.

For these companies the risk reporting, risk quantification including scenario testing, mitigation and transfer strategies will all be concerned with downside risk only. A possible exception is the calculation of the best case return which would be concerned with upside risk. Also the comparison of different transfer strategies may include determination of the lost potential for upside under each alternative.

However less risk adverse companies would be likely to separate and analyse upside risk in order to feed it into strategic decision-making, particularly the identification of potential opportunities to exploit.

The separation of upside and downside risk is not a useful concept for stochastic modelling and for calculating expected returns. In this case risk is typically defined as the variation from the expected result. For example, this approach is necessary to calculate confidence levels, probability of capital sufficiency and diversification credits.

The question was not handled well by most. Many candidates failed to note the two main points namely that risk adversity affects perspective and that distinguishing between upside and downside risk is, in most circumstances, not a particularly useful concept for stochastic modelling.

As ever, additional marks were given for other valid answers including:

- *Operational risk doesn’t normally have any monitored upside.*
- *Regulators are usually focussed on the downside. Companies will concentrate on downside when responding to/dealing with the regulator.*

- 2** (i) Professional bodies ensure that their members dealing with regulatory process are thoroughly trained and their knowledge kept up to date. This is usually done through an examination system and Continuous Professional Development requirements.

Professional regulators set the standards to which the professions must adhere and monitor how well the members are doing so. They also discipline cases of non-adherence.

Industry regulators limit and monitor firms. They can control which companies can enter a particular industry and which individuals can hold particular roles. They can monitor companies by requiring standard information to be provided at frequent intervals. They can also require oversight of strategic plans, e.g. controlling the features on new products and

by interacting with senior members of a company to understand the strategic direction of a company. They can take sanctions against companies and individuals breaking the rules.

Industry bodies can require standards from member companies. However they do not carry the same weight as industry regulators and usually represent the interests of the industry.

Government can establish legislation to provide the framework for the industry regulators. This may also include the levels of capital requirements for the particular industry.

The question was handled well by most. The candidates that performed less well mostly failed to note that professional bodies regulate their members.

- (ii) The government’s aim will be to restore/maintain confidence in that country’s banking system.

The legislation will immediately seem to meet this as it restricts exposure to the potentially riskier overseas assets.

The restriction to domestic business will also minimise the foreign exchange risk.

The legislation is also aimed to give confidence to reduce liquidity risk, i.e. to avoid account holders wanting to close their accounts in significant numbers.

However as the country is small its assets could be less marketable than the larger overseas assets which may give less favourable terms if there is a forced sale.

Conversely, the new rules could result in a surge in demand for local assets thereby negatively impacting the interest rates offered to depositors and borrowers.

The legislation does not cover interest rate risk, i.e. it could be possible to invest in securities with different terms to the accounts.

By restricting the investment choice it will force the banks to invest in similar types of asset. This would increase systemic risk as all banks would be affected if that country ran into difficulties.

The structure of multinational banks is complicated and if the country has multinational banks it will still be affected by overseas conditions.

Will add to the operational costs of banks thereby negatively impacting the interest rates offered to depositors and borrowers.

The question was handled well by most. These issues have been near the forefront of current affairs in recent years and most candidates were able to make the main points.

3 (i) Gumbel, Frank, Clayton, generalised Clayton

(ii) The main difference between the copulas is in the tail dependency.

The Gumbel copula has upper tail dependence, but no lower tail dependence and is therefore suitable for modelling dependency where association increases for extreme positive values, e.g. losses from a credit portfolio measured as a positive. Or property/liability claims aggregation.

The Frank copula has neither upper tail nor lower tail dependencies

It is therefore suitable for modelling the relationship between stock indexes and bond returns. Stocks and bonds do not usually show tail dependence because their returns are not directly dependent on each other.

The Clayton copula has heavy concentration of probability near (0,0) and depending on the parameters the Clayton copula can have either:

- Only lower tail dependency, making it suitable to use if extreme negative events are thought to happen together – for example returns from a portfolio of shares. Share market crashes of the past have demonstrated this type of behaviour.
- No upper tail or lower tail dependency – therefore similar to the Frank copula.

The generalised Clayton copula has an additional parameter which allows both upper and lower tail dependencies, and would be suitable for modelling where fat tails occur at both extreme high and low values – for example risks subject to contagion such as country credit risk.

Despite copulas being an important part of risk modelling, many candidates were unable to both describe their different properties and most likely uses. The main uses of copulas are insurance loss aggregation, default loss modelling, operational risk and market risk.

4 (i) Marine insurance is a fairly specialised form of insurance and a standardised approach is unlikely to provide an appropriate description of Endeavour’s risk.

An internal model provides Endeavour with an option to develop an economic capital model that, subject to regulatory minimum standards, is tailored to its actual risk profile.

The model may also allow the company to perform more sophisticated analysis for risk management and decision-making purposes.

Endeavour may believe that the standard formula would result in an unreasonably high capital requirement, so the internal model would allow it to use capital more efficiently.

It may already have some form of economic capital model that it could use as the starting point for the internal model build.

- (ii) Developing an internal model could involve the following steps:
- collect and validate data
 - group or modify it if necessary
 - choose the form of the model and the distributions to use
 - including any copula if used
 - identify and estimate all parameters and variables
 - estimate any correlations between variables
 - check that the goodness of fit is acceptable and attempt to fit a different model if not
 - ensure that the model is able to project all required cashflows and other outputs
 - including interactions between them, which may be modelled dynamically
 - run the model using the selected estimated variables
 - for stochastic models, this would require a large number of simulations using a random sample from the density function(s) chosen for the stochastic parameters
 - output the results in an appropriate format (e.g. summarised for stochastic models)
 - assess the sensitivity of results to different deterministic variable values
 - perform appropriate validations on the outputs

The question was handled well by most.

The question referred specifically to Endeavour. Many answers were much too generic making little or no reference to Endeavour.

As ever, additional marks were given for other valid answers including:

- *Specify the objectives of the model, ensuring that it is consistent with Solvency II requirements.*
- *Produce thorough documentation.*

- (iii) It is likely that expertise within Endeavour – or indeed the marine insurance industry – may exist which is of a qualitative nature or may not be in a sufficiently statistically credible form to meet the regulatory requirements.

However, it may be possible to use this expertise to modify or adjust the model. For example, this expertise:

- Could be used to decide whether to include / exclude outliers in the data.
- Could be used to inform the evaluation of the correlation assumptions between risks.
- Could be used to help consider alternative forms of the model.
- Could develop scenarios to assess the reasonableness of the model output.

Question 4 was intended to be a straight-forward application question. Part (iii) was not answered well by most. Some candidates appeared to not understand the term “expert judgment” and did not refer to it in their answers. Expert judgment refers to qualitative reasoning based on a persons’ experience and expertise which is of course the result of both qualitative and quantitative measures. The question was about checking a model using common sense.

- 5 (i) An organisation’s economic capital is an assessment of the capital required to cover its risks. It is the amount of capital that an organisation requires to cover its liabilities and obligations (or to maintain a particular level of solvency) under adverse outcomes, with a given degree of confidence and over a given time horizon.

VaR is a simple measure of risk, representing the maximum loss expected with a given probability (the confidence level) over a defined time horizon. A formula alternative is ok so long as the notation/variables are defined.

- (ii) Assuming liabilities are held on the balance sheet at the best estimate of 3,000 (so no hidden reserves or shortfall) then capital at 99.5% = standard deviation of liabilities $\times 2.576 = 515.2$

3,516 was also accepted being liabilities and capital.

- (iii) By holding a small buffer above the regulatory capital requirement, GHI Insurance can protect itself from daily asset market volatilities and other risks materialising which may not be large enough to cause insolvency but could reduce the resources of GHI below the 1-in-200 level.

- (iv) VaR @ 99.5th = 515.2 (from part (ii))

$$\text{VaR @ 99.999}^{\text{th}} = 200 \times 4.18 = 836$$

Assuming the tail of the economic capital distribution can be approximated linearly then

$$\text{TVaR} = (515.2 + 836) / 2 = 676$$

A range of answers were accepted as TVAR using the formula is 578. Answers leaving the liabilities in were also accepted.

- (v) The decision should take into account the costs, risks and benefits of holding additional capital:

Costs:

- An opportunity cost is incurred as the additional capital cannot be used to pursue other potentially profitable opportunities, such as...
- ...writing new business
- ... or entering into an acquisition

Reduced Risk of not meeting expectations/requirements:

- Additional capital reduces the risk that regulatory solvency is breached
- Additional capital reduces the risk that policyholder obligations are not met

Other benefits:

- The additional capital may bring the security of the firm into line with the risk appetite of GHI, for example...
... shareholders may want to target a level of security higher than 1-in-200
... shareholders may look at a longer time horizon than one year
- Additional capital may secure a higher credit rating which will lower GHI’s borrowing costs, and make it more attractive to customers and analysts.
- More generally, companies with higher solvency ratios may be better perceived by the market

This question is framed around explaining capital requirements to an interested layman. It should not be assumed that the economic model and regulatory model are one and the same. The question is looking for the general reasoning of holding extra capital and the impact of doing so.

- 6** This is likely to be true in some cases and false in others depending upon the use of the forecast.

Generally, in order to predict more features of a time series you require more parameters. Unfortunately models with a lot of parameters have a higher chance of failing to predict accurately the most important features of the time series.

The economist is suggesting that this could be true for time series modelling and that the direction of the change, e.g. an increase or a decrease in interest rates, is more important to forecast accurately than the quantum of the change.

Of course, missing the direction means that any estimate of the amount is effectively amplified by a factor of 2 (the answer should have been +2% and not minus 2%).

Modelling the direction of the change is not likely to be sufficient for the overall forecasting model that one is trying to build. Hence, either it would be necessary to build a model forecasting both direction and amount together or forecast them separately. For example, the direction could be modelled using a time series approach and the amount of the change could be modelled separately. For example, the amount could be a random result from a distribution or the scaled result of other modelled forecasts e.g. GDP growth, inflation.

The overarching objective is to avoid over-fitting the past data and in other words to use statistics such as the AIC and BIC to find the optimal trade-off between parameters and goodness of fit.

Hence the AIC and BIC could be used to compare both say a GARCH based time series model and the alternate model based on directional time series change and a separate amount model to see which approach offered the best combination of the number of parameters and goodness of fit.

Cases to model the direction only are likely to be:

- Sparse data where trying to extract both the direction of the change and the amount of the change are not statistically credible.
- Cases where the observed past amounts of change are felt to be relatively small e.g. low interest rate environment.
- Cases where the amount of the change is felt to be random (according to some distribution).

Cases to model both direction and amount are likely to be:

- Cases where the model is intended to be mean reverting, although this could be taken account of by making the directional change mean reverting.
- Cases where there is a lot of data and the amount of the change is considered to be dependent on time.
- Cases where a relatively simplistic approach to estimating magnitude is deemed to be inappropriate because the magnitude is extremely important e.g. extreme value exercises.

The question was not handled well by most. The key part of the question was concerned with whether it is more important for a model to predict directional change or the quantum of the change. This type of consideration would be appropriate for time series forecasting such as FX rate models and interest rate models. Many answers focussed on FX rates and/or interest rates and not on the question.

- 7 (i) Tier 1 capital ratio equals the sum of shareholders equity and disclosed reserves divided by the sum of risk weighted assets.

Balance Sheet in EUR millions							
	Dec 31, 2011	Dec 31, 2010	Dec 31, 2009	Risk Weight	Risk weighted exposure		
FINANCIAL ASSETS AT AMORTISED COST							
Cash and balances with central bank	5200	4200	2000	0%	0	0	0
Due from other banks	3400	4000	4500	20%	680	800	900
Loans	14000	13700	12100	100%	14000	13700	12100
Securitised loans	1200	1200	1000	100%	1200	1200	1000
FINANCIAL ASSETS AVAILABLE FOR SALE							
Debt investments	2300	2200	2100	100%	2300	2200	2100
FINANCIAL ASSETS HELD AT FAIR VALUE							
Loans	2000	1800	1700	50%	1000	900	850
Residential mortgages own book	6600	3000	1400	50%	3300	1500	700
Securitised residential mortgages	11400	5300	3000	50%	5700	2650	1500
Debt investments	600	500	500	100%	600	500	500
Derivative financial assets held for trading	5000	4900	4700	100%	5000	4900	4700
Derivative financial assets used for hedging	400	400	450	100%	400	400	450
OTHER					0	0	0
Investments in associates	60	50	50	100%	60	50	50
Intangible assets	400	390	390	100%	400	390	390
Property, plant and equipment	200	180	170	100%	200	180	170
Other assets	320	300	270	100%	320	300	270
TOTAL ASSETS	53080	42120	34330	Sum of RWA	35160	29670	25680
FINANCIAL LIABILITIES AT AMORTISED COST							
Due to other banks	2300	2200	2000				
Deposits from customers	12000	7600	2500				
Own debt securities in issue	16000	14200	14000				
Debt securities in issue related to securitised mortgages	11400	6000	4100				
FINANCIAL LIABILITIES HELD AT FAIR VALUE							
Structured debt securities in issue	3400	3100	3000				
Derivative financial liabilities held for trading	5200	5200	4500				
Derivative financial liabilities used for hedging	80	100	130				
OTHER							
Employee benefits	20	41	57				
Subordinated liabilities	800	620	570				
Other liabilities	400	320	360				
TOTAL LIABILITIES	51600	39381	31217				
TOTAL SHAREHOLDERS EQUITY	1480	2739	3113				
BCBS Tier 1 Capital	3%	7%	8%		(SH Equity - Intangible Assets)/Sum of RWA		

The question was not handled well by most. It appears that many candidates have never calculated a bank capital ratio before.

A range of weightings between 100% and 0% were accepted. Normally government bonds and cash is 0%, mortgages 50% and the rest 100%. The capital calculation was accepted both with and without intangible assets. The capital calculation was accepted both with and without year end profit after tax.

- (ii) Liquidity risk – despite increases to the absolute amounts of cash holdings, there is still a relatively low level of liquid assets (cash and cash like securities) relative to securitised loans, mortgages held, and other illiquid instruments (as illustrated by the reduction in the tier 1 capital ratio which has decreased materially from 8% to 3% as a result of the change in strategy).

4% tier 1 capital ratio is the minimum. So they have breached that.

Credit risk – the risk of default of its customers on mortgage payments, and the default of debt securities, loans to corporates or derivatives owned as assets. For example, residential mortgages own book has increased from 1,400m to 6,600m in two years and the NET residential mortgages securitised

book on balance sheet has increased from 2,000m to 10,400m in two years. The securitised mortgages held are likely to be at the highest risk tranche in the MBS securities meaning that the credit risk associated with the 10,400m will be many multiples of the credit risk associated with the 6,600m. 10,400m is 20% of total assets and 7 times total shareholders’ equity. The default loss risk in the book is potentially enough to bankrupt the bank. The rating structure of the securitised mortgages on balance sheet supports this conclusion, showing that 80% of the 10,400m is rated BB or unrated. The past is not necessarily a good guide. The bank’s own experience is extremely short and no guide to the future.

Market risk – mark to market valuation when assets are classed as available for trade rather than held to maturity.

The financial assets held at amortised value totalled 23,800m at 31/12/11.

The financial liabilities held at amortised value totalled 41,700m at 31/12/11.

The financial assets held at fair value or held for sale totalled 28,300m at 31/12/11.

The financial liabilities held at fair value totalled 8,680m at 31/12/11.

This represents a significant potential mismatch.

Approximately, 19,620m of net assets held at fair value (and so changing value as market conditions change) are supporting 17,900m of net liabilities which are changing according to the amortising value. A 20% decline in market value could reduce the asset side of the balance sheet by $0.2 \times 19,620 = 3,924$, which is more than twice shareholders’ equity.

Interest rate risk – own debt securities and future debt issuance costs, the risk of pre-payment on the securitised mortgage loans and refinancing at lower interest rates, and re-investment risk (having to invest in lower yielding securities at maturity of a previous investment).

Interest rate term mis-match (refinancing short term debt at higher costs than the interest income from the long term mortgage loans).

Currency/FX risk: may be exposed to this as have some mortgage exposure in Germany and it is not clear the extent to which there is matching for this – although may be included in the hedging derivatives.

The question was not handled well by most. Risk managers must be able to read and understand financial data and trends.

As ever, additional marks were given for other valid answers including:

- Property prices influence defaults
- Pension fund risk
- Increased gearing and increased volatility of profits

(iii) Monthly review of:

- changes in the Basel I tier I ratio
- company specific tail risk events (the worst of the worst events)
- natural disaster scenarios which may affect the mortgage book (e.g. earthquake. particularly as 95% of the residences are located in the home country)
- trends in deposit taking
- trends in mortgage re-financing
- trends in pre-payment
- trends in mortgage delinquency rates
- monitor credit events
- monitor some metric of portfolio volatility (VaR, TVaR, ShockVaR, expected shortfall)
- monitor macro economic trends
- analysis of central banker’s signalling at key events
- operational risks (cost money so need to set aside provision and charge margin to pricing).

Part (ii) asked for risks that one would expect to be modelled in the Bank’s economic capital model. Part (iii) asked for risks that needed to be monitored by the risk manager but would not be in the model. Many candidates might have found this difficult as they appear not to have thought about risks that are monitored but not in the main model.

(iv) Banks investing in their own country’s paper, which may cause pro-cyclicity/wrong way risk.

The government’s rating is likely an accurate guide to the relative riskiness of the mortgage borrowers. Rockfort lends predominantly in its own country meaning that the mortgages will be riskier and that the size of the aggregate deposits are more likely to be affected by economic downturns.

Mortgage lending for political goals – the country’s government or central bank may artificially boost the money supply or keep interest rates artificially low to acquire approval from the electorate due to higher home ownership rates.

Owning country’s own government bonds will not be risk free and likely to be risk weighted at non-zero by the Eurozone regulators and rating agencies. In any event they are not economically risk free.

Many candidates’ answers were very similar to the suggested solution.

- (v) Increase cash holdings with the central bank, although this will come at an opportunity cost of foregone income.

Reduce the short term due monies from other banks (in case of sudden insolvencies or delay in recovery).

Invest in government treasuries and government backed bonds – provided the government is highly rated (e.g. would not be the case under the circumstances in part (iv)).

Reduce exposure to complex structured finance products which may be difficult to sell or suffer large mark to market write downs if investor sentiment turns.

If it were possible to match the term structure of the 28,000m customer deposits plus own debt securities with the term structure of the 16,000m loans and 6,600m residential mortgages then the liquidity risk would substantially reduce.

Where matching is not possible then seek to extend the term structure of the unmatched element of the own debt securities in order to reduce repayment risk and in effect push the liquidity risk out further in the time horizon.

Maintain a term matched book on the derivatives held for trading. The derivatives held for hedging are not intended to be liquidated prior to expiry of the underlying asset/liability. So the term structure of these derivatives should be included with the physical asset/liability term structure calculation.

Increase withdrawal notice terms on deposit accounts

Set up an emergency/contingency funding arrangement

All candidates gave some credible answers. Most made the asset liability matching point and the point about increasing the liquidity in the investments.

- (vi) Threefold increase in residential mortgage defaults

The impact will be a combination of:

- The current default losses. It is not possible to be precise because the current cost of default losses is not explicitly shown. The impairment of financial assets item may include some anticipated write down in the mortgages but it is unlikely.
- Future growth in own book net position over the next three years. Potential for continued growth over next three years is likely to be lower as the tier 1 capital is already below 4% and so the bank will either need to raise new capital or replace existing corporate loans with residential mortgage loans in order to increase residential mortgages on its own book.

- The degree to which the default losses on the net securitised residential mortgages are worse because the bank retains the riskier tranches.
- Bank likely to increase mortgage rates to compensate.

The key items on the balance sheet are:

- Asset: residential mortgages own book 6,600, 3,000, 1,400
- Asset: securitised residential mortgages 11,400, 5,300, 3,000
- Liability: debt securities in issue related to securitised mortgages 1,000, 1,000, 1,000

For example,

6,600 with likely current default losses of say 0.5%

10,400 with likely current default losses of say 1.5%

Impact is an increase in annual default losses of say $6,600 \times 1.5\%$
 $+10,400 \times 4.5\%$ equals 567 per annum

Current pre-tax profits are less than 100 implying it will likely be very difficult for the bank to continue to be profitable if the residential mortgage default losses triple.

A dramatic fall in investment yields

The impact will depend upon:

- The market value of net fixed interest investments held at fair value should increase. Financial assets and liabilities held at amortised value/cost are potentially not impacted.
- The ability of the bank to invest in new securities/loans/mortgages at a net profit compared with its borrowing costs from government, other banks, depositors. This should be possible. In particular the depositors may have no choice but to accept lower interest rates and the bank may not have to reduce the mortgage rate by the same amount.
- Growth may be impacted. The fall in yield may increase economic growth and inflation and in turn increase the bank’s profitability.

Overall the impact is likely to be positive for the bank.

This was a difficult question that most candidates found difficult. The suggested solution is just one of many. Risk managers must be able to think about the likely effects of a wide range of different probable and improbable scenarios.

- (vii) Lack of experience and expertise in retail banking. The bank has gone from a corporate bank to a bank focussed on retail customers and mortgages in two years. It has no experience of managing this type of business. The family member owners have no experience.

The lack of experience and systems in new areas could make it susceptible to fraud both from internal and external sources.

The personnel expenses have gone from 90m to 140m in two years. Employee benefits carried on the balance sheets have fallen from 57 to 20. The bank is likely to have many more and lower paid staff than in the past.

The total assets have risen by 55% to 53,080m and yet pre tax profits are trending flat or down at 98m in 2011 or only 6% of the much reduced shareholders’ equity.

The bank is a small bank which is much more highly leveraged than before and focussed on new products and customers. Its biggest operational risk is that its inexperienced management makes a mistake.

The main operational risk should have been obvious and most candidates got it although many failed to “explain” the consequences of the risk to the bank.

- 8** (i) Agency risk – principal shareholders may be family (via trusts), and therefore management could be working in their interest (personal enrichment) rather than legitimate public shareholders (long term growth and sustainability).

The use of trusts to disguise majority shareholders may be a tactic to conceal evidence of cartel behaviour and monopolistic business practices in a poorly regulated industry.

Large dividends from unknown sources: the moneys might be the proceeds of crime. Even if legitimate, the analysts will have no way of forecasting future moneys from these sources in the future.

Financial movements to non-core or unaffiliated companies are also suggestive of:

- (1) being support for business ventures held by family or associates and also not aligned with the interests of legitimate public shareholders.
- (2) financing their acquisitions with large and unsustainable debt rather than organic growth, or hiding debt and losses via derivative financing (such as selling credit linked notes on itself)
- (3) money-laundering
- (4) potentially high concentration of counterparty risk

The lack of data on profit margins makes it impossible to verify cashflow accounting and balance sheet statistics, making manipulation of profit reporting straightforward.

Large volumes of cash through door to door sales make auditing of actual cashflow difficult (lack of invoicing etc.).

Use of a small firm of auditors suggests a lack of adequate independence. Examples would be if Happy Cow is their only client, or if there is complicit cooperation in fraudulent behaviour (securities fraud, aiding and abetting, filing false audited accounts) – e.g. Friehling & Horowitz CPAs.

Happy Cow may well be in breach of stock market rules by not divulging details of its management or board, which are in place specifically to maintain good corporate governance via separation of the two functions. It may well be that Happy Cow’s Chairman and CEO were the same person, or that the CFO or chief auditor/accountant was a relative.

The question was handled well by most. Most candidates made valid points on each of the seven analysts’ concerns.

- (ii) Almost certainly a whistleblower contacted the police. For example, an ex-insider, current insider, the auditors or a bank officer used in the chain of cash movements suspecting money-laundering.

At this point the police were likely told something about cash not being fully accounted for in the accounts either as it leaves the company or more likely as it enters the company. For example much more cash could be coming in than could possibly have been received from door to door sales.

Alternatively, police might have caught some criminals elsewhere in the chain and been able to work out that Happy Cow might be involved.

Investigative journalism might have uncovered sufficient evidence to report it to the police. This could have been initiated by concerned analysts.

The regulator may have discovered the offenses. For example, the regulator might have conducted an inspection of records during a visit.

The question was handled well by most.

- (iii) Money laundering – Cash from the door to door sales could disguise other cash brought into the company from criminal sources. Cash movements to and from the associates could launder the dirty money back into clean money.

Fraudulent accounting/reporting to the stock exchange – The cash was not being accurately reported. Hence much of the accounts would have been manufactured in order to represent the company as profitable and growing so that it could borrow more money from lenders and raise more money on the

stock exchange. This was probably done with the ultimate objective of stealing much of this money as well, i.e. embezzlement.

The embezzlement would have been relatively straightforward given the unconsolidated associates and other third party companies. Also the small firm of auditors would have not had the expertise or resources to unpick the embezzlement.

Tax evasion would have inevitably occurred as the cash was not being reported and many of the transactions between the other associates and third parties were likely to have been falsely reported.

The question was handled well by most.

As ever, additional marks were given for other valid answers including:

- *bribery*
- *price fixing*

- (iv) All of the following will depend on the particular country. Most countries are likely to have the following types of rules and regulations:

Corporations Act – Talks about limited liability, only trading whilst solvent, filing accurate financial accounts, fit and proper directors.

Money Laundering – full knowledge of the legitimate sources of all cash received.

Fraud & Embezzlement – Criminal law. penalties include fines and imprisonment.

Corporate Governance Code of Practice – make up of the board, independent directors, independent audit and remuneration committees. Non-exec directors having unfettered rights to review documents.

Compliance Committee – ensures that the company complies with all relevant legislation, regulations, codes of practice.

Audit Committee – receives the external audit report and discusses all of the issues arising to report back to the board. *(An alternate response based on accounting standards is fine)*

Stock exchange listing rules – numbers and reports which have been independently audited are given to external experts to review.

- (v) Introduce legislation to stop the cash sale of dairy products. Governments can lose a lot of tax revenues due to the black market of trading for cash. Also cash based businesses are the main sources of money launderers. Hence the government might be willing to do something like this as a part of trying to reduce the cash market.

Government takes full control of milk sales. Probably not workable but if Happy Cow controls the majority of the market anyway the Government could take it over until it could clean it up and re-list it on the stock exchange.

The question was not handled well by most. The question required two laws that might appear reasonable but would likely prove onerous to the economy. Some candidates suggested changes that did not involve the passing of new laws. Some candidates suggested new laws that were not relevant to the situation.

END OF EXAMINERS’ REPORT

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINATION

3 October 2012 (pm)

Subject ST9 – Enterprise Risk Management

Time allowed: Three hours

INSTRUCTIONS TO THE CANDIDATE

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all six questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

AT THE END OF THE EXAMINATION

Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.

In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.

1 An industry is dominated by two companies: Company A which has a fully functioning ERM framework and Company B which does not have any formal ERM framework. Both companies make similar products and have the same potential client base.

(i) Discuss the potential justifications for the two companies' ERM strategies. [5]

(ii) Discuss the potential impact on Company A's share price if Company B were to introduce a fully functioning ERM framework. [3]

[Total 8]

2 A small, poor and undeveloped country has appointed a European Solvency II expert to introduce similar risk-based regulation to the country's life and general insurance companies.

(i) Describe initiatives that the newly appointed expert could introduce which would have an immediate impact on the regulatory approach to the monitoring and measuring of an insurance company's financial risks. [7]

(ii) Describe other initiatives that the newly appointed expert could introduce which would help the insurance companies to prepare for the planned new regulation. [3]

The new regulatory framework has now been put in place.

As part of its implementation, a "whistleblowers' hotline" has been introduced. This allows persons to report breaches of the regulatory requirements to the regulator with guaranteed anonymity.

Unfortunately the regulator has been inundated with calls and all of them to date have been petty and/or malicious. The regulator therefore wishes to issue a set of guidelines regarding the future usage of this hotline, which would filter out petty and malicious reports and encourage the reporting of serious breaches.

(iii) Suggest appropriate guidelines for this purpose. [6]

(iv) Describe the process that the regulator should employ to administer, assess and resolve any reported breaches. [4]

[Total 20]

3 Southwest Re is a multinational reinsurance company that has successfully underwritten mortality and property risks for many years. The company has now decided to start insuring the operational risks of insurance companies.

(i) Define operational risk. [1]

Four of the existing clients of Southwest Re wish to insure their operational risk exposure. Each of these four insurance companies has been collecting operational loss data for several years and they have shared this data with Southwest Re so that the pricing team can calculate the premiums for one year's insurance cover.

The total annualised operational losses for the four insurance companies have the following statistical properties:

	<i>Mean</i>	<i>Variance</i>
Cornwall Insurance	20,000	250,000,000
Devon Insurance	20,000	150,000,000
Somerset Insurance	10,000	40,000,000
Dorset Insurance	40,000	600,000,000

The pricing team has no experience of calculating insurance premiums for operational risk. Two approaches have been proposed for further investigation:

Approach I

- Determine the insurance premium as the expected claim cost plus a 50% margin to cover the reinsurer's expenses and desired profit margin.

Approach II

- Fit a gamma distribution to the total operational losses using the method of moments.
- Calculate the standalone capital requirement using a Value at Risk (VaR) methodology consistent with a 1 in 200 loss (i.e. 99.5% confidence).
- Determine the insurance premium as the expected claim plus the cost of capital plus a 25% margin to cover the reinsurer's expenses and desired profit margin. The cost of capital is defined as 6% of the standalone capital requirement.

(ii) Calculate the insurance premiums under each approach for each of the four insurance companies, using the operational risk loss data provided above and the gamma distribution tables provided at the end of this examination paper. [7]

(iii) Discuss the advantages and disadvantages of each approach, including recommendations for improving the calculation of the insurance premium. [11]

Dorset Insurance believes that the insurance premium quoted by Southwest Re is too high and has decided not to purchase the insurance.

- (iv) Describe other options that might be available to Dorset Insurance to mitigate its various operational risks. [8]

Cornwall Insurance, Devon Insurance and Somerset Insurance all decide to purchase the insurance, which Southwest Re will underwrite in a newly created subsidiary.

- (v) (a) Calculate the capital requirement for the subsidiary using a VaR methodology (at 99.5% confidence), assuming that the operational risks for each of the three insurance companies are independent.
- (b) Hence calculate the diversification benefit derived from underwriting operational risks for the three insurance companies.
- (c) Comment on any implications of (b) for the calculation of the insurance premium.
- (d) Comment on the appropriateness or otherwise of the independence assumption.

[6]

[Total 33]

4 ABC Mortgages is an A-rated mortgage lending company. It secures funding for a tranche of retail mortgages by borrowing cash in the wholesale capital markets. It uses this cash to provide mortgages to the public. When it has sold a sufficient number of mortgages these are packaged into a collateralised mortgage-backed security that ABC Mortgages then sells in order to repay the cash it has borrowed.

- (i) Describe the two types of “market risk” to which ABC Mortgages is exposed. [2]

Prepayment risk is the risk that a mortgage holder chooses to repay his mortgage early thereby reducing the profitability of the security.

- (ii) Explain why it may not be appropriate to treat prepayment risk as its own risk category. [2]

DEF Bank is a large, AAA-rated multinational retail bank which to date has no exposure to ABC Mortgage’s domestic economy. It decides to acquire ABC Mortgages in order to expand into this new market.

- (iii) Explain the likely impact of the acquisition on the profit margin of ABC Mortgages. [2]
- (iv) Outline the likely impact of the acquisition on DEF Bank’s risk profile. [4]
- (v) Give an example of a systemic risk event which could impact both the domestic business of ABC Mortgages and DEF Bank’s international operations. [1]

[Total 11]

- 5** XYZ Bank is a large multinational bank. As part of its employment strategy it provides its staff with life and health insurance cover. It has opted to insure these risks with a wholly owned captive insurance company. The captive then purchases reinsurance to transfer the risk to third party reinsurers.
- (i) Outline the advantages and disadvantages of providing the life and health insurance cover in this way. [3]
 - (ii) Explain why reinsurance may not remove all of the risk relating to this cover. [3]
 - (iii) Suggest actions which XYZ Bank could take to reduce the mortality and morbidity risks which are being insured. [4]
- [Total 10]
- 6**
- (i) Outline Solvency II's mandatory risk framework. [6]
 - (ii) List the six risk categories underlying the standard formula for the Solvency Capital Requirement. [3]
 - (iii) Give examples of key risk indicators (KRIs) for the risk categories in (ii). [3]
 - (iv) Explain the various internal and external stakeholders that would be interested in monitoring KRIs of a company on a regular basis. [3]
 - (v) Discuss whether a metric used as a key performance indicator can also be used as a KRI. [3]
- [Total 18]

Information for Question 3

Tabulation of the 99.5th percentile for the gamma distribution

Lambda	1/4000	1/4500	1/5000	1/5500	1/6000	1/6500	1/7000	1/7500	1/8000	1/8500	1/9000	1/9500	1/10000	1/10500	1/11000	1/11500	1/12000	1/12500	1/13000	1/13500	1/14000	1/14500	1/15000
Alpha																							
1.500	25676	28886	32095	35305	38514	41724	44934	48143	51353	54562	57772	60981	64191	67400	70610	73819	77029	80238	83448	86658	89867	93077	96286
1.533	25957	29201	32446	35691	38935	42180	45424	48669	51914	55158	58403	61647	64892	68137	71381	74626	77871	81115	84360	87604	90849	94094	97338
1.567	26236	29515	32794	36074	39353	42633	45912	49192	52471	55751	59030	62309	65589	68868	72148	75427	78707	81986	85266	88545	91824	95104	98383
1.600	26513	29827	33141	36455	39769	43083	46397	49711	53025	56339	59653	62967	66281	69595	72910	76224	79538	82852	86166	89480	92794	96108	99422
1.633	26788	30136	33485	36833	40182	43530	46879	50227	53576	56924	60273	63621	66970	70318	73667	77015	80364	83712	87061	90409	93758	97106	100455
1.667	27062	30444	33827	37210	40592	43975	47358	50740	54123	57506	60889	64271	67654	71037	74419	77802	81185	84567	87950	91333	94716	98098	101481
1.700	27334	30750	34167	37584	41001	44417	47834	51251	54668	58084	61501	64918	68334	71751	75168	78585	82001	85418	88835	92251	95668	99085	102502
1.733	27604	31055	34505	37956	41407	44857	48308	51758	55209	58659	62110	65560	69011	72462	75912	79363	82813	86264	89714	93165	96615	100066	103516
1.767	27874	31358	34842	38326	41810	45295	48779	52263	55747	59231	62716	66200	69684	73168	76652	80137	83621	87105	90589	94073	97558	101042	104526
1.800	28141	31659	35177	38694	42212	45730	49247	52765	56283	59800	63318	66836	70353	73871	77389	80906	84424	87942	91459	94977	98495	102012	105530
1.833	28408	31959	35510	39061	42612	46163	49714	53265	56815	60366	63917	67468	71019	74570	78121	81672	85223	88774	92325	95876	99427	102978	106529
1.867	28673	32257	35841	39425	43009	46593	50177	53762	57346	60930	64514	68098	71682	75266	78850	82434	86018	89603	93187	96771	100355	103939	107523
1.900	28937	32554	36171	39788	43405	47022	50639	54256	57873	61490	65107	68724	72341	75959	79576	83193	86810	90427	94044	97661	101278	104895	108512
1.933	29199	32849	36499	40149	43799	47449	51098	54748	58398	62048	65698	69348	72998	76648	80298	83947	87597	91247	94897	98547	102197	105847	109497
1.967	29460	33143	36826	40508	44191	47873	51556	55238	58921	62603	66286	69968	73651	77334	81016	84699	88381	92064	95746	99429	103111	106794	110477
2.000	29721	33436	37151	40866	44581	48296	52011	55726	59441	63156	66871	70586	74301	78016	81731	85446	89162	92877	96592	100307	104022	107737	111452
2.033	29979	33727	37474	41222	44969	48717	52464	56212	59959	63706	67454	71201	74949	78696	82444	86191	89938	93686	97433	101181	104928	108676	112423
2.067	30237	34017	37797	41576	45356	49136	52915	56695	60475	64254	68034	71814	75593	79373	83153	86932	90712	94492	98271	102051	105831	109610	113390
2.100	30494	34306	38118	41929	45741	49553	53365	57176	60988	64800	68612	72423	76235	80047	83859	87670	91482	95294	99106	102918	106729	110541	114353
2.133	30750	34593	38437	42281	46125	49968	53812	57656	61500	65343	69187	73031	76874	80718	84562	88406	92249	96093	99937	103780	107624	111468	115312
2.167	31004	34880	38756	42631	46507	50382	54258	58133	62009	65884	69760	73636	77511	81387	85262	89138	93013	96889	100764	104640	108515	112391	116267
2.200	31258	35165	39073	42980	46887	50794	54702	58609	62516	66423	70331	74238	78145	82052	85960	89867	93774	97681	101589	105496	109403	113310	117218
2.233	31511	35450	39388	43327	47266	51205	55144	59083	63021	66960	70899	74838	78777	82716	86654	90593	94532	98471	102410	106349	110288	114226	118165
2.267	31762	35733	39703	43673	47644	51614	55584	59555	63525	67495	71465	75436	79406	83376	87347	91317	95287	99258	103228	107198	111168	115139	119109
2.300	32013	36015	40016	44018	48020	52021	56023	60025	64026	68028	72030	76031	80033	84035	88036	92038	96040	100041	104043	108044	112046	116048	120049
2.333	32263	36296	40329	44362	48395	52427	56460	60493	64526	68559	72592	76625	80658	84690	88723	92756	96789	100822	104855	108888	112921	116953	120986
2.367	32512	36576	40640	44704	48768	52832	56896	60960	65024	69088	73152	77216	81280	85344	89408	93472	97536	101600	105664	109728	113792	117856	121920

Lambda	1/4000	1/4500	1/5000	1/5500	1/6000	1/6500	1/7000	1/7500	1/8000	1/8500	1/9000	1/9500	1/10000	1/10500	1/11000	1/11500	1/12000	1/12500	1/13000	1/13500	1/14000	1/14500	1/15000
Alpha																							
2.400	32760	36855	40950	45045	49140	53235	57330	61425	65520	69615	73710	77805	81900	85995	90090	94185	98280	102375	106470	110565	114660	118755	122850
2.433	33007	37133	41259	45385	49511	53637	57763	61889	66015	70140	74266	78392	82518	86644	90770	94896	99022	103148	107274	111400	115525	119651	123777
2.467	33254	37410	41567	45724	49880	54037	58194	62351	66507	70664	74821	78977	83134	87291	91448	95604	99761	103918	108074	112231	116388	120544	124701
2.500	33499	37687	41874	46061	50249	54436	58624	62811	66998	71186	75373	79561	83748	87935	92123	96310	100498	104685	108872	113060	117247	121435	125622
2.533	33744	37962	42180	46398	50616	54834	59052	63270	67488	71706	75924	80142	84360	88578	92796	97014	101232	105450	109668	113886	118104	122322	126540
2.567	33988	38236	42485	46733	50982	55230	59479	63727	67976	72224	76473	80721	84970	89218	93467	97715	101964	106212	110461	114709	118958	123206	127455
2.600	34231	38510	42789	47068	51347	55626	59905	64183	68462	72741	77020	81299	85578	89857	94136	98415	102693	106972	111251	115530	119809	124088	128367
2.633	34474	38783	43092	47401	51710	56020	60329	64638	68947	73256	77566	81875	86184	90493	94802	99112	103421	107730	112039	116348	120658	124967	129276
2.667	34715	39055	43394	47734	52073	56412	60752	65091	69431	73770	78110	82449	86788	91128	95467	99807	104146	108485	112825	117164	121504	125843	130183
2.700	34956	39326	43695	48065	52435	56804	61174	65543	69913	74282	78652	83021	87391	91760	96130	100500	104869	109239	113608	117978	122347	126717	131086
2.733	35197	39596	43996	48395	52795	57195	61594	65994	70393	74793	79192	83592	87992	92391	96791	101190	105590	109990	114389	118789	123188	127588	131987
2.767	35436	39866	44295	48725	53154	57584	62013	66443	70873	75302	79732	84161	88591	93020	97450	101879	106309	110738	115168	119597	124027	128456	132886
2.800	35675	40135	44594	49053	53513	57972	62432	66891	71350	75810	80269	84729	89188	93647	98107	102566	107026	111485	115944	120404	124863	129323	133782
2.833	35913	40403	44892	49381	53870	58359	62849	67338	71827	76316	80805	85294	89784	94273	98762	103251	107740	112230	116719	121208	125697	130186	134675
2.867	36151	40670	45189	49708	54227	58745	63264	67783	72302	76821	81340	85859	90378	94897	99415	103934	108453	112972	117491	122010	126529	131048	135566
2.900	36388	40937	45485	50034	54582	59131	63679	68228	72776	77325	81873	86422	90970	95519	100067	104616	109164	113713	118261	122810	127358	131907	136455

END OF PAPER

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

September 2012 examinations

Subject ST9 – Enterprise Risk Management

Introduction

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and using past papers as a revision aid and also those who have previously failed the subject.

The Examiners are charged by Council with examining the published syllabus. The Examiners have access to the Core Reading, which is designed to interpret the syllabus, and will generally base questions around it but are not required to examine the content of Core Reading specifically or exclusively.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report; other valid approaches are given appropriate credit. For essay-style questions, particularly the open-ended questions in the later subjects, the report may contain more points than the Examiners will expect from a solution that scores full marks.

D C Bowie
Chairman of the Board of Examiners

December 2012

General comments on Subject ST9

The ST9 exam generally requires bullet point form or short form essay style answers that apply general principles to directly address specific circumstances. The answers given below are just one possible set of acceptable answers. Candidates are awarded marks for all reasonable answers including different but still reasonable numerical solutions. Marks are awarded for working in the case of numerical answers.

Comments on the September 2012 paper

The September paper included, relative to past papers, fewer and larger questions. Many of the questions were loosely based on actual events. Examples include pricing operational risk insurance, introducing regulation and a large bank operating a captive insurer. Practical examples of ERM are common place in the press. Candidates should find that regular reading of financial press will prove to be very helpful to their understanding of the issues and concepts contained in the core reading.

Well-prepared candidates scored acceptably well across the whole paper. The comments that follow the questions concentrate on areas where candidates could have improved their performance.

1 (i) ERM is not mandatory by legislation or regulation.

Company A could be listed on a stock exchange that requires formal ERM.

But the difference is more likely to be due to either the judgment of the board/senior management or to the result of a cost benefit analysis, or a combination of the two.

Company A may believe it is important to have stated risk appetite and risk tolerances and to monitor all risks to maintain within the appetite/ tolerances. In doing so the company will believe that has more control over its risks and will be less likely to make large unexpected losses in the future.

Company A may believe that the ERM allows it to maintain a holistic risk culture which should further help to prevent risks from crystallising into loss.

Company A may be in more need of a higher credit rating (e.g. because it relies more on the bond markets for capital raising) which is supported by its stronger ERM framework.

Company B may believe that it doesn't need a formal ERM as its informal practices are sufficient.

Company B may not believe that the benefit is worth the time and expense of monitoring the risks.

Company B may believe that it is a relatively simple business: profit and sales are targeted and all of the risks can be identified, estimated, mitigated and transferred in the separate business units. There is no need or cost savings in considering them all together.

Company A's structure is such that having a good ERM framework is important for capital allocation purposes.

Company A believes that ERM will help it to spot upside opportunities more readily.

Company A has learned from past mistakes / losses.

Company B might be a relatively new or rapidly growing company and just has not yet got round to full implementation.

(ii) Public shareholders are likely to believe that a company with ERM is better managed with less risk of unexpected losses. As Companies A and B dominate the industry, the shareholders could re-rate the entire industry thereby increasing A's share price.

Maybe investors that favoured A over B due to concerns about their risk management processes will have less reason to do so and A's share price might fall.

Maybe B will be shown to be less efficient and more risky in its ERM reporting and investors will shift to A.

Maybe the quality of B's framework will highlight issues that A should have been considering but hasn't. This may result in A's share price falling at least until it evidences that the issues have been resolved.

Part (i) – The question was handled well by most.

Part (ii) – The question was handled well by most.

As ever, additional marks were given for other valid answers including:

- *One possible outcome is that the share price stays broadly the same, since nothing has changed within Company A.*
- *Company A's share price might rise as it might look better in the short-term than Company B due to B's costs of implementation of the framework without any guarantee of benefits*

2 (i) There is very limited money and likely no expertise in government or in the insurance companies. The initiatives will have to be practical and affordable.

The new regulator should collect currently available financial reports, corporate governance, board papers, internal and external audit reports.

This material should be analysed to see the strengths and weaknesses of the current reporting structure.

Some weaknesses might be easily remedied. For example, the timing of and/or frequency of certain reports could be improved.

Or the detail contained in some of the reports might be quickly extended to include valuable information.

The new regulator should meet with and form a relationship with the insurance companies.

The companies should be encouraged to form a working relationship and made to believe that honesty and transparency is important.

For example, small breaches in guidelines can be tolerated.

The regulator should introduce regular inspections of insurance companies.

The regulator should issue guidelines of the areas to be inspected.

The regulator must adopt a pragmatic approach as the insurance companies won't have many of the needed practices, information etc in place. The

regulator should provide the company with an inspection report to help the company to introduce change.

If not already in place the regulator should make external audits mandatory. This will provide the regulator with another independent view of many aspects of the companies.

The regulator could require that investments are traded on exchange with reputable brokers and held by international custodians. This should help to ensure that all investments are contained on the company's reports and that they are properly valued at the time of each report.

For the same reason the regulator might introduce minimum internal control requirements for all money movements to ensure that all reports are complete and accurate.

The regulator should commence the systematic collation of available information.

As appropriate the regulator should seek to start to gather new information using surveys and forms.

(ii) The regulator could ask the companies to introduce or strengthen:

- ERM committee
- including its composition, committee charter, reporting templates
- Corporate governance
- Internal audits
- Internal reporting and analysis.
- ERM risk register to help to ensure that risks are being identified, monitored, measured and mitigated or transferred.

The regulator could provide guidance on the likely reporting to be required in the future.

(iii) The guidelines should:

State that the purpose of the hotline is to bring to light dishonesty or incompetence on a significant scale.

State what types of action are likely to have given rise to a breach.

- For example, it should state that intentionally underestimating key risks or excluding them from the regulatory reporting could potentially give rise to a serious breach.

State what actions are not likely to be appropriate to report to the hotline.

- Past calls to hotline might be helpful examples for the guidelines. Personnel issues including expense fiddling are not likely to be appropriate

to report to the hotline. Further, generalised issues such as management incompetence which cannot be supported with significant under-reporting would not be appropriate to report.

State amounts which are not likely to be appropriate to report to the hotline.

- Even small insurance companies may have capital in the tens of millions of dollars. It is not likely that failings causing losses of less than \$100,000 would be material to the regulator. They should be reported elsewhere in the company and potentially to other government agencies. This level may be different for different sized companies.

State the minimum information necessary to report to the hotline.

- The call cannot be anonymous to the regulator. Contact information must be left.
- The caller must also expect that he will be required to provide some form of evidence to prove his assertions.

State the potential required future involvement of anyone using the hotline.

- For example, a follow up call and the evidence if needed.

State the potential voluntary future involvement of anyone using the hotline.

- For example, act as a witness in future proceedings.

State the minimum service levels that someone using the hotline can expect.

- For example, the maximum period of time before the caller can expect a return call.

- (iv) Appoint an officer to handle the alleged breach.

Review the information given to the regulator by the company which is relevant to the alleged breach.

Discuss the alleged breach with the caller to ascertain any further details.

Approach the company and seek further information relevant to the alleged breach.

If necessary, conduct an unscheduled inspection of the company to obtain records if it is felt that evidence might be destroyed.

Make a decision on whether the alleged breach is valid, and if so how serious it is.

Inform the company of the decision and implications.

This might be a fine or other disciplinary action.

And likely also increased levels of inspection in the future.

There may need to be an appeal process, but ideally all relevant evidence will have been provided and discussed adequately prior to the final decision.

Part (i) – The question was answered poorly by many. The question required initiatives with IMMEDIATE impact. Many candidates ignored this. Also, many candidates failed to appreciate that there is very limited money and likely no expertise in government or in the insurance companies. The initiatives will have to be practical and affordable.

As ever, additional marks were given for other valid answers including:

- *Although implementing full new Solvency II liabilities is not realistic on an “immediate” basis, the regulator could reasonably request information on existing balance sheet scenario.*
- *Introduce counterparty exposure limits.*
- *Introduce a risk taxonomy.*
- *Set up an advisory service.*
- *Provide a timetable for the intended full implementation process.*
- *Provide education and training on the new regime.*
- *Require companies to set up a Central Risk Function with a Chief Risk Officer.*

Part (ii) – The question was handled well by most.

Part (iii) – Many candidates scored poorly. Many made too few points. The regulator is hoping that the hotline might bring to light dishonesty or incompetence on a significant scale before it otherwise would have come to light and hopefully when the impact of the breach is less.

Other valid points include:

- *Encourage whistleblower to discuss with someone else before reporting*
- *Have designated whistleblowing champions in each main company*
- *Make it clear that the call will be recorded*
- *Set out penalties for inappropriate use*
- *A couple of candidates also mentioned giving “rewards” for good use, but didn’t make it clear how that would actually work; indeed, advertising the potential for monetary awards might even encourage more time-wasters who call in on the off chance.*

Part (iv) – As for the preceding question, many candidates scored poorly. Many made too few points.

Other points include:

- *Log all calls into the system and prioritise them by severity*
- *Keep full documentation of the subsequent process*
- *Have a defined timescale (or turnaround standards) for each step of the process*

- 3 (i) Operational risk is the risk of losses resulting from inadequate or failed internal processes, people and systems, or from external events.

(ii) **Approach I**

The reinsurance premiums are calculated by simply multiplying the mean operational risk losses submitted by each of the four insurance companies by 150%.

Hence, the reinsurance premiums for the four insurance companies are as follows:

<i>Insurance company</i>	<i>Reinsurance premium</i>
Cornwall Insurance	30,000
Devon Insurance	30,000
Somerset Insurance	15,000
Dorset Insurance	60,000

Approach II

Using the method of moments we have:

$$E(X) = \alpha / \lambda$$

$$V(X) = \alpha / \lambda^2$$

so that after rearranging the terms we have:

$$\lambda = E(X) / V(X)$$

$$\alpha = E(X)^2 / V(X)$$

Hence, the parameters for the gamma distribution for each of the four insurance companies are as follows:

<i>Insurance company</i>	<i>Alpha (α)</i>	<i>Lambda (λ)</i>
Cornwall Insurance	1.600	1 / 12,500
Devon Insurance	2.667	1 / 7,500
Somerset Insurance	2.500	1 / 4,000
Dorset Insurance	2.667	1 / 15,000

Based on the inverse Gamma distribution tables the 99.5th percentile capital requirement for each of the four insurance companies is as follows:

<i>Insurance company</i>	<i>Capital requirement</i>
Cornwall Insurance	82,852
Devon Insurance	65,091
Somerset Insurance	33,499
Dorset Insurance	130,183

Since the reinsurance cover is provided for one year only the cost of capital is the capital requirement multiplied by 6%. Hence, the cost of capital for each of the four insurance companies is as follows:

<i>Insurance company</i>	<i>Cost of capital</i>
Cornwall Insurance	4,971
Devon Insurance	3,905
Somerset Insurance	2,010
Dorset Insurance	7,811

The reinsurance premiums are now calculated by adding the cost of capital to the mean operational risk losses submitted by each of the four insurance companies, and then multiplying the sum by 125%.

Hence, the reinsurance premiums for the four insurance companies are as follows:

<i>Insurance company</i>	<i>Reinsurance premium</i>
Cornwall Insurance	31,214
Devon Insurance	29,882
Somerset Insurance	15,012
Dorset Insurance	59,764

- (iii) Approach II is reasonably simple to calculate and takes account of both the expected level of claims and the variability of those claims (through the capital charge) in respect of operational risk losses.

However, the approach does not take into account higher moments such as how skewed the losses tend to be.

Approach I is even simpler to calculate. However, it is arguably too simplistic since the approach only considers the expected costs and not the variability of these costs and higher moments.

Approach II has the advantage of explicitly allowing for the reinsurer's cost of capital, whilst Approach I only implicitly allows for this through the loading.

Therefore, Approach I may lead to the reinsurer charging a premium that is too low, as can be seen by comparing the insurance premiums for Cornwall Insurance under Approach I and Approach II.

However, whilst Approach II takes account of the capital charge through the cost of capital, this has been done on a standalone basis. We are told that Southwest Re is a multinational reinsurer so in practice the incremental capital charge in respect of this business is likely to be negligible. Assuming this is the case then it may be appropriate to cost for a lower capital charge, perhaps even on a marginal basis.

Both Approach I and Approach II allow for expenses through the expense loading. It is not clear how the expense loading has been determined or

whether this is on a full or marginal basis. Where this business is deemed incremental to the reinsurer's business plans, there may be an argument for loading for marginal expenses rather than full expenses.

However, the reinsurer is likely to have limited expertise available to assess the expenses and it may therefore be better to err on the side of caution. In particular, the reinsurer may find that claims in respect of operational risks tend to be more contentious requiring greater legal assistance and hence, higher legal fees than is the case for the mortality and property reinsurance claims.

Both Approach I and Approach II are based solely on the insurance companies' historic loss data. Relying on this data alone is unlikely to give a reliable indication of future losses since even where insurance companies have been collecting operational risk losses for a number of years the data is likely to be scant at best.

Further, there are often issues around the quality of reporting, with managers unclear on what is and isn't to be reported, and even a lack of reporting, with truncation of data a distinct possibility. Whilst the size and variability of the losses for the insurance companies may reflect the nature and size of their operations, it may also reflect differing reporting standards and varying levels of disclosure dependent on the culture of the organisation.

Additionally, the historic loss data will not take into account near misses which might provide valuable additional data on the likelihood of further losses.

Finally, the loss data that is available may not be relevant where the insurance company in question has upgraded its framework of controls and mitigating actions to reduce the risk of such losses occurring again.

Therefore, the reinsurer may wish to conduct due diligence on the insurance companies' framework of controls to satisfy itself as to the level of risk that it is exposed to.

However, the reinsurer may not have a competency in managing operational risks, so as an alternative it may wish to employ some other consultancy to conduct the due diligence on its behalf.

Either way, this will lead to additional costs that must be factored into the reinsurance premium.

In addition, there may be other data sources, such as industry wide consortiums that could provide a valuable source of information on operational risk losses. This information could be used by the reinsurer in the selection of underwriting factors and hence, lead to an underwriting process that is more sophisticated than one relying on the historic losses alone.

Once the insurance companies have reinsurance protection in place for operational risks, they may unintentionally relax their framework of controls due to the comfort provided by the reinsurance. Worse still, some of the insurance companies may intentionally relax their framework of controls exposing the reinsurance company to moral hazard. Either way, the claims experience may turn out to be worse than expected as a result.

However, the fact that the reinsurer already has a relationship with the insurance companies may mitigate this risk to a limited extent. This could be further mitigated through an on-going level of due diligence similar to that described above, although this would result in additional costs that must be factored into the reinsurance premium.

- (iv) Dorset Insurance's operational risks are generally best controlled through the implementation of an appropriate system of processes and controls.

These may, for example, include doer and checker processes and/or spot checks to guard against errors and deliberate and unintentional bias.

New processes that are introduced should be subjected to stress testing to understand what may go wrong with those processes, how material the resulting issues may be and how best to manage those issues.

Outsourcing some processes to external organisations can also be used to manage operational risk. However it should be recognised that whilst outsourcing might provide a benefit through the use of dedicated expertise, it requires additional resources to be spent on monitoring and results in less control over the outsourced function, plus exposure to counterparty default risk.

There are also more specific approaches that can be adopted in respect of specific operational risks. These include:

Dorset Insurance will be exposed to business continuity risk that can be managed through the adoption of contingency plans for an alternative business location (with property either owned outright or an option to use a property at short notice) and the ability to use backup servers and data.

Regulatory risk can be managed through the employment of an in-house department that focuses on regulations and imminent changes and to disseminate them around the firm. The department may also undertake lobbying directly on behalf of Dorset Insurance or support existing lobbying groups.

Technology risk can be managed through the employment of a dedicated central IT resource. One of the key decisions in this respect relates to how much work relating to technology to carry out in-house and how much to outsource. The central IT resource, whether internal or external, should provide a response to IT problems in a time scale appropriate to the nature of the issue.

Crime risk, such as fraud risk, can be managed through the framework of controls, where these are consistent with the size of the risk. In other words, a framework of controls that reduces the cost of frauds but costs more than that saving is not a good framework.

People risk is one of the most important as Dorset Insurance's human capital will be a key driver of profitability. People risk can be managed through the employment of a sufficiently skilled human resource team that oversees:

- recruitment processes designed to ensure the right people are recruited
- performance management and remuneration to ensure the right people are promoted and retained
- training to ensure the people have the necessary skills to carry out their work
- cultural aspects to ensure the organisation encourages openness and diversity
- alignment to the needs of the many stakeholders in the business

Legal risk can be managed through the employment of a central legal team, along with the use of external legal teams on areas of contention, so that appropriate legal counsel is sought on areas of concern.

- (v) (a) Assuming the operational risks for the three insurance companies are independent we can employ the simple square root of the sum of squares in order to assess the diversified capital charge for the subsidiary utilising the standalone capital requirements from part (ii).

The diversified capital charge for the subsidiary is calculated as follows:

$$110,560 = \sqrt{82,852^2 + 65,091^2 + 33,499^2}$$

- (b) Hence, the diversification benefit is calculated as follows:

$$39\% = 100\% - 110,560 / (82,852 + 65,091 + 33,499)$$

Or may express it as an absolute figure

$$= 70,882 (= 82,852 + 65,091 + 33,499 - 110,560)$$

- (c) This emphasises the fact that assessing the insurance premium on a standalone basis is prudent since the cost of capital could be considered too great once you allow for some diversification when calculating the capital requirement.
- (d) The assumption that the operational risks of the three insurance companies are independent is unlikely to be the case in practice. The three insurance companies may operate in differing countries and sell differing products. However, where there is commonality in these

aspects, there is the risk that operational risks crystallise in several of the insurance companies at the same time. This would occur, for example, where the sales processes for each of the three insurance companies are similar so that all three insurance companies are exposed to the same risk of mis-selling.

Part (i) – Most candidates received the full mark. Some candidates’ answers were based on the context of the remainder of question 3. It is always the case that the answer to a question relies solely on the context and questions PRECEDING the question. No knowledge of following descriptions or questions is required. Hence the required answer to 3(i) was a generic one.

Part (ii) – Many candidates scored full or near full marks for this question.

Part (iii) – Many candidates scored marks for the advantages and disadvantages of each approach but most candidates did not make a sufficient number of points regarding how the calculation could be improved.

Part (iv) – Many candidates made several good points in their answers. A number of candidates made points which were not relevant to the mitigation of operational risks and so received no marks for these points.

Other valid points included finding cheaper insurance elsewhere.

Part (v) – The calculation approach in (a) is quite commonly used but was not known by many candidates. Marks were awarded for other reasonable approaches. Sub-questions (c) and (d) were mostly well handled although as with the preceding question some candidates failed to contain their answer to operational risks only.

- 4** (i) Market risk encompasses risks arising from changes in investment market values or other features correlated with investment markets, such as interest and inflation rates. This would include the consequence of investment market value changes on liabilities, and may also include the consequence of mismatching asset and liability cashflows.

And it can refer to the risk of lower sales or profit margins resulting from changes in market conditions, where “market” is interpreted as the market into which the products or services of that entity are sold.

- (ii) The level of prepayment risk will be heavily influenced by the level of interest rates, i.e. if rates fall customers would be more likely to refinance their homes and prepayments to ABC would increase.

So closely related are they that from a quantitative perspective it may be impossible to separate the impact of the change in interest rates from the customers’ propensity to prepay. As a consequence the two risks are likely to be considered as one exposure by management.

- (iii) DEF has a higher credit rating and is therefore likely to be considered a better credit risk than ABC. DEF's borrowing costs are therefore lower than ABC's.

Assuming the combined entity retains the higher credit rating the cost of funding (i.e. of borrowing funds to finance the mortgages) will fall. Thus the profit margin can be expected to increase.

Possible benefits from economies of scale

Possible benefits from tax synergies

- (iv) Examples include:

- Foreign exchange risk: ABC is likely to operate in a different currency to DEF
- Strategic risk: acquisition may fail
- Agency risk: DEF has no familiarity with the new territory and market so will have to rely on ABC's management whose incentives may not be aligned to the overall entity
- Operational risk: similar to the above issue (familiarity of DEF senior management) plus management distraction due to the acquisition process
- Political, legal, regulatory risks: new territory has new rules and regulations
- Economic risks: new economy, potentially involved in a new industry
- Credit risks: increased borrowing to sustain ABC's business model
- Liquidity risk: acquisition may reduce available cash
- Reputational risk: DEF has "lent" its brand to ABC
- The aggregate risk position of the combined entity will include diversification credits which were not there prior to the acquisition in DEF Bank.

- (v) A slowdown in the world economy could act to increase borrowing costs while at the same time weakening the housing market and reducing demand for mortgages.

Part (i) – This question was handled well by most. The question came after a brief description of ABC Mortgages and so the answer should be made within the context of the preamble above it.

Part (ii) – Candidates either knew that prepayment risk was linked to interest rate changes or not. Hence, the candidates either scored well or no marks.

Part (iii) – This question was handled well by most.

Part (iv) – This question was handled well by most.

Part (v) – This question was handled well by most. Many candidates lost marks for not suggesting a scenario that would clearly affect both ABC's domestic business and DEF's international operations.

5 (i)

<i>Advantages</i>	<i>Disadvantages</i>
<ul style="list-style-type: none"> • Likely to be more cost-effective than going to the retail market as the direct market reinsurers at least in part large risks to reinsurers anyway. • Also a certain level of claims are virtually inevitable. Cash can be retained in the captive to meet these claims which reduces the cost of the reinsurance premiums. 	<ul style="list-style-type: none"> • Captive is subject to regulatory requirements – so there will be additional costs / regulations. • The internal administration costs of the captive may not be less than the savings in the expense loading in the direct premium.
<ul style="list-style-type: none"> • May be the only way XYZ can get cover for all its employees through a single scheme. 	<ul style="list-style-type: none"> • May be an industry that XYZ does not have existing internal expertise in.
<ul style="list-style-type: none"> • Affords XYZ a degree of control over the level of benefits and servicing requirements which may not be available through a retail arrangement 	<ul style="list-style-type: none"> • May not provide adequate protection for extreme events
<ul style="list-style-type: none"> • Possible tax benefits 	<ul style="list-style-type: none"> •

- (ii) Reinsurance will transfer the insurance risk. However, this is replaced by a new credit risk exposure to the event that the reinsurer defaults.

In addition, the risk exposure is so concentrated in the event of a catastrophe – for example, a single event could trigger a large number of claims from staff in a single location such as a head office – it may not be possible to arrange sufficient reinsurance and some risk will have to be retained.

At the very least, this could mean that the credit risk exposure is not insignificant.

Further, claims from this event may create a liquidity constraint while XYZ waits to recover from the reinsurer.

Insurance risk events may trigger risk events in other categories. For example, in the extreme scenario the loss of a large number of staff will not only have financial but also operational consequences.

For direct insurance there is one contract between the company and the insurer. In the case of the captive there is a contract between the company and the captive and then another contract between the captive and the reinsurer. This gives rise to potential basis risk between the two contracts leaving the company in the position that it may be exposed to claims that are not covered under the reinsurance.

(iii) Examples include:

- Investment in physical measures to improve safety, for example better fire prevention measures or security at office buildings
- Health and safety screenings of all suppliers (e.g. canteen operators)
- Regular medical examinations for staff
- Encouragement of healthy lifestyle e.g. healthy food options in the canteen
- Or provision of sports/gym facilities to encourage exercise
- Have some degree of underwriting, particularly for higher sums assured
- Exclude pre-existing conditions from insurance cover
- Other exclusions e.g. claims due to hazardous hobbies
- Have robust and active sickness management policies, e.g. regularly following up those off work due to sickness
- Have rehabilitation policies, e.g. allowing employees to return to work part-time after a long illness
- Staff training programs to reduce the risk of accidents in the workplace
- Reduce amounts of cover provided
- Limit cover to a subset of staff

Part (i) – A straight-forward question that was well handled by many.

Part (ii) – Another straight-forward question that was well handled by many.

Other valid points include:

- *reinsurance cover not being 100% (e.g. retention limit and/or upper limit).*
- *There may be some form of currency risk, depending on how the reinsurance is set up.*

Part (iii) – This question was well handled by most.

6 (i) Solvency II comprises three pillars.

Pillar 1: Quantitative Requirements

Solvency II prescribes the minimum amount of capital that must be set aside based on the estimated aggregated financial risk of the company.

The calibration of the Solvency Capital Requirement (SCR) is a 99.5% level of confidence over a one year time horizon.

The aggregated financial risk is either modelled using an “internal model” or is calculated using a prescribed standard formula.

In order to estimate or calculate the aggregated financial risk it is necessary to identify and model many types of risk including market risk and credit risk.

If an internal model is used, it must meet a number of criteria including the “use test”, and be approved by the regulator.

There is also a Minimum Capital Requirement (MCR) below which the company would lose its authorisation.

As for ERM, the requirements call for complete and up to date documentation and back testing to evidence the appropriateness of the results.

Pillar 2: Qualitative Requirements

Assessing risk through the other business practices including corporate governance, health and safety, business plans, management experience and expertise. Plus regulatory scrutiny of overall strategy and business models.

Pillar 3: Disclosure

Seeking to encourage the full disclosure of risks in order to encourage companies to fully identify, monitor, measure, mitigate, transfer etc, keeping net risks which are in line with the stated company's objectives.

(ii)

- Non-life underwriting risk
- Life underwriting risk
- Health underwriting risk
- Market risk
- Counterparty default risk
- Operational risk

(iii) Underwriting risks

- Risk aggregations (sum insured)
- Split for example by region, peril/product type, distribution channel
- New business levels by similar splits
- Reserve strengthening/release

Market risk

- Value at Risk (VaR)
- Stress and scenario test results

Counterparty default risk

- Counterparty credit quality and diversity for assets and liabilities – credit rating analysis

Operational risk

- Analysis of key risks (operational risk profile)
- Internal audit results
- IT downtime
- Staff turnover rates

- (iv)
- Audit Committees – To monitor material financial risks and mitigation of those
 - Executives – To review risk information for completeness
 - Managers – To review risk information for completeness and changes in risk profile or control effectiveness
 - Risk Owners – To update risk information and escalating changes in likelihood, impact or control effectiveness as required
 - Control Owners – To update status of treatments for controls that they are responsible for
 - Internal Audit – To reviewing the effectiveness of internal control measures
 - External Stakeholders – Reviews by supervisory bodies for regulatory solvency purposes
 - Credit Rating Agencies – As part of their credit rating monitoring and review process
- (v) KPIs are used to monitor the performance of the organisation. They are therefore associated with the return side of the risk-return equation and wouldn't strictly be an indicator of the risk exposure.

However, to the extent that both KPIs and KRIs use proxies for the underlying risk and return drivers, they may well be the same.

For example, a life company selling unit-linked policies may use an equity index as a KPI (to proxy changes to the level of fund management charges it expects to receive) and as a KRI (to proxy changes in market risk capital).

The key difference between the use of a metric as a KPI and KRI is the interpretation which is applied to it and the subsequent set of actions / responses it will result in. For example, KPIs will result in actions by the Finance function, while KRIs will result in actions by the Risk function.

Part (i) – A straight-forward question which was well handled.

Part (ii) – A straight-forward question which was well handled.

Part (iii) – Most candidates who tried to answer the question scored good marks. There were many nil responses indicating that many candidates had not previously thought about specific risk measures.

Part (iv) – Most candidates were able to list a number of internal and external stakeholders and explain why they would be interested in monitoring the company's KRI's.

Part (v) – This question was answered poorly by most. Most candidates were unable to distinguish between the purpose and use of KPIs and KRIs and hence were not able to answer the question.

END OF EXAMINERS' REPORT

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINATION

23 April 2013 (am)

Subject ST9 – Enterprise Risk Management

Time allowed: Three hours

INSTRUCTIONS TO THE CANDIDATE

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all seven questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

AT THE END OF THE EXAMINATION

Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.

In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.

- 1** (i) Outline different protection measures that government regulators can implement for financial services companies. [4]

Insurance Company A's risk management department focuses its activities only on meeting government regulatory requirements.

- (ii) Explain the benefits for the insurer if the risk department also started to take account of other stakeholders. [4]
[Total 8]

- 2** A small general insurance company, which writes only property insurance, has decided to use risk maps as part of its risk identification and assessment process.

- (i) Describe the process of developing and implementing a risk map. [5]
- (ii) (a) Give two contrasting examples of risks to which the insurance company may be exposed.
- (b) Sketch them on a risk map. [4]

As a result of this process, the insurer has decided to reduce the risks to which it is exposed but without increasing its counterparty risk.

- (iii) Recommend actions that it may take in order to achieve this. [6]
[Total 15]

- 3** Solvania is a large European country that has decided to change the way in which its universities are financed.

Following many years of growth in the number of university students, the government has decided to scale back the funding that it has traditionally provided to the universities. In order to replace the lost funding, the universities will be allowed to charge substantial tuition fees. This policy has drawn protests across the country. Despite these protests the new tuition fees will be charged for the first time next year, having been approved by the government.

One such university, the Solvania Institute of Arts and Drama, is particularly popular with overseas students and ranked 15th out of the 45 universities in Solvania for academic quality. It is looking to raise debt finance to fund the construction of additional student accommodation. Whilst the new accommodation will be built on the university's out-of-town campus, it will be separated from the other university buildings by a busy major road. The accommodation can be reached by a 15 minute walk or more quickly by a footbridge over the road.

The proposed loan will have the following features:

- The amount of the loan will be £40m to cover the cost of construction of additional student accommodation on campus.
- The interest rate payable on the loan will be 4% above the relevant Solvanian interbank rate.
- The loan to value ratio will be 70%, with full amortisation over the 35 year term.
- The security for the loan will be a 50 year leasehold on the student accommodation.
- After completion, the ratio of students to available beds will be 3 to 2 (compared to 2 to 1 currently).
- Rental income from the student accommodation will be used to service the payments on the mortgage; the ratio of rental income to loan payments is estimated to be 150%. It is further estimated that this would fall to 100% should the student to bed ratio fall to 6 to 5.
- The rents charged to students will normally increase in line with the country's retail price inflation index plus 1%, with all changes being subject to a minimum and maximum increase of 0% and 5% respectively.

The construction company has experience of similar construction projects and a credit rating of A+. The university has a BBB credit rating and extensive gearing of its balance sheet to support the recent development of its academic and accommodation facilities.

The National Bank of Solvania ("NBS") is a multinational bank with major operations in Solvania, including significant experience underwriting commercial mortgages. Typically these commercial mortgages are written with an interest rate that is 2% above the relevant Solvanian interbank rate. However, the bank has now been invited by an intermediary to underwrite the above loan, which represents a divergence from its usual commercial mortgage business.

(i) Discuss the risks to the bank which will arise from underwriting the loan. [18]

The bank wishes to test how well the loan would perform under stressed conditions.

(ii) List the sensitivities and scenarios that should be investigated. [3]
[Total 21]

4 (i) Define longevity risk. [1]

The Solvanian Life Assurance Society (“SLAS”) primarily writes term assurance business, which it largely reinsures, and a small volume of immediate annuity business. It operates a defined benefit pension scheme for its employees, which guarantees to pay employees one 40th of their final salary for each year of service. Following the introduction of a risk-based capital regime, SLAS is considering how to manage its risks better.

(ii) Describe ways in which SLAS could mitigate its longevity risk. [8]

Following a large drop in the value of its assets, the surplus assets on the Society’s risk-based balance sheet have reduced substantially.

SLAS has entered into discussions with the National Bank of Solvania (“NBS”) to investigate the possibility of improving the surplus assets by transferring longevity risk to the capital markets.

NBS has proposed a non-standard longevity swap with the following features:

- The term of the swap is ten years.
- The longevity swap does not protect SLAS from small changes in the mortality rates.
- However, once mortality rates have improved by 10% the longevity swap protects SLAS from further improvements in mortality rates up to a limit of a 20% improvement in mortality rates.
- The reference mortality rates are those published by Solvania’s National Statistics Office for the population as a whole, as at the start and end of the swap period. The weight given to each age will reflect the actual ages of SLAS’s annuitants.
- SLAS immediately pays NBS a premium for the longevity swap.
- SLAS does not receive or make any payments during the ten year term.
- SLAS receives a maturity payment from NBS at the end of the ten year term, although this maturity payment may be zero.
- After ten years, if the reference mortality rates have improved by more than 10%, SLAS receives a payment equal to any excess of the value of the liabilities at that date over the value of the liabilities assuming a 10% improvement in mortality rates. The maturity payment is subject to a maximum limit equal to the value of the liabilities assuming a 20% improvement in mortality rates less the value of the liabilities assuming a 10% improvement in mortality rates.
- In valuing the liabilities at maturity, differences between the “actual” (reference rates at maturity) and “expected” (reference rates at outset) mortality rates over the ten years are to be extrapolated. There is some flexibility regarding the method of extrapolation, although this must be agreed up front between NBS and SLAS.

- (iii) Illustrate SLAS's profit profile under the longevity swap for varying mortality rates. [4]
 - (iv) Discuss the advantages and disadvantages to SLAS of structuring the longevity swap in this way. [10]
 - (v) Give reasons why SLAS may seek to transfer longevity risk to the capital markets rather than to a reinsurer. [4]
- [Total 27]

5 Southwest Re is a start-up reinsurance company that is assessing its economic capital using a Value at Risk approach calibrated to the 95th percentile loss over one year.

During its first year, Southwest Re underwrote four excess of loss reinsurance treaties with the following features:

	<i>Excess</i>	<i>Probability of no loss occurring (i.e. below excess)</i>
Cornwall Insurance	£50m	0.995
Devon Insurance	£50m	0.985
Somerset Insurance	£50m	0.975
Dorset Insurance	£50m	0.965

Claims on the reinsurance treaties are assumed to be linked by a Gumbel copula with parameter $\alpha = 2.5$.

The generator function for a Gumbel copula with parameter α is:

$$G_{\alpha}\Psi_{\alpha}(F(x)) = [-\ln(F(x))]^{\alpha}$$

The Chief Capital Officer has suggested that, because the probability of no losses occurring on the four reinsurance treaties is greater than 95%, the reinsurer does not need to hold any economic capital.

- (i) Verify the Chief Capital Officer's claim that the probability of no losses occurring on the four reinsurance treaties is greater than 95%. [4]
 - (ii) State with reasons whether the reinsurer should hold capital in respect of the reinsurance treaties, including consideration of the parameterisation of the copula. [6]
- [Total 10]

- 6 (i) Outline how governments and stock exchanges have mitigated or transferred liquidity risk. [3]
- (ii) Describe the possible consequences of liquidity risk crystallising. [3]
- (iii) State with reasons the most common cause of sudden illiquidity in a banking system. [2]
- [Total 8]

7 A financial adviser has produced the following calculations for a client who is considering investing in a portfolio of bonds with one year to maturity.

<i>Bond</i>	<i>Current Price</i>	<i>Coupon</i>	<i>Probability of Default</i>	<i>Loss Given Default</i>
A	90	3%	5.0%	100%
B	95	5%	4.0%	100%
C	103	11%	3.5%	100%
D	98	7%	3.0%	100%

Note:

- All of the bonds have one year to maturity.
- All of the bonds pay par (100) plus the coupon at maturity.
- They are large issues, with no structural complications, and are widely traded on a major exchange.

$$\begin{aligned} \text{Maximum Return} &= ((100 - 90 + 0.03 \times 100) \times 100/90 \\ &+ (100 - 95 + 0.05 \times 100) \times 100/95 \\ &+ (100 - 103 + 0.11 \times 100) \times 100/103 \\ &+ (100 - 98 + 0.07 \times 100) \times 100/98)/400 = 10.5\% \end{aligned}$$

$$\begin{aligned} \text{Expected Return} &= ((100 - 90 + 0.03 \times 100) \times 100/90 \times (1 - 0.05) \\ &+ (100 - 95 + 0.05 \times 100) \times 100/95 \times (1 - 0.04) \\ &+ (100 - 103 + 0.11 \times 100) \times 100/103 \times (1 - 0.035) \\ &+ (100 - 98 + 0.07 \times 100) \times 100/98 \times (1 - 0.03))/400 \\ &- (0.05 + 0.04 + 0.035 + 0.03) \times 100/400 = 6.2\% \end{aligned}$$

$$\begin{aligned} \text{Return if only bond A defaults} &= ((100 - 95 + 0.05 \times 100) \times 100/95 \\ &+ (100 - 103 + 0.11 \times 100) \times 100/103 \\ &+ (100 - 98 + 0.07 \times 100) \times 100/98)/400 \\ &- 0.25 = -18.1\% \end{aligned}$$

$$\text{Return if only bond B defaults} = -17.2\%$$

$$\text{Return if only bond C defaults} = -16.5\%$$

$$\text{Return if only bond D defaults} = -16.8\%$$

Probability all bonds default = $0.05 \times 0.04 \times 0.035 \times 0.03 = 0.0002\%$

Probability no bonds default = $(1 - 0.05) \times (1 - 0.04) \times (1 - 0.035) \times (1 - 0.03)$
 $= 85.4\%$

Probability the two riskiest bonds only default = $0.05 \times 0.04 \times (1 - 0.035)$
 $\times (1 - 0.03)$
 $= 0.2\%$

Probability of an AA rated bond defaulting in one year = 0.2%

Current yield to redemption on a one year AA rated bond = 2%

- (i) Outline the points that the financial adviser is likely to make in discussion with the client, based on the above calculations. [5]

After the initial conversation with the client, one of the financial adviser's colleagues produced the following two sets of calculations for the client.

$$Pr(F(x_1), F(x_2), \dots, F(x_N)) = -\frac{1}{\alpha} \ln \left[1 + \frac{\prod_{n=1}^N (e^{-\alpha F(x_n)} - 1)}{(e^{-\alpha} - 1)^{N-1}} \right]$$

If $\alpha = 8$ then:

$Pr(\text{all bonds default}) =$

$$-\frac{1}{8} \ln \left[1 + \frac{(e^{-8 \times 0.05} - 1)(e^{-8 \times 0.04} - 1)(e^{-8 \times 0.035} - 1)(e^{-8 \times 0.03} - 1)}{(e^{-8} - 1)^3} \right]$$

$= 0.06\%$

$Pr(\text{the two riskiest bonds only default})$

$= 1.18\%$

OR

$Pr(\text{exactly two bonds default}) =$

$$(1 - e^{-\lambda_{12}}) e^{-(\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 + \lambda_{13} + \lambda_{14} + \lambda_{23} + \lambda_{24} + \lambda_{34} + \lambda_{123} + \lambda_{124} + \lambda_{134} + \lambda_{234} + \lambda_{1234})} +$$
$$(1 - e^{-\lambda_{13}}) e^{-(\lambda_1 + \dots)} +$$
$$(1 - e^{-\lambda_{14}}) e^{-(\lambda_1 + \dots)} + \dots$$

$= 0.76\%$

- (ii) State the processes or models underlying these new calculations. [2]
- (iii) Interpret the results of the three different sets of calculations. [2]
- (iv) Outline the follow up points that the financial adviser should make to the client as a result of the new calculations. [2]

[Total 11]

END OF PAPER

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

April 2013 examinations

Subject ST9 – Enterprise Risk Management

Introduction

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and using past papers as a revision aid and also those who have previously failed the subject.

The Examiners are charged by Council with examining the published syllabus. The Examiners have access to the Core Reading, which is designed to interpret the syllabus, and will generally base questions around it but are not required to examine the content of Core Reading specifically or exclusively.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report; other valid approaches are given appropriate credit. For essay-style questions, particularly the open-ended questions in the later subjects, the report may contain more points than the Examiners will expect from a solution that scores full marks.

The report is written based on the legislative and regulatory context pertaining to the date that the examination was set. Candidates should take into account the possibility that circumstances may have changed if using these reports for revision.

D C Bowie
Chairman of the Board of Examiners

July 2013

General comments on Subject ST9

The ST9 exam generally requires bullet point form or short form essay style answers that apply general principles to directly address specific circumstances. The answers given below are just one possible set of acceptable answers. Candidates are awarded marks for all reasonable answers including different but still reasonable numerical solutions. Marks are awarded for working in the case of numerical answers.

In this paper, as with previous ST9 papers, marks are earned by stating correct points. Examples of points are stating a valued type of risk, describing the type of risk or calculating a quantity correctly. Valid points need to be directly relevant to the question asked and be made coherently.

Comments on the April 2013 paper

The April paper followed the style of September, 2012 by including fewer and larger questions. Many of the questions were loosely based on actual events. Examples include the risks associated with bank loans and longevity risks. Practical examples of ERM are extremely common place in the press. Candidates should find that regular reading of financial press will prove to be very helpful to their understanding of the issues and concepts contained in the core reading.

Question 7 was a calculation question with a twist. Instead of asking the candidate to perform the calculations, the calculations were given in the question. The candidates were asked to describe the nature of the calculations, their potential short comings and the conclusions that should be drawn from them.

Well-prepared candidates scored acceptably well across the whole paper. The comments that follow the questions concentrate on areas where candidates could have improved their performance.

1

(i)

- Requirements to provide regular information to investors
- Requirements to provide regular information to customers
- Restrictions on the establishment of new financial institutions
- Establishment of quantitative minimum capital requirements
- Qualitative requirements for the management, systems and processes of firms
- Requirements on the quality of directors, management and staff
- Restrictions on insider trading
- Restrictions on lines of business e.g. separating investment and retail banking
- Establishment of industry-wide insurance or compensation schemes
- Acting as lender of last resort
- Intervention in the management of companies
- Intervention in the ownership of companies

(ii) The regulatory risk and capital adequacy framework may not be very sophisticated.

By considering risks affecting many stakeholders the company will have a better understanding of the full range of risks, i.e. risks are less likely to be missed out.

The insurer may gain greater appreciation of concentrations of risk and diversification issues e.g. activities of the insurer that give rise to diversification/correlation of risks.

It may also help eliminate different levels of risk appetite in different areas of the company.

In particular the company may have missed commercial opportunities and exploitation of strategic advantages by concentrating on regulatory aspects which will tend to focus on reducing downside risk.

Having more information will allow the company to take more appropriate action when managing the risks.

In particular, considering the balance between the needs of different stakeholders (e.g. shareholders v. policyholders) should help the company to optimise its risk/return trade-off.

By taking account of credit rating agency requirements the insurer might improve its credit standing and so obtain cheaper access to funding.

Part (i) – The question was handled well by most.

Additional marks were given for other valid answers including:

- *controls on distribution methods and channels.*
- *restrictions on investments held.*
- *restrictions on counterparty exposures.*
- *regular reporting requirements.*
- *regular inspections.*
- *keeping different units separately capitalised.*

Part (ii) – Many candidates did not include in their answers the additional risks that would be managed by the department if it were to consider the risks which would be important to other stakeholders.

2 (i)

- Establish a top-down framework: an overall taxonomy for all risks
- Create a bottom-up list of specific risks by business and functional units based on loss history and self assessments
- Evaluate the probability [or frequency] and severity of each risk based on judgement or risk models
- Develop the risk map and plot each risk in turn against the probability and severity axes
- Identify existing controls to incorporate their impact into the risk map (e.g. well-managed / managed / needs more management) and to determine whether new controls are required
- Assign responsibilities for implementing new controls and for monitoring and reporting on specific risks
- Aggregate the individual risk map into an enterprise risk map and determine if new controls are required at the enterprise level.
- Return to first step

(ii) Example risks

High severity, low frequency:

- Default of a reinsurance company
- Property claims arising from a catastrophic earthquake / collapse of a high rise building / terrorist attack e.g. 9/11
- Own business disruption / operational problems arising from a similar event

Low severity, high frequency:

- Minor mismanagement in claims area leading to higher than expected claims payments
- Aggregation of small property claims due to concentration of sales in a specific area

Plotted on risk map per diagram from Lam (Figure 18.1)

(iii) If the insurer extends the range of policies sold there will be a diversification benefit, particularly if the policies are different in nature to the existing policies.

It should consider selling in different geographical areas, either different parts of the country it operates in or abroad.

Withdraw from the riskier classes of business.

Improve the underwriting of the business it chooses to keep.

Reduce underwriting and pricing risks through more intelligent data analysis.

Introduce lower maximum benefit amounts.

Having higher policy excesses.

Reduce market risk by investing in assets which better match the liabilities.

Diversify assets more across individual counterparties.

Reduce operational risks through the implementation of strong governance and controls.

Reduce any existing credit and counterparty risks by using counterparties with higher credit ratings or by using tougher service agreements.

It may be possible to reduce agency risk through the use of intelligent remuneration and bonus systems that align better the interests of different stakeholders.

Increase the capital it holds in order to reduce overall solvency or wind-up risk.

Part (i) – The question was handled well by most although several candidates answered parts of (ii) in (i) and vice versa.

Part (ii) – The question did not require the student to explain why the risks are contrasting. Many different examples were used including fraud. Almost all candidates sketched an adequate risk map.

Part (iii) – The question was handled well by most.

Additional marks were given for other valid answers including:

- *improve the claims management processes.*
- *tighten up and otherwise alter policy conditions.*
- *business continuity plans.*
- *staff training.*
- *increase pricing margins.*

- 3** (i) The higher interest charged presumably reflects the higher risk associated with the loan relative to NBS's current commercial mortgage book. So the obvious question is whether the higher interest payments received represent adequate compensation for the additional risk that is accepted in underwriting the loan.

The key risk is credit risk: the failure of the university to make one or more of the interest and/or full capital redemption payments.

The interest payments are linked to the Solvania interbank rate which may increase substantially over the term of the loan, resulting in the university's inability to meet the interest payments.

The long term nature of the loan will require funding from the bank for a long time, potentially leading to an asset/liability mismatch where the bank's deposits are of a shorter term.

The long term nature of the loan also means that the bank will have to consider prepayment risk.

The introduction of Basel III introduces the risk of regulatory changes to require the bank to set aside a larger amount of capital due to this mismatch in the future, leading to a lower return of capital.

The mismatch of short term liabilities to long term locked-in assets can also increase liquidity risk for the bank.

NBS has no experience of underwriting loans for the construction of student accommodation and hence there may be increased operational risk.

e.g. in setting appropriate terms that should be included in the contract to protect the bank.

NBS will also be exposed to model risk in quantifying the risk associated with the loan, potentially leading to a suboptimal decision on the analysis of the pricing of the loan and therefore on the decision to go ahead or otherwise. The university is popular with overseas students. However, the number of overseas students may be impacted by the political whims of those in government potentially increasing or decreasing their numbers (political risk).

The number of overseas students might also be subject to exchange rate risk: the tuition fees could become significantly more expensive to overseas students as a result of adverse changes in the Solvanian to domestic currency exchange rates.

More fundamentally, overseas students may choose different overseas countries for university education if the Solvanian tuition fees are prohibitive.

The university's focus on arts and drama courses may mean that the university is at risk of lower demand where: tuition fees dissuade potential students from taking non-science courses; and/or changing employment patterns mean employers focus more on science graduates.

Demand may also fall if the university's academic rating (currently 15th) falls, e.g. due to losing highly regarded key tutors.

The introduction of tuition fees is likely to impact negatively on the numbers intending to go to university. This may lead to a decrease in the numbers attending the university.

There is also the political risk of the tuition fee decision being reversed (e.g. by a replacement government), which could invalidate modelled assumptions.

Alternatively, there may be a flight to quality that insulates the better universities. Thus, student numbers at the university in question may not be as adversely impacted by the introduction of tuition fees as first expected.

Some students will have a preference for private accommodation off campus. This is perhaps more likely for students in their second and third years. Therefore, the ratio of students to beds may not offer as much income protection as initially anticipated.

Following the introduction of tuition fees it is possible that more students decide to choose universities near their parents' homes to minimise the cost of obtaining a university education, thus reducing demand for student accommodation.

In addition, Solvania (like much of Europe) may be suffering from an aging population with a trend of fewer 18 year olds each year. This may impact upon demand for university places.

The student accommodation is to be built on a site whose primary access is over a foot bridge. If access to the accommodation via the foot bridge was limited for any reason – such as a vehicle crashing into the bridge – then the attractiveness of the accommodation may be reduced due to the longer time required to access the rest of the university campus. Similarly if there was a high profile accident (student being run over crossing the road). This may lead to a decrease in the number of students selecting the new accommodation.

A prolonged period of economic uncertainty may impact on the desire of potential students to attend university, thereby increasing or decreasing demand for student accommodation.

Any fall in student numbers (for any of the above reasons) could reduce tuition fees and thus strain the university's finances.

Any reduction in demand for this student accommodation (for any of the above reasons) could reduce the income cover for the loan as a result of needing to keep rental level low (due to the fall in student to bed ratio) or there may even be "voids" i.e. student accommodation rooms not filled.

Furthermore, private landlords may react by increasing their rents more slowly forcing the university to do likewise and, in the absence of an ability to reduce rents, accept voids and hence further reductions to the income cover for the loan.

The income cover will also be affected by the structure of the rental increases. Under very high inflation, the university will be not be able to increase rents accordingly (due to the 5% cap) and assuming that interest rates are also high under such economic conditions, this would also reduce income cover.

The credit risk relating to the university is increased due to the fact that it is known to be highly geared already.

And similarly there may be contagion risk: its other borrowings are also likely to be adversely affected under the same low student demand conditions.

Some of the above demand factors may even cause the university to fail due to its weak finances (noting also the low credit rating).

It may be possible to mitigate this by restructuring the loan to release funds gradually or perhaps directly to the building company, as the building company is more highly rated than the university.

Following the failure of the university there may be alternative uses for the accommodation. However, as the accommodation is at the university's out-of-town campus these may be limited.

Furthermore, the security is a leasehold on the accommodation. This further limits the ability of the bank to extract value from the property on default of the university.

The recovery of monies on default will also be subject to the risk of low property values at that time.

Alternatively the university may decide to postpone the completion of the construction due to falling student numbers, with possible restructuring of the loan necessary and an adverse impact on the value of the loan.

Whilst the building company has a better rating than the university, there is still the risk that the builder fails and the construction is therefore completed at greater expense or not at all. This could potentially be mitigated through purchase of insurance.

The bank's general expenses relating to the underwriting and maintenance of the loan within the portfolio could be higher than expected.

- (ii) It would be useful to investigate the following scenarios in order to test how well the loan performs in stressed circumstances:
- Construction delayed and e.g. first year rents not received
 - Construction costs $x\%$ (e.g. 20%) higher than anticipated and the university is unable to cover the additional costs
 - Other costs significantly higher than anticipated (e.g. insurance)
 - Demand for student accommodation is $x\%$ (e.g. 10%) lower than anticipated
 - Inflation index sensitivities
 - Base interest rate sensitivities
 - Rental growth sensitivities which test the impact of the cap/floor
 - Combination tests, e.g. combined inflation / interest rate scenarios
 - Corporation tax increased by $x\%$ (e.g. 10%)
 - Efficiency of possible loan restructuring arrangements

Part (i) – A wide range of reasonable points were made by the well prepared candidates. There are many ways to make the same or similar points.

Part (ii) – Most candidates mentioned demand for accommodation, inflation and/or interest rates. Very few candidates suggested other sensitivities/scenarios.

- 4**
- (i) Longevity risk is the risk that a business experiences losses due to mortality being lighter than expected.
- (ii) SLAS can manage its longevity risk using the following tools:
- It should ensure that its annuity rates are priced with appropriate allowance for future mortality improvements.

- It could withdraw from the immediate annuity market, particularly as it does not appear to be a key strategic product.
- It can undertake more detailed underwriting / premium rating for its new annuity business so as to generate differing annuity rates for different potential customers reflecting how long it expects those potential customers to live (e.g. by postcode, or by smoker status or by health status (e.g. impaired lives)).

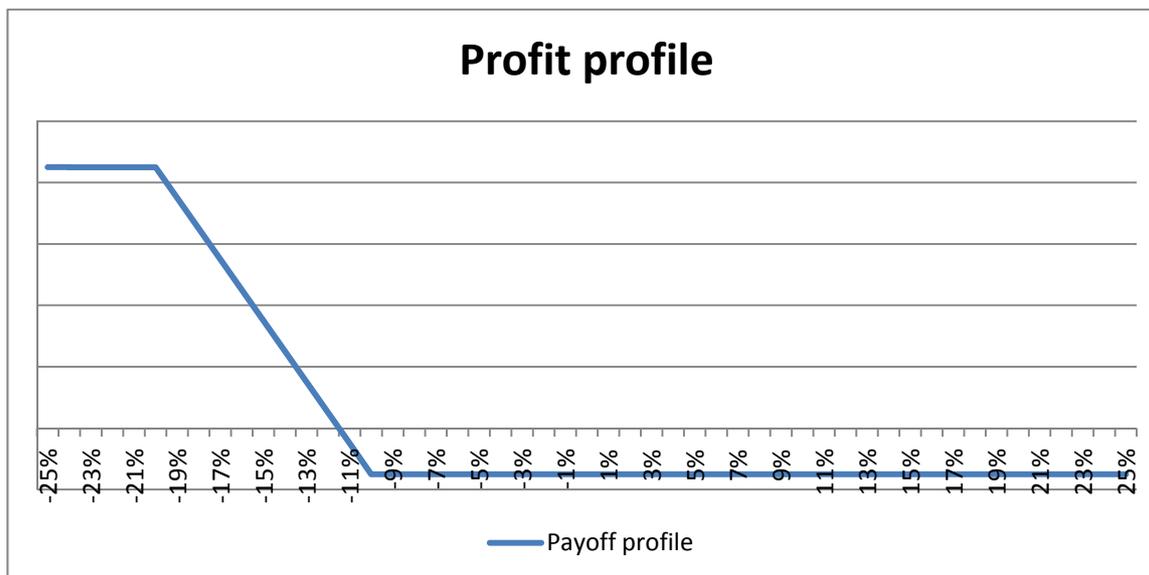
However, given that it underwrites only a small volume of annuity business it may find that significant investment in underwriting models is not cost effective. Further it will not have sufficient own-experience data to support this development and so would have to rely on others' data to do this.

- It can reinsure its annuity business. This could be proportional – e.g. an identical proportion of each annuity is reinsured with the reinsurer – or non-proportional – e.g. stop loss to limit losses that may arise from advances in medical technology and hence the longer lives of annuitants.
- It may decide to utilise a longevity swap. This typically involves an insurance company making fixed payments based on the expected longevity of the reference population, whilst receiving variable payments based on their actual survival.
- It may elect to close its defined benefit pension scheme to future accruals or to new members, or go further and close the scheme fully.
- Having closed the defined benefit pension scheme, it could seek to transfer the liabilities to another life insurer through a buy-in or buy-out arrangement.
- It could reduce the value of the defined benefit pension scheme to employees through reducing the rate at which benefits are accrued. In other words, the scheme could guarantee to pay employees one 60th of their final salary for each year of service rather than one 40th as is currently the case.
- SLAS should ensure that its exposure to longevity risk avoids concentrations of risks that may occur, for example, due to underwriting annuities for a high wealth socio-economic group with greater access to private medical facilities.
- It should seek to diversify its longevity risks through underwriting risks that are not or only very loosely connected with longevity risk.

Some risks may even result in a partial hedge for the longevity risk. For example, mortality risk on the term assurance business may partially hedge the longevity risk on the annuity business and defined benefit pension scheme.

However, this partial hedge is likely to be far from perfect as term assurances tend to be purchased by policyholders that are younger than those purchasing annuities. Also policy durations will be mismatched, e.g. term assurance business may have 10-20 year terms while annuities are likely to be life annuities.

(iii) SLAS's profit profile for the NBS longevity swap is as follows:



(iv) The advantages of structuring the longevity swap in this way are as follows:

- SLAS's balance sheet can probably handle small variations in mortality, but not larger movements, so the longevity swap is focused on providing some protection from the larger improvements in the mortality rates.
- The capital markets may like this as they are being offered an out-of-the-money guarantee rather than an at-the-money guarantee; the swap is therefore more likely to be affordable to SLAS.
- The NBS longevity swap is also a potentially efficient way of managing capital downwards if the risk-based capital stress scenario involves an improvement in mortality rates in excess of 10%.
- Because the NBS longevity swap references population mortality rates there will not need to be an exhaustive due diligence of SLAS's annuity book and defined benefit pension scheme.
- The annuity portfolio is relatively small (and there may be a limited number of pensioners in the pension scheme), and this structure avoids use of actual experience which could be highly volatile due to random fluctuations.

- Because the NBS swap is “standardised” by referencing population data, SLAS may be able to sell on this asset at a future date if views on / appetite for longevity risk were to change.
- The NBS longevity swap variant leaves SLAS exposed to upside risk (i.e. can benefit from worsening mortality experience).

The disadvantages of structuring the longevity swap in this way are as follows:

- Unlike standard longevity swaps, the guarantee is some way out-of-the-money so that the protection does not kick in so early.
- There is no protection for longevity improvements of 0%–10% or in excess of 20% over the ten year period.
- Unlike standard longevity swaps, there is an upfront premium to be paid for the one sided protection. To be of immediate benefit to SLAS the premium needs to be smaller than the released capital requirement.
- SLAS will make an overall loss on the transaction if mortality improvements are lower than 10% (cost of premium).
- Unlike standard longevity swaps, the term is limited leaving SLAS potentially exposed in the longer term. It is perhaps in the longer term that there will be greater uncertainty over the mortality rates.
- The maturity payment is based on the extrapolated differences between the expected mortality rates and actual mortality rates subject to the specified limits. If improvements in the mortality rates only become evident just before the maturity of the NBS longevity swap then, depending on the extrapolation method, the maturity payment may not fully reflect the change in mortality rates expected going forward.
- Similarly, if a cure for a particular medical condition – e.g. a particular cancer – is found just before the maturity of the NBS longevity swap then this won’t have been recognised in the actual mortality rates, and hence the maturity payment won’t reflect the perhaps marked change in mortality rates expected going forward. So the NBS longevity swap may offer little protection against medical advancements that occur during the ten year term.
- Further, the maturity payment on the NBS longevity swap is based on Solvania population data rather than SLAS’s annuity book, thereby introducing basis risk.
- This may be particularly pertinent where the NBS longevity swap is to cover the longevity risk associated with the defined benefit pension scheme, as the mortality experience of the members is likely to be very different to that of Solvania’s population at large.

- The basis risk will reduce the credit that should be taken for any capital reduction relative to a similar transaction that references SLAS’s annuity book.
 - Unlike standard longevity swaps there is no collateralisation. The lack of collateralisation of the NBS longevity swap will result in SLAS being exposed to counterparty risk in the event that the NBS longevity swap becomes in-the-money at some future time. Where this occurs early on in the contract the counterparty risk may persist for a long period of time.
 - Due to the one sidedness of the protection (and the basis risk) the calculation of the value of the NBS longevity swap will be more complicated and most likely require stochastic modelling.
 - There may also be complications with regards to the accounting and tax treatment of the NBS longevity swap.
 - There may also be complications with regards to the regulatory treatment of the swap, depending on the regulatory credit available for capital markets transactions compared to traditional reinsurance.
 - Even population mortality is susceptible to period volatility – hence the “point to point” nature of the swap structure will reflect any volatility. This risk could be mitigated by averaging at the start and end.
- (v) SLAS may decide to transfer longevity risk to the capital markets rather than to a reinsurer because:
- Reinsurers may have limited capacity or may be reluctant to take on longevity risk at a competitive price.
 - Capital market investors are looking for returns uncorrelated with those from the other asset classes they have invested in and hence are willing to accept the longevity risk at a competitive price relative to the reinsurers.
 - There may be a wider range of capital market investors looking for opportunities like this.
 - Long-dated exposures to reinsurers create significant counterparty risk.
 - SLAS may already have significant exposure to those reinsurers willing to accept longevity risk due to the reinsurance of its term assurance business, so it may not be willing to accept further exposure to those counterparties.
 - SLAS may find it faster to transact with the capital markets using NBS’s generic terms and contracts for the NBS longevity swap.

- The out-of-the-money capital market transactions may be more efficient at improving the surplus assets on the SLAS’s risk-based balance sheet (although this may be at the expense of genuine risk transfer as above).
- There may be tax advantages.

Part (i) – Straight-forward bookwork.

Part (ii) – Other valid points include:

- transferring the annuity portfolio to another insurer.
- offering enhanced transfer values to deferred members of the pension scheme.
- other suitable changes to benefit design, e.g. change from final salary to career average.

Part (iii) – The phrase “profit profile” was not well understood. It means the change in total profit over varying mortality rates. Also, many candidates did not sketch or draw a picture to illustrate the profit profile.

It does not matter whether the profit is on the x-axis or the y-axis.

Part (iv) – Many candidates found this question difficult. It seems that they didn’t fully understand how the swap worked. The complete answer included advantages and disadvantages for SLAS, NBS, the capital market counterparties and the structuring and pricing of the swap.

Part (v) – The question was handled well by most.

5 (i) The Gumbel generator for each of the reinsurance treaties is:

Reinsurance treaty	${}_{Gu}\Psi_{\alpha}(F(x)) = (-\ln F(x))^{\alpha}$
Cornwall Insurance	$-(\ln(0.995))^{2.5} = 0.000002$
Devon Insurance	$-(\ln(0.985))^{2.5} = 0.000028$
Somerset Insurance	$-(\ln(0.975))^{2.5} = 0.000102$
Dorset Insurance	$-(\ln(0.965))^{2.5} = 0.000240$

These can then be combined to give the joint probability of no losses by calculating:

$$\begin{aligned}
 & {}_{Gu}C_{\alpha}(F(a), F(b), F(c), F(d)) \\
 &= \exp[-\{(-\ln F(a))^{\alpha} + (-\ln F(b))^{\alpha} + (-\ln F(c))^{\alpha} + (-\ln F(d))^{\alpha}\}^{(1/\alpha)}] \\
 &= \exp[-((0.000002 + 0.000028 + 0.000102 + 0.000240)^{0.4})] \\
 &= 95.8\% > 95\%
 \end{aligned}$$

(ii) Southwest Re should hold capital.

Reasons include:

- Economic or not, the regulator will require Southwest Re to hold capital in respect of the risks written. There may even be a minimum amount of capital that has to be held whilst the book grows.
- There will be model risk associated with the capital assessment. For example, it is not clear why a Gumbel copula is appropriate for these risks.
- There will be calibration risk associated with the assumptions employed in the model. For example, it is not clear why the parameter α was set to 2.5.
- Setting the parameter α to 1 yields the independence copula. Alternatively, as α tends to ∞ , it tends to the minimum copula (i.e. co-monotonicity). Assigning a larger value to α would be appropriate where the risks that drive each of the four insurers to claim are similar.
- The probability of no loss is 95.8% which is very close to the 95th percentile, magnifying the risk associated with the selection of the model and calibration. Sensitivity analysis utilising differing models and parameters would be useful to understand the variability of the results.
- Another tool to use includes scenario testing. A range of extreme scenarios could be developed and investigated to understand the impact on the four insurance companies and the knock on impact on their likelihood of claiming and the size of any potential claim.
- Other risks are not covered by the analysis including operational risk, expense risk and market/credit risk. Capital may need to be held to cover these risks.
- The economic capital has been determined using a Value at Risk approach calibrated to the 95th percentile loss over one year. The use of a Tail VaR approach and/or a higher percentile loss would appear more appropriate for this type of business.

Part (i) – Approximately one-half of the candidates were able to complete the calculation.

Part (ii) – Most candidates’ answers included reference to the calculations in part (i) but a large number of candidates did not include general ERM reasons for holding reserves in their answer.

Extra valid points include:

- *It is more important to hold capital if the technical provisions are either weak or at best estimate levels.*

- *The company's risk appetite should always be taken into account when considering required capital.*

6 (i) Many large stock exchanges will automatically cease all trading if prices move by more than a prescribed amount during a brief prescribed time frame. The intention is to allow participants to assess the new information and restart trading in a calmer frame of mind.

Derivatives transaction exchanges will generally use a clearing house to hold margin calls.

Governments support the system with cash loans.

Governments have used IOUs.

Governments have resorted to printing money and to quantitative easing.

Governments have allowed companies not to mark to market so that illiquid assets' volatile values do not overly influence company results.

Capital requirements for all market participants designed to cover periods of illiquidity.

(ii) A crystallised liquidity risk is not having sufficient cash to meet ones' obligations and perhaps wants. Its short term consequences might be cost and inconvenience as well as reputational damage.

Its longer term consequences can include bankruptcy.

The consequences of a systemic liquidity risk crystallising due to contagion will likely include higher interest rates, impaired capital markets, credit downgrades, reduced economic growth, reduced bank lending, increased personal bankruptcies.

(iii) Loss of confidence in the trading system.

New information that flows into the system, for example the failure of a major player, may precipitate the loss of confidence, but it is not likely to be the cause; the cause often being the larger economic circumstances that led to the failure of the market participant in the first place. The trading system relies on parties making many trades and when one party has lost confidence in other parties meeting their obligations they will stop trading with those parties and they may delay payments that they otherwise owe.

Part (i) – Most candidates were not able to satisfactorily answer this question. It might be due to the fact that there are several alternative definitions of liquidity risk. It can refer to the risk of money markets not being able to supply funding to businesses when required, or more broadly to the management of short term cashflow requirements. Alternatively it

may refer to an insufficient capacity in the market to handle asset transactions at the time when the deal is required (without a material impact on price).

Liquidity risk is an important risk and arguably fear associated with illiquidity started the 2008 credit crisis.

The question can also be answered from the institution's viewpoint.

Part (ii) – This question was handled reasonably well by most. As ever, marks were awarded for other valid points.

Part (iii) – Approximately one-half of the candidates' answers included a major event and the resulting loss of confidence in the trading system.

7 (i) I've put together a high yield bond portfolio for your consideration.

Since they are all large uncomplicated issues and widely traded on a major exchange, the yield pick up over risk-free should be related to the credit risk.

I've assumed the total investment is spread equally between the four bonds at current prices.

I've estimated the probability of default based on benchmark statistics produced internally by my firm and I have assumed that there are no recoveries in the event of a default. This seems likely as the high coupon structure usually reflects a bond with relatively little security.

I have assumed that the bond's are independent from one another regarding their likelihood of default.

A typical one year AA bond is currently trading at a yield to redemption of 2% and has a 0.2% probability of default. In the event of a default on the AA bond, the bondholder would expect to recover some monies. If it were 50% then this would compare roughly with the bond portfolio which has a 0.2% chance of the two riskiest bonds defaulting. Obviously two of the other bonds could default, and the probability of that would be smaller, so I felt that calculating the probability of the two riskiest bonds defaulting would suffice.

Investing in the AA bond would result in a 2% return with near certainty. Investing in the bond portfolio will result in a 10.5% return 85% of the time. In the vast majority of the remaining 15% of the time your return would be around minus 17%.

In summary, the market is offering an 8.5% credit spread over an AA rated bond where the main risk is the small but significant risk of loss of circa 17% of the capital.

(ii) The first set of calculations assumes that the bond's default dependency structure is described by a Frank copula with $\alpha = 8$.

The second set of calculations assumes that the bond defaults are linked by Poisson processes, often referred to as a common shock Poisson model.

- (iii) The first calculation set that was originally presented to the client suggested that the probability of the two riskiest bonds defaulting was 0.2%. The new calculations assume that the likelihood of default is dependent in some way.

They estimate the probability of the two riskiest bonds defaulting to be 1.18% and 0.76% (for any two bonds defaulting). The new calculations estimate the probability of default of these bonds to be approximately 5 times greater than the original calculations.

The Frank copula result is based on an alpha assumption which is not validated. Further the choice of copula is not validated.

The lambda parameters in the common shock Poisson model are not validated, as is the common shock Poisson model itself.

Given estimation uncertainty it is reasonable to conclude that the probability of two bonds exactly defaulting is approximately 1% and the probability of all bonds defaulting is approximately 0.06%.

- (iv) The main points made in the earlier conversation remain unchanged. However following some additional calculations, there is more uncertainty as to what is the best estimate of the default probability of two bonds. It is now possible that the probability of losing circa 50% of the portfolio investment could be in the order of 1% and not 0.2%. Further it is possible that the probability of losing the entire investment is approximately 0.06%. The average implied rating of the bond portfolio is therefore lower than AA.

Part (i) – This question challenged many candidates. Most candidates made some valid points. Marks were given for other valid points including that increasing the number of bonds in the portfolio would likely reduce the loss given a single default.

Part (ii) – This question was handled well by most. The poisson process can also be referred to as an extrapolation transition.

Part (iii) – This question was handled well by many.

Part (iv) – This question was handled well by many.

END OF EXAMINERS' REPORT

INSTITUTE AND FACULTY OF ACTUARIES



EXAMINATION

1 October 2013 (am)

Subject ST9 – Enterprise Risk Management

Time allowed: Three hours

INSTRUCTIONS TO THE CANDIDATE

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all nine questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

AT THE END OF THE EXAMINATION

Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.

In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.

- 1** Compare the data typically used for modelling credit risk with that for modelling operational risk. [7]
- 2** Over the last few years the price of aviation fuel has generally been increasing, as has the volatility of the price of aviation fuel. In response, Snooze Air plc negotiated the purchase of forward contracts from an investment bank relating to the company's forecasted usage of aviation fuel over the following 18 months. Shortly after completing the purchase the price of aviation fuel has started to fall in response to a sharp downturn in the global economy.
- An Executive Director of Snooze Air has suggested that the negotiations required to extract the company from the forward contracts would take too long and has instead suggested selling futures contracts to mitigate the risk that the price of aviation fuel falls further.
- Discuss the advantages and disadvantages of the Executive Director's suggested mitigation strategy. [4]
- 3** (i) Describe the various tools and techniques that can be used to identify risks. [5]
- ABC is an international charity funding medical research to develop cures for cancer and other terminal diseases. The charity has been set up so that all donations are paid into an endowment fund. This fund is invested to generate a real return that is in turn used to fund research grants.
- ABC has established a subsidiary management company, ABC ManCo, to administer the investments in the fund, to allocate the research grants and to meet all the other costs of running the charity. ABC ManCo earns its income by levying an annual management charge on the endowment fund.
- (ii) Discuss the extent to which this structure affects ABC's principal risk exposures. [4]
- The ABC endowment fund has been invested in a wide and diversified range of assets, including a prestigious commercial property portfolio. ABC ManCo currently leases its headquarters from a third party. As a number of the endowment fund properties are currently vacant, it has been suggested that it may be financially advantageous for ABC ManCo to move into one of these properties on a temporary basis.
- (iii) Discuss how this suggested arrangement could impact the risk profile of ABC. [4]
- (iv) Propose terms and conditions which could be included in the arrangement to help mitigate any additional risks for ABC. [2]
- [Total 15]

- 4 Island Life Insurance is a long-established composite (i.e. both life and general) insurance company which has grown organically and now has operations across the world.

Amongst its product portfolio is “coconut injury insurance”. This niche product is written on a short term (annually renewable) basis and provides a fixed lump sum payout to policyholders who have sustained an injury as a result of being hit by a falling coconut. In recent years the demand for this product has been steadily rising and Island Life is now the leading insurer in this market.

Part of Island Life’s competitive advantage with this product has been its ability to assess and price accurately the underlying risk. A sophisticated generalised linear model has been developed to estimate the likelihood of an injury occurring, taking into account a number of factors including the number of coconut trees in an area, population density and weather patterns.

As Island Life is headquartered in Europe, it will be subject to the Solvency II regulatory regime.

- (i) Assess the suitability of the Solvency II standard formula approach for the coconut insurance product. [5]

To maintain its competitive advantage, the Board of Island Life would like to minimise the capital requirements which must be met. It is therefore proposing to apply for internal model approval.

- (ii) Describe the six tests which an internal model must meet under Solvency II. [6]

To build on its dominance in this market, the Board is currently considering a new variant of the product. Instead of paying a fixed lump sum, the benefit will be on a full indemnity basis.

- (iii) Describe the additional risk modelling considerations for this new product variant. [5]

The Board would like to include this new product in its internal model application.

- (iv) Explain how this is likely to impact the ability of the insurer to meet the six tests. [3]

[Total 19]

- 5** Domestic Insurance is a life insurance company that sells a range of savings products, using domestic banks as the main distribution channel.

Although its assets are invested in a diversified portfolio across many classes, about 30% of the portfolio comprises government bonds. Of this, over two-thirds is in debt issued by the local government.

The Board has suggested that, for risk management purposes, the exposure of Domestic Insurance to sovereign default risk should be measured and monitored.

- (i) Outline the metrics and approaches which could be used to measure and monitor the sovereign default risk exposure of Domestic Insurance. [4]
 - (ii) Contrast the likely impact on Domestic Insurance of a potential default of either the local or foreign government bonds. [3]
- [Total 7]

- 6** (i) Define the terms economic capital and economic value. [2]

Company X is a life insurance company which uses an economic approach to support its enterprise risk management framework. Under this framework it defines economic profit as the change in economic value over the period.

- (ii) Comment on the use of economic profit as a key performance indicator. [4]

At the end of each year Company X carries out an analysis of the change in the economic value over the year. Under this process, each source of profit or loss is compared with the amount expected and allocated to a high level risk category (e.g. market, insurance, operational etc.).

- (iii) Discuss the advantages and disadvantages of presenting the economic profit in this way. [4]
- [Total 10]

- 7 (i) Define the term model risk. [1]

Quantitative Logistics is an international parcel delivery business with a heavy reliance on technology. As a start-up, the competitive advantage of the company lay in its sophisticated quantitative model which allowed it to develop delivery routes which were quicker and more cost effective than those of established firms in the industry. Today, the company is a market leader in the industry with operations across the world.

The model works by describing the journey each parcel takes. Every parcel entrusted to the firm has to go through five different “states”. These are the receiving depot, the receiving distribution centre, the delivery distribution centre, the delivery depot and the end user. Each transition or journey between these “states” is then explicitly modelled taking into account the other parcels in the system, the transportation options available, the incremental cost of each option, the journey time agreed with the sender and the likely time each option will take. These are then aggregated using a copula approach. The model is run stochastically and a large number of simulations are considered in order to evaluate the optimal path for the delivery of the parcel.

In recognition of the importance of the model to the business, Quantitative Logistics has set up a Model Governance Committee which will have responsibility for the management and mitigation of model risk.

- (ii) Describe the experience and expertise which the Committee as a whole should possess. [3]

- (iii) Outline the activities that the Model Governance Committee should oversee. [4]

- (iv) Discuss the role of the Internal Audit function in relation to the model. [2]

To help add flexibility and aid decision-making, a “short form” of the model has been proposed. This “short form” model will analyse the simulations from the full model using a form of regression analysis to describe each transition as a linear function of cost and time.

- (v) Discuss the possible advantages and disadvantages of the proposed “short form” model. [5]

The Board of Quantitative Logistics is proposing to use “reputation at risk” as a new measure in its risk appetite statement. Under this measure, the company’s delivery times will be compared to those of its competitors. Whenever a competitor’s overall delivery time is shorter, Quantitative Logistics’ “reputation at risk” measure increases, with the increase being proportional to the delivery time difference.

- (vi) Describe how the existing model could be developed in order to carry out a “reputation at risk” assessment for each parcel. [5]

[Total 20]

- 8** An investment company is analysing the likelihood of two corporate bonds defaulting and is trying to decide which copula to use to model their dependence structure.

Bond A has a probability of default in the following year of 0.05.

Bond B has a probability of default in the following year of 0.15.

You are given the following generator functions:

$$\text{Gumbel copula } G_u\Psi_\alpha(F(x)) = [-\ln(F(x))]^\alpha$$

$$\text{Clayton copula } C_l\Psi_\alpha(F(x)) = 1/\alpha \cdot [(F(x))^{-\alpha} - 1]$$

- (i) Calculate the probability of both bonds defaulting in the following year using:

(a) a Gumbel copula with parameter $\alpha = 2$

(b) a Clayton copula with parameter $\alpha = 2$

[4]

- (ii) Explain which copula would be more appropriate.

[2]

[Total 6]

- 9** A major heavy goods repair company has contracts with a number of suppliers on which it relies for the timely supply of quality parts at agreed prices. The chief buyer for the repair company has asked the group risk function if it can recommend changes to these contracts that will impose some aspects of ERM onto the suppliers, in order to improve and de-risk the supply chain. The changes have to be practical, proportionate and reflect the fact that the suppliers are unrelated third parties.

- (i) Suggest terms and conditions that should be included in the supply contracts.

[5]

Some input goods are very large, very expensive, take many weeks to manufacture and, whilst only needed rarely, are then needed very quickly.

- (ii) Outline the risks and costs that the company must consider when purchasing such goods.

[4]

- (iii) Describe ways in which the company could transfer or mitigate these risks and costs.

[3]

[Total 12]

END OF PAPER

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

September 2013 examinations

Subject ST9 – Enterprise Risk Management

Introduction

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and using past papers as a revision aid and also those who have previously failed the subject.

The Examiners are charged by Council with examining the published syllabus. The Examiners have access to the Core Reading, which is designed to interpret the syllabus, and will generally base questions around it but are not required to examine the content of Core Reading specifically or exclusively.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report; other valid approaches are given appropriate credit. For essay-style questions, particularly the open-ended questions in the later subjects, the report may contain more points than the Examiners will expect from a solution that scores full marks.

The report is written based on the legislative and regulatory context pertaining to the date that the examination was set. Candidates should take into account the possibility that circumstances may have changed if using these reports for revision.

D C Bowie
Chairman of the Board of Examiners

January 2014

General comments on Subject ST9

The ST9 exam generally requires bullet point form or short form essay style answers that apply general principles to directly address specific circumstances. The answers given below are just one possible set of acceptable answers. Candidates are awarded marks for all reasonable answers including different but still reasonable numerical solutions. Marks are awarded for working in the case of numerical answers.

Candidates' answers are made up of a series of points. For example, a point can be stating a valid type of risk, describing the type of risk or (part of) a calculation. Some points are more fundamental to the correct answer but, in the main, candidates earn one-half mark per correct point up to the limit of marks available for the question.

Comments on the September 2013 paper

The paper had a balance of bookwork and mini case study style questions. Some of the questions were loosely based on actual events. Examples include the risks associated with life insurance products and logistics. Practical examples of ERM are extremely common place in the press. Candidates should find that regular reading of financial press will prove to be very helpful to their understanding of the issues and concepts contained in the core reading.

Well-prepared candidates scored acceptably well across the whole paper. The comments that follow the questions concentrate on areas where candidates could have improved their performance.

1 For both types of risk, data are needed for both severity and frequency.

There are different types of credit risks. The main distinction is between government, companies and individuals.

For credit risk, frequency refers to the probability of default and severity to the expected level of recovery which can be made (or the expected loss) given default.

There are a variety of sources of data on the levels of credit risk.

And these are more likely to be subject to greater scrutiny or review than operational risk data, therefore more likely to be robust.

And similarly are more likely to be up-to-date.

For example credit agencies may provide information on the level of financial soundness of a counterparty (and ratings can be a condition of some stock market listings).

If the company is listed it will have a market price which will give some information on the likelihood of default.

Spreads on corporate bonds and credit default swap spreads can also give some insight.

Operational risks are more likely to be heterogeneous than credit risk events and so it may be necessary to do more detailed analysis of data splits.

Information on operational risks from errors in internal processes will be generally available.

However there is a risk that some data will not be available as staff may not record near misses which may affect their remuneration.

There will also be operational risks that do not happen often, but which are severe enough to bring down a company if they transpire, e.g. a large one-off fraud.

The data for such risks will be very scanty.

External operational risk data may be more credible, but is unlikely to be relevant to the specific company.

Particularly reflecting its actual operating processes, business mix, size and environment and the governance, controls and other mitigation actions which have been implemented.

It is more important for operational risk data than for credit risk data to take into account the specifics of the company.

Expert judgement is more likely to be required for operational risk data.

Experts may also be needed to construct worst case scenario examples for analysis.

However, credit risk is likely to be more influenced by external events (e.g. general state of the economy) and so therefore it may be necessary to adjust historic credit risk data to reflect aspects such as the economic cycle and also to adjust appropriately for significant contagion events (to which credit risk events are likely to be more prone).

The question was handled well by most.

As ever, additional marks were given for other valid answers including:

- *operational risk data is more sparse.*
- *operational risk data is more qualitative.*
- *operational risk data is often the result of relatively unique circumstances and difficult to categorise by risk factor*
- *credit risk data is widely available from many sources, much more quantitative and able to be grouped for analysis*

2 Selling futures contracts would provide a quick way of mitigating Snooze Air plc's exposure to falling aviation fuel prices.

Futures contracts are transacted through exchanges, which improves the liquidity and also removes the counterparty risk between Snooze Air plc and the ultimate purchaser.

However, there are two important issues with the mitigation strategy:

Forward contracts are not generally subject to margin requirements, whereas futures contracts are.

If this mitigation strategy was executed, the company would need to submit margin if the price of aviation fuel subsequently started to rise, potentially leading to liquidity issues.

In addition, the forward contracts and futures contracts may reference differing measures of the price of aviation fuel, exposing the company to basis risk.

There is a lesser issue that futures contracts are generally more standardised, and therefore Snooze Air plc would have less flexibility e.g. in delivery date.

This straight-forward question was handled well by most.

3 (i) Tools

- SWOT analysis: considers both the downsides and the positive implications of risk for future strategies, through the identification of strengths, weaknesses, opportunities and threats.
- Risk check lists or taxonomy: reference lists of possible risks, sourced from information obtained through experiences and from external documented knowledge.
- Risk prompt lists: higher level categories intended to prompt a more specific list, e.g. PEST (political, economic, social and technological) analysis.
- Risk trigger questions: lists of situations in particular areas of an organisation that can lead to risk, based on previous risk events.
- Case studies: “real world” examples can suggest specific current risks if clear similarities with own organisation, otherwise could suggest areas where similar risks might occur in future.
- Risk-focussed process analysis: construction of detailed flow charts for every process in the organisation and analysis of the points at which risks and failures can occur.

Techniques

- Brainstorming: unrestrained or unstructured discussion involving experts, led by an experienced facilitator in order to draw out a wide range of ideas in depth.
- Independent group analysis: all participants document their views on risks in silence and without collaboration, in order to avoid bias; these are aggregated by a facilitator and then discussed.
- Surveys: questions about different aspects of the area(s) being considered and related risks are distributed to a large number of staff.
- Gap analysis: a survey-based approach seeking to answer two questions: the desired level of a given risk and its actual level; the two questions would not necessarily be asked of the same people.
- Delphi technique: another type of survey with greater flexibility, whereby acknowledged experts are asked to comment on the risks anonymously and independently; the answers are then analysed in detail and follow-up surveys issued until consensus is reached.
- Interviews: these are carried out with specific individuals, with clarification being sought immediately on any unclear answers.
- Working groups: once a risk has been identified, small groups of experts familiar with the risk can analyse and discuss it further.

This straight-forward question was handled well by most.

(ii) ABC's risk exposures are principally:

- Market risk: This is the risk that the investments in the ABC endowment fund underperform or are subject to losses in market value. The structure in itself does not particularly enhance or detract from the management of

market risk. However it could be argued that it creates conditions conducive to good market risk management by increasing the transparency of the fund.

- Reputational risk: There may be additional reputational risk of the structure being perceived as “hiding” the way in which costs are met. There may also be potential reputational risk to the charity if ABC ManCo is not well managed.
- Expense risk: All of the operational costs and therefore the expense risk are now met by ABC ManCo. These are funded from a single source of income – the management fee on the fund. Cost control and managing the sources of expense risk will be important. The form of the management fee is also important. If it is a percentage of funds under management then it should increase in real terms and help to mitigate inflation risk, but there is additional market risk. If it is fixed in monetary terms then there will not be any inflation hedge.
- Operational risk (*could also be described as counterparty risk or agency risk*): As all of the operations of the fund are administered by ABC ManCo, all of the sources of operational risk are within the management company. However, in the event of a significant operational failure of ABC ManCo it is likely that funds from the endowment would be needed to cover these costs. This creates a potential misalignment of incentives (agency risk) or even moral hazard.

This question was handled well by most. Marks were awarded for legal risk providing that the discussion was pertinent.

(iii) **Reputational risk**

The key impacts are likely to be on reputational risk exposure.

- Could create the impression that charity funds are being misused for the benefit of management
- Blurs the line created by the structure between administration and charity
- + Shows thrift – could be portrayed as a cost-saving step, particularly if temporary
- + May allow ABC ManCo to be located in better areas than otherwise, which could allow for better networking

Market risk

- If rent is set to be below market levels then there is an opportunity cost and risk that investment returns are lower than they would otherwise have been
- + although this should be weighed against the costs of holding a vacant property and the nil rental currently being received so also need to consider the likelihood of the commercial rental market picking up again and new tenants being found in the short term

Expense and operational risk

- the rental level could be higher than ABC ManCo would have expected to pay (due to the “prestigious” nature of the vacant property) and this could put pressure on it to cut other costs, which could increase the exposure to operational risk
- If the intention is that ABC ManCo will occupy the property until it can be let on the open market then ABC ManCo is likely to be looking for new premises at the same time as the commercial property market picks up, thus the strategy may be costlier in the long term
- The move itself is not without risk and so moving with the view to moving again in the near future increases the related operational risks.

Many candidates found this question to be a little more difficult. Many answers noted market risk only. As ever marks were given for other valid points including:

- *Increased concentration risk. If the building were to be destroyed then both the charity and the service company would suffer.*
- *Reduced risk of vandalism as the unoccupied building is now occupied.*

- (iv) The lease should be on a short term, renewable basis to allow ABC ManCo to leave when it makes economic sense for the group.

There could be some adjustment to the management fee as a result of the tenancy.

The rent should be at rates which are attractive to both ABC ManCo and to the endowment fund, taking into account all other factors (e.g. at or slightly below market rates).

The contracts and approval process should follow the same process that is used for third party tenants.

Candidates who scored well on part (iii) also scored well on part (iv).

- 4 (i) The standard formula is calibrated to the capital requirements of the “average” insurer in the industry.

It uses a standardised approach to assess the capital requirements in respect of the following risk categories:

- Underwriting risk: The coconut injury product is very unusual. It is highly unlikely that an average approach such as the standard formula will accurately reflect the risk exposures of this product.
- Market risk: Island Life is likely to back its liabilities with a portfolio of short term fixed interest securities. This is a typical investment approach for short term insurance products and so it would appear that the average approach prescribed by the standard formula is appropriate. [However, it may be that some of the local markets in which Island Life operates are not particularly well developed and as a result a more bespoke examination of the market risk is warranted.]
- Counterparty default risk: The suitability of the counterparty default risk module will be similar to the underwriting risk module assessment (reinsurance assets) or the market risk module (all other assets) assessment.
- Operational risk: By definition, under the standard formula operational risk capital is assessed using a formulaic approach. This inevitably means that the standard formula therefore does not capture any firm’s operational risk exposures accurately.

The coconut injury insurance product would seem a good candidate for an internal model under Solvency II (i.e. the standard formula is unlikely to be appropriate).

However, although Island Life is the market leader, this could be a relatively low volume product which does not comprise a significant proportion of Island Life’s overall portfolio. In which case, also allowing for any diversification with other products, it may be acceptable for the insurer to use a standard formula across the whole business.

Valid points made in the context of the question were given marks.

- (ii) To get internal model approval a model must pass the following tests:
- The “use” test: Firms must demonstrate that the model has not been developed solely for regulatory purposes but is widely used in the firm to support risk management, decision making, economic capital allocations and the solvency capital assessment.
 - Statistical quality standards: The assumptions used in the model should be realistic and based on accurate, appropriate and up-to-date information.

- Calibration standards: This is to ensure that the output of the model reflects the 99.5% (over one year) level of confidence required to set the SCR.
- Profit and loss attribution: The causes and sources of profit and loss for each major business unit need to be analysed at least annually.
- Validation standards: These prescribe the criteria for continual review, monitoring and improvement of the internal model.
- Documentation standards: These set the minimum documentation requirements for the model. Documentation needs to go beyond methodology and audit trail, also recording the theory, assumptions and reasoning behind the model.

This straight forward question was well handled by most.

- (iii) Island Life's current model only covers the frequency of an injury occurring; because of the fixed nature of the payment it does not model the severity of the injury.

To provide full indemnity cover the model will need to be extended to model severity as well.

It will also be necessary to collect any available data on the severity of falling coconut related injuries.

It is unlikely that Island Life has been collecting this information to date given the nature of its product, but there may be a limited amount of information already available.

External sources of data should also be investigated: for example hospitals and universities may have information available.

It may be necessary to use data from similar types of injuries as a proxy.

The availability of relevant research should be investigated.

The insurer needs to consider the extent to which the factors underlying frequency (e.g. number of coconut trees in an area, population density and weather patterns) also impact severity, or whether any additional risk factors are required.

To model severity the company could use a parametric or non-parametric approach.

Given that there is likely to be limited data available initially, a simple approach is likely to be preferable. Such as using an empirical approach rather than fitting a distribution.

The output from the severity and frequency models needs to be combined in some way.

This is likely to require some form of correlation assumption.

The indemnity payment could result in payments being made over a long period of time including hospital and other care costs so claims inflation will need to be considered.

Indemnity payments also increase the risk of the company paying out for things that it didn’t expect to cover and hence didn’t include in the pricing.

For example, pain and suffering, hair replacement, plastic surgery, lost wages.

It may be difficult to formulate an analytical / closed form representation of the loss model.

In this case a Monte Carlo simulation would be the best way to produce the full loss distribution.

Well handled by many. Other points include:

- *the volume which will be sold is another unknown*
- *and similarly the mix of business (e.g. by risk factor) might differ from the existing product*
- *the use of a copula (for modelling dependencies between frequency and severity)*
- *setting up different types of risk management activities for this product variant (e.g. may set up preferred hospital provider agreements to limit costs), which need to be allowed for in the modelling*
- *there will be new/different operational risks to model, e.g. because claims management will need to be more complex and because it is a new type of product*

- (iv) The company will probably have a limited amount of severity data, which will make meeting the statistical quality criterion considerably harder...

And similarly for the calibration standards criterion – particularly since it is even less likely that there is credible data on extreme events.

In addition the company has no track record of “using” the model as this is a new product – so difficult to evidence for the “use test”.

The company can argue it passes the use test as it used it to develop pricing and it is imbedded going forward and it is a new product.

Similarly the model and product being new makes the profit and loss attribution process more difficult.

Validation should still be achievable, as part of the new model development process, but may be more difficult due to lack of past results against which to backtest.

Although the model is now more complex, the documentation standard should still be achievable.

Overall it therefore may be appropriate to use the standard formula for regulatory purposes at first while the model is fully developed and run in parallel for internal management purposes only.

Most candidates mentioned the paucity of data and the difficulty of passing the use test for new products.

- 5 (i) The range of metrics and approaches include:
- Simple measures such as the amount (by market value or nominal amount) split by each issuing government
 - The difference between the company's solvency ratio as it stands and after applying an adjustment (e.g. a haircut to the market value) for sovereign default risk.
 - The Value at Risk or Tail Value at Risk on the asset portfolio for sovereign default.
 - The Value at Risk or Tail Value at Risk on the overall net asset-liability (solvency) position for sovereign default (which takes into account the fact that much of the risk may be passed to policyholders).
 - Measures of the likely probabilities of default.
 - For example a comparison of government bond yields or credit default swap prices.
 - Estimates of the loss on the bonds should default occur.

The question was well handled by most. The above points are largely metrics. Any reasonable approaches were also given marks including:

- *stress testing, scenarios*
 - *monitor the various government's credit ratings and*
 - *try to estimate the potential contagion between them*
- (ii) Default (or the perception that default is likely) of the local government may lead to a run on local banks with associated adverse implications for liquidity and for Domestic Insurance's ability to sell new business, given its distribution channel.

Domestic Insurance holds a higher proportion of local government bonds and so the direct financial impact of a domestic default would be greater than for a foreign default.

This is particularly the case if the latter portfolio is spread over several different issuing governments although there may be contagion effects.

However, it is often the case that governments default on foreign held bonds before defaulting on locally held bonds. For example, the government could cease to make international payments. This increases the risk of the foreign bonds relative to the local government bonds.

This question was well handled by most.

- 6** (i) An organisation’s economic capital is an assessment of the capital required to cover its risks. It is the amount of capital that an organisation requires to cover its liabilities and obligations (or to remain solvent) under adverse outcomes, with a given degree of confidence and over a given time horizon.

Economic value is the present value of all future shareholder profits, determined on a realistic economic basis.

This question was well handled by most.

- (ii) The formula for calculating economic profit is relatively clear and straightforward therefore should be an objective measure that is not particularly susceptible to manipulation.

There may however still be some element of discretion required (and therefore potential for manipulation) if the economic value calculation requires subjective assumptions to be set relating to future experience.

It is a risk-based measure of profit.

It should therefore link better to the true underlying profit of the business than the accounting profit.

However, the accounting profit remains important and economic profit will have to supplement this.

Economic profit links performance measurement to the risk framework.

It will be aligned with the risk appetite framework of the firm.

However it may be volatile, which could have issues in terms of stakeholder communication and buy-in.

It also may be difficult to compare with peer companies.

This question was not well handled. Most candidates did not appear to be familiar with the concept and uses of economic profit. Economic profit is a useful performance indicator and particularly for life insurance companies which write contracts for much longer periods than the 12 month accounting year.

- (iii) + Can provide valuable management information
 - + Could use as a way to link risk appetite and risk thresholds/limits directly
 - + Supports evaluation of the risk / return trade-offs in decision making
 - + Shows that risks can have upsides and downsides
 - The analysis of surplus (or the “expected” figures) on which it is based may be very subjective or contain a number of implicit assumptions which could distort the result or lead to the wrong interpretation
 - The measure may be very volatile
 - It can be difficult to allocate some effects to one particular risk category (or may depend on the order of analysis)
 - How to allow for diversification / correlations between risk drivers
 - A more detailed breakdown might be more useful to gain most benefit from the above advantages

Candidates who had difficulty with part (ii) also had difficulty here.

- 7** (i) Model risk is risk arising from the use of an inappropriate or inaccurate model when assessing or managing risks. It may result in incorrect or suboptimal decisions being made.

A straight-forward question.

- (ii) There should be members with strong technical skills to consider the model methodology.

At least one member of the Committee must have specific experience and detailed knowledge of this model.

But wider modelling exposure would also be useful to help benchmark and consider issues in a more general context.

At least one member should have operational experience of how the output from the model is used by workers on the front line and key decision makers.

There should also be representation of senior management responsibilities and risk management skills.

At least some of the members of the Committee should have formal (relevant) qualifications.

Committee members are not expected to do the work but some of them must have done it or managed it in the past in order to both understand it and check it for reasonableness.

This question was handled well by most.

- (iii) The Model Governance Committee would be tasked with establishing and monitoring:
- The control environment in which the model runs are carried out.
 - The control environment in which the model output is aggregated for reporting.
 - The control environment in which changes to the model are made.
 - The control environment / criteria for model testing.
 - The criteria for the quality of data inputs into the model (e.g. use of the risk register).
 - The criteria for the quality of any assumptions used in the model.
 - The quality of the communication of the outputs, including ensuring that the users fully understand any modelling limitations.
 - Feedback learning loops from any problem deliveries.
 - Training of users.
 - Model documentation.
 - Reporting requirements (to the Committee and to management).

This question was handled well by most. Other valid points include:

- *authorising different levels of access to the model*
- *processes for handling significant model changes in the future*

- (iv) Internal Audit will be independent of the Model Governance Committee.

They would in the normal course of their business be expected to check the general compliance with internal model procedures and use.

And highlight any perceived weaknesses in internal controls.

However, Internal Audit may lack the technical skill sets to consider the accuracy and appropriateness of the model so may need to utilise external experts.

This straight-forward question was handled well by most.

(v) Advantages:

- Quicker to run so can make decisions more rapidly
- And may be more cost-effective
- Possibly simpler to understand and explain
- Which facilitates the embedding of the model into the business
- Metrics produced are likely to be more intuitive – i.e. point estimates rather than distributions
- Produces a more tractable assessment, which could allow the model to link more directly to other types of analyses

Disadvantages:

- Increases the model risk exposure: new / second model and also risk of misalignment between the two models
- It may not be possible to find an appropriate simplified regression which will continue to give optimal or near optimal results
- If an approach is found, it may oversimplify the analyses which could lead to sub-optimal decisions being made which could have a detrimental impact on the company’s costs, reputation and business volumes.
- May not be appropriate for considering extreme events, i.e. worst case scenarios

This question was handled well by most. Other valid points include:

- *Disadvantage – time/cost/expertise required to set up and then maintain the regression model.*

(vi) Competitor benchmark times (separated into appropriate risk factors including location and distance) would need to be input into the model as an additional set of parameters.

Setting these parameters is likely to require external / industry data.

Expert judgement may also be needed to supplement this.

Although care should be taken that this does not make the process overly subjective.

The model code needs to be extended: for *each transition* the benchmark comparison time for each competitor will need to be recorded and then summed over each transition stage for the full delivery journey.

These competitor total time outcomes will then need to be compared to the company’s own modelled time outcome.

Where the delivery takes longer than a competitor’s benchmark, the difference should be recorded as the amount at risk.

Where the delivery takes longer than more than one competitors’ total benchmark, the amount at risk would be the maximum difference across all competitors.

Where the delivery is shorter than that of all competitor benchmarks, no contribution to the amount at risk is made.

The analysis of the model output also needs to be adapted.

The simulated distribution of the “reputation at risk” should be compiled from the results of the simulations.

Many candidates handled this question quite well and made the majority of the above points.

8 (i) (a) ${}_{Gu}\Psi_2(F(A)) = (-\ln(F(A)))^2 = -\ln(0.05)^2 = 8.974412$

and ${}_{Gu}\Psi_2(F(B)) = (-\ln(F(B)))^2 = -\ln(0.15)^2 = 3.599064$

Summing these and “taking the pseudo-inverse” we get

probability = $\exp[-(8.974423+3.599064)^{(1/2)}] = 0.028842$

OR, directly from using the bivariate version of the formula if remembered:

${}_{Gu}C_2(F(A), F(B)) = \exp[-\{(-\ln F(A))^2 + (-\ln F(B))^2\}^{(1/2)}] = \dots = 0.028842$

(b) By the same process:

${}_{Cl}\Psi_2(F(A)) = 1/2 \cdot [(F(A))^{-2} - 1] = 1/2 \cdot [0.05^{-2} - 1] = 199.50$

and ${}_{Cl}\Psi_2(F(B)) = 1/2 \cdot [(F(B))^{-2} - 1] = 1/2 \cdot [0.15^{-2} - 1] = 21.72222$

Summing these and “taking the pseudo-inverse” we get

probability = $[2 \cdot (199.5 + 21.7222) + 1]^{(-1/2)} = 0.047488$

OR, directly from using the bivariate version of the formula if remembered:

$${}_CIC_2(F(A), F(B)) = \max \{[(F(A))^{-2} + (F(B))^{-2} - 1]^{-(1/2)}, 0\} = \dots = 0.047488$$

A straight-forward question for well-prepared candidates. Many candidates scored full marks.

- (ii) If there are very poor general economic circumstances then the likelihood of both bonds defaulting is significantly increased. The Clayton copula has lower tail dependency and better deals with this situation, therefore would be preferred. This is illustrated in the higher probability of joint default as calculated in part (i).

Well handled by many. Other answers were accepted providing that adequate reasoning for the choice was given.

- 9** (i) The more onerous conditions need not be included in supply contracts which are not business critical to the company, e.g. where the parts are relatively quickly available from multiple suppliers at a similar price.

Information

- Supplier to provide the company with pre-agreed financial information at pre-agreed intervals.
- Supplier to continuously monitor key financial statistics and advise the company immediately of breaches.
- This could include typical debt style covenants such as debt to equity ratio, liquidity ratio.
- Supplier reports re issues (strikes, legal, machine maintenance etc.)

Penalties

Financial penalties to incentivise the supplier to identify, monitor and manage the risk of failure to meet the contract terms.

These can include:

- comprehensive product guarantees
- free expedited shipping as needed to meet deadlines
- monetary penalties for failing to supply goods on time

Supplier to provide trade credit terms to ensure that payment delays do not affect the timely supply of goods.

Contract to require supplier to maintain pre-agreed stock levels on business critical goods.

Contract to stipulate the process for returning goods including damaged and broken goods.

In particular, the policy for damaged and dead on arrival goods should require immediate expedited replacement at the supplier’s expense.

Even though the circumstances of the question were unusual many candidates handled the question well. Other valid points include:

- *requirement for minimum quality testing processes*
- *termination clauses, e.g. if quality standards not met*

- (ii) As these parts are needed very quickly but take a long time to manufacture, the company would likely choose to hold some in stock

There are therefore risks related to storage, including physical risks (loss of stock) e.g. through fire, water damage, theft

And risk of obsolescence

There would also remain a risk of needing more of these parts than are currently held

This could jeopardise its contracts with its customers

The parts appear to be complex and specialised, so there may be greater risk of defect

The following could impact on the company’s profit:

- storage costs
- costs of insuring stock
- the impact of the time value of money on stock held for long periods
- stock which has to be dumped due to obsolescence or damage
- loss of business

Many candidates handled the question well. Other valid points include:

- *liquidity risk (having sufficient liquidity to pay for the parts when needed)*
- *counterparty risk (completely failure of supplier) and*
- *unexpected price increases (due to the time delays)*

(iii)

- Specialist shared warehouses co-owned by supplier and a number of customers potentially wanting the same part. This shares the costs of keeping spare parts.
- Rental of goods pending repair. For example, it may be possible to rent certain types of heavy machinery whilst waiting for repairs.
- Differentiated pricing with own customers to reflect different service levels regarding parts that take time to manufacture. This passes some or all of the costs on to the end customers.
- Purchase of fire/theft etc. insurance for the stock storage risks (however although this reduces risk it increases costs).
- It may be possible to purchase insurance to meet end user customer penalties in the event that a part is not supplied on time and this is outside of the control of the company. This could mitigate costs but does not protect the company's reputation.
- In the near future it is likely 3d Laser printer technology could make certain parts on site.
- Could acquire a supply business in order to integrate and control the production process.

Again, this question was well handled by most.

END OF EXAMINERS' REPORT

INSTITUTE AND FACULTY OF ACTUARIES



EXAMINATION

24 April 2014 (pm)

Subject ST9 – Enterprise Risk Management

Time allowed: Three hours

INSTRUCTIONS TO THE CANDIDATE

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all four questions, beginning your answer to each question on a new page.*
6. *Candidates should show calculations where this is appropriate.*

Graph paper is required for this paper.

AT THE END OF THE EXAMINATION

Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.

In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.

1 Everyman Investments is an online stockbroker which has grown and established itself successfully in recent years. Part of its success is attributed to its dynamic founder and his small but flexible management team.

The company is currently preparing for an initial public offering of its shares, which will lead to the eventual retirement of its founder. Everyman Investments wants to convince investors that it has the structures in place to ensure continued growth after his departure.

(i) Describe the “key man” risks arising from the proposed retirement. [2]

(ii) Outline how these risks could be mitigated. [5]

[Total 7]

2 General Conglomerate (GC) is a large manufacturing company with operations across the world. As part of its benefits package, it provides all managerial grade employees with access to a company car. The cars are owned by GC Leasing, a group subsidiary, and leased to employees at preferential rates. GC Leasing in turn has set up a captive insurer, GC Insurance, to provide insurance to its fleet of motor cars. GC Insurance may purchase reinsurance to mitigate its exposure.

(i) Suggest financial management advantages of setting up a group captive insurer in this way. [2]

(ii) Describe the likely insurance risk profile of GC Insurance. [2]

GC Insurance is regulated as an insurance company. Its regulator is proposing to adopt new regulations, under which there will be no distinction between open market and captive insurers.

(iii) Comment on the appropriateness of this proposal. [2]

[Total 6]

3 In order for retail banks to be profitable, they will generally have to accept short term deposits and invest the proceeds in longer term and less liquid assets. In order to be as profitable as other companies in a competitive environment, they will seek to keep equity capital as low as possible. Furthermore, many governments in the world seek to protect retail deposits through a combination of legislation, regulation and compensation schemes.

(i) Describe the main risks that a retail bank will be carrying in its asset-liability management program. [6]

A loan to deposit ratio (LDR) is the ratio of a bank’s nominal loan book to its deposits.

A liquidity coverage ratio (LCR) is the ratio of a bank’s high quality liquid assets to its 30-day stressed net cash outflows. Stressed net cash outflows are substantially higher than normal net cash outflows.

A net stable funding ratio (NSFR) is the ratio of a bank's stable funding to its weighted long term assets. Stable funding includes equity, customer deposits and long term wholesale funding. Long term assets includes all loans with maturities longer than one year, a percentage of loans with less than one year to maturity and a percentage of government and corporate bonds.

Two banks operate with the following ratios:

	<i>Bank A</i>	<i>Bank B</i>
LDR	200%	90%
LCR	100%	85%
NSFR	60%	110%

(ii) Explain the risks that the banks are carrying given these ratios. [6]

Basel III will likely introduce a minimum LCR requirement of 100% and a minimum NSFR requirement of 100%.

(iii) Outline the steps that banks should undertake to optimise their funding mix, given these upcoming requirements. [3]

[Total 15]

4 Abe's Cola Company (ACC) was established by Abe and his friends in a small town in the USA in the 1970s. Abe and his friends' core values then and now are:

- To produce and serve tasty food and drink using 100% natural ingredients at a fair price.
- To care for the environment.
- To trade fairly with everyone.

ACC has been extremely successful over the years. It is now a large food and soft drinks company listed on a major exchange. It owns worldwide recognised brands. It manufactures and distributes food and drink and operates restaurants and small food stores across several different continents. The four main subsidiaries are:

- Brands, Franchising and Marketing.
- Drink Distribution.
- Confectionery and Food Snacks.
- Family Restaurants.

The main subsidiaries are operated on an arm's-length basis with separate employees. All of the consolidation of the businesses is carried out at the group level. The subsidiary Chief Executive Officers (CEOs) report in to Abe, who is the group Chairman, President and CEO. The only other group employees are the group Chief Financial Officer (CFO), the group Legal Counsel and the group Head of Mergers and Acquisitions. The group board comprises Abe, the three other group personnel and the four CEOs of the main subsidiaries.

Abe and his company are viewed quite fondly by both the shareholders and the lending banks. Abe is seen as being a passionate chef and environmentalist. The company is viewed as being his family company. As it has a long track record of consistent growth, profits and dividends, shareholders and banks are willing to accept the very secretive nature of the company and its unwillingness to provide detailed financial information in its accounts.

The tables below show:

- numbers extracted from the most recent consolidated balance sheet.
- the most recent annual revenues and costs for each subsidiary.

Abe's Cola Company
Consolidated Balance Sheet Extract
In \$ millions

Assets

Brands and secret ingredient	3,000
Property (mainly restaurants)	2,000
Plant and equipment	2,000
Trade debtors	400
Cash	100

Liabilities

Long term bank debt	2,000
Short term bank debt	3,000
Trade creditors	100
Shareholders' funds	2,400

Abe's Cola Company
Revenues and Costs by Subsidiary
In \$ millions

<i>Brands, Franchising and Marketing</i>		<i>Confectionery and Food Snacks</i>	
Annual Revenues	900	Annual Revenues	725
Annual Costs		Annual Costs	
Marketing expenses	250	Ingredients	300
Franchising administration	50	Packaging and distribution costs	100
Other sundry expenses (with receipts)	100	Production line annualised capital cost	150
Other sundry expenses (no receipts)	25	Other sundry expenses (with receipts)	50
Employees	25	Other sundry expenses (no receipts)	-
Annual Profit	450	Employees	25
		Annual Profit	100
<i>Drink Distribution</i>		<i>Family Restaurants</i>	
Annual Revenues	1,150	Annual Revenues	700
Annual Costs		Annual Costs	
Ingredients including the costs of bottles, cans and kegs	200	Ingredients	100
Packaging and distribution costs	250	Rent	100
Licensing	400	Kitchen and furniture annualised capital cost	100
Production line annualised capital cost	150	Other sundry expenses (with receipts)	100
Other sundry expenses (with receipts)	50	Other sundry expenses (no receipts)	-
Other sundry expenses (no receipts)	-	Employees	200
Employees	50	Annual Profit	100
Annual Profit	50		

- (i) Describe the key risks that ACC is carrying. [Your answer should include reference to both the narrative description of ACC and the numbers in the tables.] [13]
- (ii) Explain why ACC would be extremely interested in long range weather forecasts and the prediction of floods. [2]

ACC has established a small team of weather derivatives traders in its Brands, Franchising and Marketing Division. The team trades derivatives for the Drink Distribution subsidiary at its request. To help to motivate the team to trade at the best prices, the manager has allowed the team to build a book of speculative trades. The team reports the following statistics on a monthly basis to the manager:

- The total premiums paid on derivatives purchased and the total premiums received on derivatives sold.
- The total net sums received/paid on triggered derivatives.

The team receives a percentage of the net profit, being the premiums received plus the sums received less the premiums paid less the sums paid. The amount paid to the team at the end of each financial year increases as the net profit increases and cannot be less than zero.

The manager reports the net profit to the group CFO on a quarterly basis.

- (iii) Describe the risks that ACC is carrying as a result of these operating arrangements. [Your answer should **not** include the risks associated with trading in derivatives.] [4]
- (iv) Suggest ways in which these risks could be mitigated, transferred or removed. [3]

The team has collected the following information regarding flood levels in an area that provides water to one of the drink production companies:

<i>Flood Data in Consecutive Year Order</i>				<i>Flood Data sorted from High to Low</i>	
<i>Year</i>		<i>Year</i>			
1	42,000	31	22,600	230,000	59,200
2	102,000	32	8,860	203,000	58,600
3	118,000	33	20,300	185,000	55,700
4	81,000	34	58,600	185,000	54,800
5	128,000	35	85,400	152,000	54,400
6	230,000	36	19,200	140,000	46,400
7	16,300	37	185,000	135,000	45,600
8	140,000	38	8,080	128,000	42,400
9	31,000	39	152,000	122,000	42,400
10	75,400	40	84,200	118,000	42,000
11	16,400	41	110,000	113,000	36,700
12	16,800	42	108,000	110,000	36,400
13	122,000	43	24,900	108,000	34,500
14	81,400	44	60,100	102,000	31,000
15	42,400	45	54,400	102,000	28,200
16	80,400	46	45,600	94,000	24,900
17	28,200	47	36,700	92,100	23,400
18	65,900	48	16,800	92,000	22,600
19	23,400	49	46,400	85,400	22,400
20	62,300	50	92,100	84,200	20,300
21	36,400	51	59,200	83,100	19,200
22	22,400	52	113,000	81,400	16,800
23	42,400	53	54,800	81,000	16,800
24	64,300	54	13,000	80,400	16,400
25	55,700	55	203,000	80,100	16,300
26	94,000	56	83,100	75,400	14,000
27	185,000	57	102,000	65,900	13,000
28	14,000	58	34,500	64,300	11,600
29	80,100	59	135,000	62,300	8,860
30	11,600	60	92,000	60,100	8,080

- (v) (a) Outline two possible approaches to fitting a distribution to extreme values, using a different probability density function for each.
- (b) Plot these approaches for the flood level data on two probability density function charts, including for each a sketched fitted curve. [Hint: For one approach consider blocks of five years.]
- (c) Compare and contrast the two approaches.
- (d) State the circumstances under which the shape parameter of the two fitted probability density functions would be expected to be nearly the same.

[13]

- (vi) Discuss whether the team should use the flood data to price rainfall derivatives in the given area. [2]

- (vii) Discuss whether an extreme value approach should be used to measure and price the number of days in the summer with a temperature in excess of 80 degrees Fahrenheit (27 degrees Celsius) in a given area. [2]

At the end of each calendar quarter, Abe meets with his group Head of Mergers and Acquisitions to discuss business ideas that are in line with ACC's core values. At a recent meeting they discussed the following business ideas:

1. Country X has approximately 100 million people. The vast majority of the people live off the land (subsistence agriculture) and are extremely poor. The country has suffered under the rule of a harsh dictator for the past 25 years. The dictator has recently been overthrown and the fledgling government is encouraging foreign investors to invest in the country and in particular its natural resources, which include land suitable for farming cacao, coffee, maize, wheat and rice. It is suggested that ACC builds a drink distribution plant and a snack foods factory, and opens up a number of small kiosk-style restaurants in the main towns and cities.
2. Purchase a large health foods manufacturer based in the USA. Its main products are a wide range of food bars and vitamin drinks.
3. Purchase a number of micro-breweries with the aim of manufacturing some of their beers in bulk and marketing them through the soft drink distribution subsidiary.

- (viii) Compare and contrast the main risks that ACC would carry during the early years of implementing each business idea. [11]

- (ix) State with reasons which, if any, business ideas should be pursued by ACC. [3]

ACC does not currently operate any formal enterprise risk management (ERM) process or framework.

- (x) Recommend, with reasons, an appropriate ERM framework and governance structure for ACC. [16]

- (xi) Describe the changes that should be made to the recommended ERM framework if ACC decided to replace some of its bank debt with rated bonds listed on a major stock exchange. [3]

[Total 72]

END OF PAPER

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

April 2014 examinations

Subject ST9 – Enterprise Risk Management

Introduction

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and using past papers as a revision aid and also those who have previously failed the subject.

The Examiners are charged by Council with examining the published syllabus. The Examiners have access to the Core Reading, which is designed to interpret the syllabus, and will generally base questions around it but are not required to examine the content of Core Reading specifically or exclusively.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report; other valid approaches are given appropriate credit. For essay-style questions, particularly the open-ended questions in the later subjects, the report may contain more points than the Examiners will expect from a solution that scores full marks.

The report is written based on the legislative and regulatory context pertaining to the date that the examination was set. Candidates should take into account the possibility that circumstances may have changed if using these reports for revision.

D C Bowie
Chairman of the Board of Examiners

July 2014

General comments on Subject ST9

The ST9 exam generally requires bullet point form or short form essay style answers that apply general principles to directly address specific circumstances. The answers given below are just one possible set of acceptable answers. Candidates are awarded marks for all reasonable answers including different but still reasonable numerical solutions. Marks are awarded for working in the case of numerical answers.

Candidates' answers are made up of a series of points. For example, a point can be stating a valid type of risk, describing the type of risk or (part of) a calculation. Some points are more fundamental to the correct answer but, in the main, candidates earn one-half mark per correct point up to the limit of marks available for the question.

Comments on the April 2014 paper

At first glance the paper appears to be dominated by a single 78 mark question. In fact the question is made up of several different and distinct sub-questions based on a single situation or case study. The examiners felt that it would be quicker and easier for candidates to apply their knowledge to a single situation rather than the alternative of using a number of different situations to ask the same questions. Regardless of whether or not a paper is dominated by a single case study, the overall paper will always contain the targeted balance of bookwork and application and the range of content needed to reasonably cover the syllabus.

As is common practice, some of the questions were loosely based on actual events, for example, question 1 which was focussed on the positives and negatives of a single key individual running a company. Question 3 was based on recent Basel III developments. For these reasons, candidates are encouraged to read the financial press and to consider how current news items can be applied to the issues and concepts contained in the core reading.

Well-prepared candidates scored acceptably well across the whole paper. The comments that follow the questions concentrate on areas where candidates could have improved their performance.

1 (i) The risk that the loss of the founder will pose to the ability of that organisation to:

- continue to achieve its strategic objectives
- maintain its profitability
- keep its customers
- avoid an adverse share price impact
- and meet its obligations to customers.

This includes the loss of the founder’s intellectual capital and potential contagion risk from the loss of other members of the management team who might no longer remain loyal to the company.

(ii) Key man risk is not a risk that can be removed by transferring it to an insurer or another party. It has to be retained and the emphasis should therefore be on taking active steps towards reducing the risk exposure.

The main strategy should be a succession plan, which will set out the actions the firm is taking in this regard.

For example, it should cover:

- Early identification of the intended successor(s) and “job-sharing” towards the retirement date.
- Capturing the founder’s knowledge and ensuring that all processes in which they are involved are well documented.
- Training programs for other staff members.
- Communicating externally to clients and other stakeholders including moving other staff members into key relationship roles.
- Communicating internally to staff on the issue of succession in order to help set career paths.
- Recruitment activities, if necessary.
- An employment contract with the key man with a notice period and other conditions designed to give the company time to replace the key man.
- For example, keep him on in a non-executive role

There may be “golden handcuff” bonus arrangements with other important staff members, to avoid a contagion effect.

Part (i) – This part was handled well by most. Virtually all of the candidates made at least some of the above points.

Part (ii) – This part was handled well by most. As ever, additional marks were given for other valid answers including the introduction of a non-compete clause for the key man and other important staff members and also the possibility of purchasing key man insurance.

2 (i) Cheaper – may have lower overhead costs.

Access to wholesale insurance / reinsurance markets.

Increased purchasing power – buying in large volume rather than by company.

Possible tax advantages.

(ii) Insurance risks will be either property damage or liability:

Property damage: Large number of very small claims. Because of large number, the aggregate claims will be stable → low risk and thus can be retained.

Liability risk: Lower number of claims but can be very large. Therefore likely to be transferred to reinsurers via captive.

(iii) For:

- Ensures captive insurers are held to the same standards as open market insurers in terms of prudent management and governance.
- No opportunity for regulatory arbitrage.
- May be simpler for the regulator

Against:

- Does not recognise that captives generally take lower overall levels of risk than open market insurers.
- Can add to the overhead costs of running a captive insurer.

Part (i) – This part was handled well by most. As ever, additional marks were given for other valid answers including:

- *Cheaper – can retain risk and therefore avoid transferring profit to external insurance providers. Similarly it avoids cash swapping which means paying a premium with the almost certainty of having a large portion of it returned as claims.*
- *May give the group greater control e.g. over which risks (and how much) are retained.*

Part (ii) – This part was handled poorly by most. Many candidates did not appear to understand what insurance risk is and so they either didn't answer this part or answered a different part. Insurance risk refers to the risks that GC Insurance are insuring.

Part (iii) – This part was handled well by most. Many candidates scored near full marks.

- 3** (i) Credit risk – A bank's counterparty is unwilling or unable to make payments required under an agreement.

Interest rate risk – First, the risk of changes to the asset-liability value due to changes in interest rates i.e. the change in the net present value of assets less liabilities. Second, optionality risks which arise from products that have an option to take certain actions and are more likely to do so in a rising or falling interest rate environment, e.g. early redeemable loan assets.

Currency risk – A bank's net exposure to changes in foreign exchange rates. For example the bank might borrow in US dollars and report in US dollars, and may lend some monies in Euros without hedging the exposure.

Liquidity risk – The ease with which assets can be converted to cash. Liquidity risk generally increases as the average term of assets less the average term of deposits increases (this is called the liquidity gap). Liquidity is highly subject to systemic (contagion) risk as the willingness of banks to lend to each other in times of financial crisis is materially restricted.

- (ii) Bank B's LDR is 90% meaning that the bank is fully funded by customers' deposits. Customers' deposits are relatively long term in behaviour even though they may be short term contractually. Bank B is conservatively funded. With an LDR of 200%, Bank A is reliant on wholesale funding. Short term wholesale funding disappeared in the 2007-08 financial crisis causing banks reliant on wholesale funding to collapse, so Bank A is significantly more exposed to the risk of a future such event.

Bank A could withstand 30 days of stressed cash outflows by selling assets. Bank B could not. Bank B is carrying higher liquidity risk and is more exposed to certain types of extreme financial conditions.

Bank A is operating on a relatively mismatched basis as its NSFR is well below 100%, suggesting that its long term assets are not fully covered by its long term stable funding. Bank A needs to continue to rely on short term wholesale bank funding including inter-bank lending to support its assets or sell its assets. As such loans are often fixed rate, Bank A is likely to be relatively more exposed to interest rate risk, liquidity risk and extreme financial conditions. With a NSFR of 110%, Bank B's long term assets are covered by its stable funding base.

- (iii) The development of a comprehensive funding plan.

A review of current liabilities ordered by cost to the bank.

Determination of the cost of every type of funding and its characteristics over the past 5 years.

Determination of the expected cost and range of costs of every type of funding and its characteristics over the next 5 years.

Determination of the optimal funding mix based on stable/non-stable split, regulatory impact and value for money.

A target date to reach the optimal funding mix and a deposits plan to work to in reshaping the balance sheet.

Part (i) – This part was handled well by most. Whilst the above answer gives the three main risk types, additional marks were given for other valid answers including regulatory, operational and model risk.

Part (ii) – This part was handled well by most. Many candidates made at least one-half of the key points made above.

Part (iii) – Marks were given for a wide range of reasonable points. Many candidates scored poorly because they did not make a sufficient number of different reasonable points.

- 4** (i) There appears to be some significant agency risks. The shareholders and the lenders risk Abe behaving in a way that is detrimental to them. Abe appears to be a dominant CEO. He is running the company as he chooses with little oversight. He is chairman, CEO and president. There are no independent directors on the group board.

Operating risks associated with lack of controls and no apparent ERM. Corporate governance is likely to be very weak, at least at the group level. It may exist in the subsidiaries. Subsidiaries are operating independently.

Key man risk - Abe is approximately 60 years old. There does not appear to be an obvious successor, and his retirement is likely to lead to significant adverse implications for the ongoing viability and profitability of the business.

Operating risks associated with likely insufficient management information. The group operates on several continents and with many different products and businesses. The group function appears to be grossly insufficient.

Leverage – Too much leverage exposes the company to bankruptcy in a downturn. The long term bank debt is \$2bn and short term bank debt is \$3bn. This totals \$1bn more than the booked value of property and plant and machinery. The booked value could exceed the realisable value. It appears that the banks are lending without full security or are relying on the security of intangible assets (brands and secret ingredient).

Pre-tax profit totals \$700m. The interest charge on \$5bn could be \$250m or more than one-third of profits. Shareholders' funds total \$2.4bn meaning that the debt to equity ratio is 5/2.4 or more than 2. The company can afford its current debt levels although they appear high. But the company is at risk of financial difficulty in the near term if it is unable to replace the short term debt. A new lender may be uncomfortable lending without security on tangible assets.

Interest rate risk – The company also risks financial difficulty if it can only replace its short term debt with arrangements at much higher interest rates. If any of the debt arrangements are on floating rates, it is similarly exposed to the risk of increased interest rates.

Liquidity – The company has \$100m of cash. This is about 4 months’ of employee costs at the subsidiaries. Ingredients in the subsidiaries total \$600m. It appears that the company has virtually no working capital. This puts it in danger of needing to borrow more short term funds or failing to pay its creditors.

Credit risk – Trade debtors total \$400m. The risk of default loss is not small but should be manageable for a company with annual profits of the order of \$450m after interest payments.

Currency risk – There is a risk of adverse movements in exchange rates and the negative impacts on repatriated profits, given that the company operates across a wide range of continents.

Reputational risk – This is a major risk for the company. It is a brands business. The brands are valued at \$3bn on the balance sheet and could be worth much more (or less) than this.

Given that the brand prides itself on fair trade and care for the environment, the brand could be damaged by media exposure of unethical activities by one of its subsidiaries or a member of staff, even if not directly related to the company’s own activities.

Operating risk – Exposed to fraud, bribery and corruption due to apparently poor governance. The Brands division paid \$25m in expenses without receipts. It is possible that one or more employees is stealing from the company or bribing people with cash. An employee could leak the secret recipe.

Water quality – The drink division’s main ingredient is water. Water quality is the single biggest risk of the company. Brands division’s annual revenue total \$900m. Much of this will be from the drink distribution companies whether owned or franchised. The water quality risk is no doubt spread across several different factories and several different continents but a failure in water quality would shut down a plant and likely result in large losses.

Reputational risks – Product contamination. A failure in water quality, if not spotted, might result in products reaching the market which are contaminated. This would no doubt result in product recall and damage to brand value. Product contamination can occur for many reasons and may even be deliberate sabotage. The company needs to have quality control processes in place.

Legal risks – If there is any product contamination or other failure that is not caught in time, the company is exposed to the risk of litigation and the need to pay substantial compensation.

Weather risks – The drink division is likely to perform better in hotter weather. The other divisions may also have some exposure to weather.

Business risks – Market demand is the main business risk carried by the company. Competition is likely to be relatively strong in all of the company’s three trading subsidiaries and the actions of competitors (or a new competitor) into the market contribute to such risk.

There is also the risk of the brand going out of fashion with consumers. However, the company will be well used to this and will have well developed practices including marketing, promotions, product innovation and acquiring competitors.

Inflation risk – there is a risk of higher than expected input price inflation (e.g. ingredients, staff costs) if this cannot be matched by inflation of retail prices without damaging demand.

This part was very well handled by many. Marks were given for a wide range of reasonable points. Additional points included:

- *Physical risk, e.g. property fires, also leading to business interruption.*
- *Property value (market) risk, given that property comprises a high proportion of the balance sheet assets.*
- *Regulatory/compliance risk, e.g. the secretive nature of the company and lack of accounting information might be tolerated now, but this could change.*
- *The brand value is a big part of both the assets and the annual profit as the bottlers pay to bottle and sell the popular brand. Risk of overreliance on brand is like a reputational risk.*

(ii) Water is the largest ingredient for the drink distribution companies.

The quality of the water is of paramount importance to the drink’s taste and health.

Floods can contaminate a water supply.

Long range forecasts are useful for predicting disturbances to the water supply i.e. flood or drought.

Long range forecasts may also help predict periods of unusually hot or cold weather which can materially impact the amount of soft drinks consumed and which allows them to plan mitigation strategies.

Floods can also disrupt operations and distribution e.g. restricts customer access.

Floods can damage property holdings.

Floods could at least temporarily increase the cost of other ingredients e.g. price and availability of ingredients.

This part was reasonably well answered by many although only a minority of candidates mentioned that water is the largest ingredient for drinks either directly at the distribution plant or indirectly at the agricultural stage.

- (iii) Agency risk – The team is incentivised to build a large book of weather derivatives without fear of loss (due to the zero floor on the bonus).

Operational risk – the financial exposure to loss is not being reported to the manager or to ACC.

The team only reports monthly in arrears to the manager.

It does not appear to have any limits as to how much it can buy and sell.

The premiums and settlement amounts are reported to the manager. There is no information regarding size of exposures, type and geographic concentration of exposures, probability of profit or loss from existing contracts.

ACC is a more natural buyer of weather derivatives than seller. The team is being incentivised to sell them and not buy them because the bonus is based on the net premium. It is easy to generate a bonus by selling a derivative. The team then simply hopes that the event doesn't occur triggering a loss. The team can receive a profit on premiums received before the risk has expired.

The manager only reports the net profit quarterly in arrears to the CFO, which is insufficient information and too late.

The answer is focussed on the risks associated with the operations. Several candidates ignored this part and included risks associated with trading derivatives.

- (iv) Disband the team and trade through a bank.

Stop or limit speculative trades.

Ban selling weather derivatives.

Find other (non-financial) ways to motivate the team.

Receive greatly improved management information re the size of potential losses (i.e. exposure and concentrations).

More frequent reporting and monitoring.

Change incentive structure to incentivise risk-appropriate decisions.

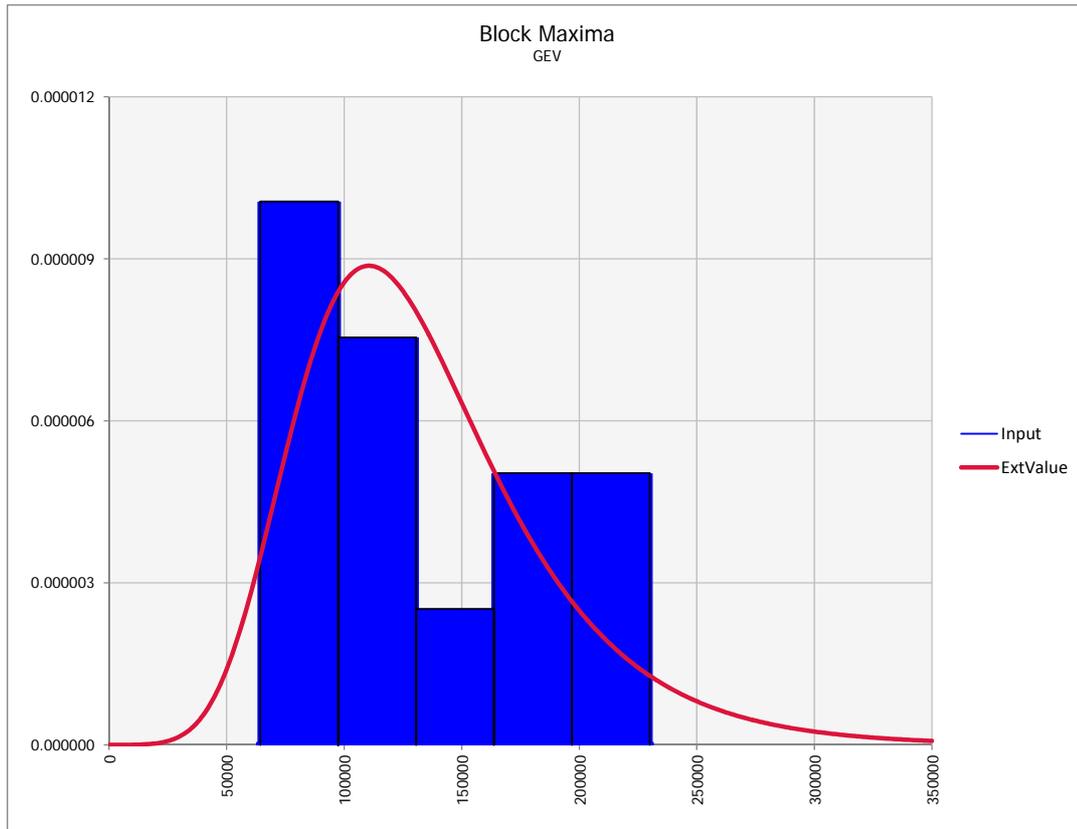
Include multi-year deals and deals that haven't expired at bonus time.

This part was well handled by many. Most candidates made points which are included in the answer. As ever, additional marks were given for other reasonable points.

(v) **Block Maxima (Return Level) Approach**

Separate the time series data into even sized blocks. Select the highest observation in each block and fit a generalised extreme value distribution function to the data using a maximum likelihood estimator.

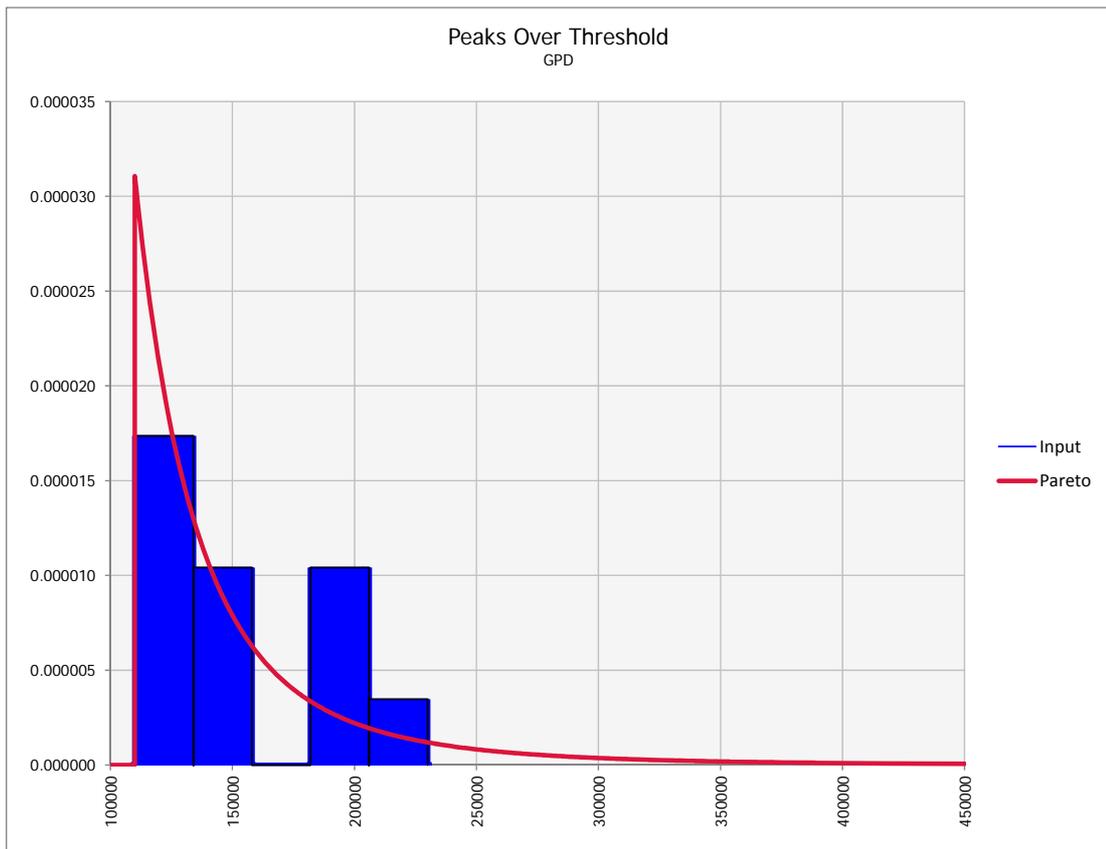
Plot of flood data under this approach:



Peaks Over Threshold Approach

Choose a threshold level over which the observed data are considered to be extreme. Fit a generalised Pareto distribution to all observations minus the threshold (for those observations exceeding the threshold) using a maximum likelihood estimator.

Plot of flood data under this approach:



The block size choice is crucial. If it’s too big then too much data is discarded. If it’s too small then too much non-extreme data will be fitted and the goodness of fit will be unduly weighted towards non-extreme data. In this case the curve will likely under fit the tail. That is the extreme values will be underestimated.

The GPD will typically keep more data and so is often preferred. The choice of the threshold is important for the same reasons that the choice of the block size is important with the block maxima approach.

Both methods assume that the underlying data are independent and identically distributed. Seasonality, trends and serial correlation in the data will violate this assumption.

Extreme Value Theory’s asymptotic law states that for long block lengths the block maxima approach will result in a generalised extreme value function and that for high thresholds the peaks over threshold approach will result in a

generalised Pareto distribution. At this point the shape parameters of the fitted GEV and fitted GPD will be effectively the same and their means and variances will be related.

This part was very poorly answered overall. The vast majority of candidates were not prepared to answer this part. A small minority of candidates handled this part very well. Marks were given for answers based on different block sizes and thresholds.

- (vi) Flood levels are different from precipitation data and precipitation data is likely to be available.

Flooding can occur from rainfall occurring in a different area, e.g. river systems with different catchment areas and snow melt versus rain.

If they are trying to protect against flooding and only precipitation derivatives are available then the results are likely to be helpful but the precipitation data should also be collected and analysed.

The flooding data would provide the information regarding the appropriate trigger points for the precipitation weather derivative.

This part was reasonably well handled by many. Marks were given for a wide range of reasonable points. Additional points included that flooding and precipitation could well be correlated and that flood defences would need to be taken into account. This part could be answered without needing to attempt part (v) above. Some candidates seemed to not attempt parts (vi) and (vii) because they had not attempted (v). This approach might have lost them marks.

- (vii) Yes, if 80 degrees Fahrenheit is relatively extreme for the area and if the assumption that the observed temperature data are independent and identically distributed is valid. No, otherwise.

The comments for part (vi) apply equally well to this part.

- (viii) Risk of failing to meet ACC's values

All three ideas can be managed within ACC's core values. The main concern would be with the developing country venture where the government may be more likely to be less concerned with the environment as it pursues economic growth and the suppliers may be more likely to mistreat their own suppliers and the environment in the pursuit of profit.

Reputational risk of negatively impacting ACC's reputation and its current brands

ACC is likely to be trying to make its own products healthier whilst not sacrificing taste and enjoyment. There is a risk that if it buys a health food company then people would see that as an admission by ACC that its own products were not healthy. In other words some brand value would be destroyed.

Alcohol products carry different brand values and reputational risks. There is a risk that people would not want their family restaurant, for example, to be associated with an alcoholic drink producing company.

It is possible that the developing country venture could enhance the group’s other brands and reputation if it was seen as helping a country to grow and develop and not simply profiteering. However, if the new government also proves to be corrupt then there could be issues arising from what could appear to be a close relationship.

The impact on ACC’s group leverage and cash flow

Projects often require funding over time with a certain amount of flexibility to change the funding requirement as the project unfolds. In this sense the developing country venture is likely to have the smallest impact on the group’s leverage and outward cash flows.

ACC would need to fund itself to purchase the health food company unless it bought it with its own shares. Presumably the health food company would produce a steady stream of positive cash flows to the group.

The brewery company venture would likely require some up front outlay and then major alterations to one of the group’s existing distribution companies to cope with brewing and distributing beer. The funding need will depend on the proposed scale of the venture but the net cash flows are likely to be negative for some time.

There is the related risk that the actual costs of establishing any of these projects turn out to be materially in excess of what was expected.

Strategic risk of failing to meet the plans and objectives of the business venture and ultimately failing to produce the budgeted returns on investment

This risk will be increased or reduced depending on:

1. How closely the venture fits the group’s existing core competencies.
There is overlap in all three ventures. The group’s snack foods and drinks divisions would have a lot of overlap with the health food company. The group’s drinks division would understand how to package and distribute bottled and canned beer. The group would be introducing its own products to the developing country. The greater the overlap with existing competencies, the lower the inherent operational risks.
2. Understanding of the country and marketplace including people’s tastes, culture, values. The group will understand the health food company’s market. It will have some understanding of the brewery’s market due to the geographical overlap. It will have virtually no knowledge of the developing country.

3. How much of the venture is a project and how much of the venture is an established going concern. The developing country project is the most risky in this respect; the health food manufacturer the least.
4. Agency risk associated with new employees who will have different cultures and values. This risk will depend on the extent to which existing ACC staff are integrated into the new projects. The greatest agency risk might come with the health foods manufacturer, as it is a large established company and the management might resent the takeover. There is more scope with the developing country project to instil ACC values at outset, but these may not necessarily be compatible with the local culture.
5. Political risk, being the risk of future government interaction. The developing country venture includes substantial political risk. The government could change in the near term and do many things including punitive tax, nationalise the company's assets or prevent monies being repatriated offshore. Political risk in the other two ventures is likely to be much reduced, but it still exists. For example, governments regularly seek to try to reduce the amount of alcohol being drunk.
6. Regulatory and tax changes can be a new point and a new mark
7. Business risks being mainly competition, supply, demand, and input price inflation. These risks will be more manageable, the greater the knowledge and understanding of the market. The developing country might have greater volatility and more unpredictability, particularly given the government's overall plans to kick-start the economy.
8. There would be currency risk involved in the developing country project (in respect of repatriation of profits), no such risk for the health food market (or limited, depending on its markets), and possible such risk for the brewing project, depending on where the micro-breweries are situated and the intended distribution markets.

This part was reasonably well handled by many. Marks were given for a wide range of reasonable points. Additional points included those related to operational risks and those related to the flexibility of entry and exit. For example, the first option is a start up project meaning that there is a lot of control over the timing and cost of the future growth. The second option can be re-sold or re-listed on the stock exchange. The third option is likely to be much more difficult to sell or downsize.

- (ix) Only the developing country venture should be pursued. ACC already operates in several continents. It would be easy and very inexpensive to start up operations in the country by importing goods and commencing a small number of kiosks and restaurants on a trial basis.

The potential cost savings from combining the health food operation into ACC are not likely to offset the potential brand damage to the existing products.

Beer is a relatively saturated market. There is considerable risk that the launch of new mass market beers would fail. There is also the potential for the beer brand to negatively impact the value of the other brands.

This part was reasonably well handled by many. Marks were given for answers pursuing other business options provided that the arguments were reasonable.

- (x) The purpose of ERM is to identify, quantify and holistically manage all of the individual risks of the enterprise in order to maintain an overall level and set of risks that have been stated to be acceptable to the enterprise in pursuit of its other objectives. Managing the risks will include monitoring and reporting on the risks and, as appropriate, mitigating, transferring and accepting the diversified pool of remaining risks.

The ERM framework must be fit for this purpose. Further, it must be sized to fit the nature, size and complexity of the enterprise.

ERM must be embedded into the enterprise in order for it to monitor risks in a timely fashion and in order for it to identify new risks as they arise.

In order to be embedded, to save time and costs and to not duplicate work, the framework should start with existing departments and activities in the enterprise. For the three trading subsidiaries these will include:

1. Quality control
2. Purchasing managers
3. Health and safety
4. Human resources
5. Food standards laws and agencies
6. Management information

The subsidiaries operate autonomously. This is a business decision and as such each division should employ a part time or full time risk manager depending on workload.

The risk manager will then be responsible for working with all relevant areas to build and maintain a risk register and supporting management information.

The frequency of the management information and the regular risk register review will depend on the nature of the underlying risks.

For ACC monthly management information and a 6 monthly review of the risk register will likely suffice.

This said, the framework needs to include the mechanism for ad hoc risk reporting to the risk manager.

The risk manager will then use the management information to produce a set of risk measures and report these monthly to each subsidiary's risk management committee (RMC).

The risk management committee is likely to include the chief executive officer, chief operating officer, chief financial officer and chief investment officer and legal counsel if any.

The committee will also include the (newly appointed) group chief risk officer.

Following the monthly meetings, the management may make decisions designed to mitigate, transfer or differently manage the various risks.

The group chief risk officer, working with the various risk managers, will then produce a set of group reports taking into account the various RMC packs and management decisions.

These packs will be presented to the group risk management committee and they will be discussed with the board when it meets.

One of the additional considerations at group level is to ensure that the group is operating within its stated risk appetite, profiles and tolerances. The framework does not only collect and process information in one direction. The framework must be designed to report suggested business changes to the appropriate persons and to then ensure that they are acted upon.

For example, the subsidiary risk management committee might be concerned that the held stock position is relatively high and it could cause a hazard. The chief operating officer being present at the committee will agree to reduce the stock position and the committee will then monitor the impact of the action in future meetings.

Another example would be random hygiene checks at the restaurants.

The framework will include the processes for setting operational limits and rules that seek to ensure that risk levels are not breached.

At regular intervals the various chief executive officers and chief operating officers would discuss the risk register, the risk appetite, risk profiles and risk tolerances to design operational limits, rules and systems to work within the appetite, profiles and tolerances.

Turning to corporate governance:

The governance structure specifies the distribution of rights and responsibilities among different participants in the corporation (such as the board of directors, managers, shareholders, creditors, auditors, regulators, and other stakeholders) and specifies the rules and procedures for making decisions in corporate affairs.

Governance should be driven from the top of ACC downwards. It should prescribe an appropriate culture and put in place the mechanisms to deliver it throughout the company.

Abe should be either the chairman or the CEO and not both.

The board composition should change. The subsidiary CEOs might leave the main board and be replaced with non-executive directors with appropriate experience and expertise.

Ideally the board could have a majority of independent directors.

The chief risk officer should join the board.

The board should establish committees including risk management, remuneration and audit.

The committees’ roles and responsibilities will be established in writing and the committees will be chaired by an independent board member.

There should be no need for a formal corporate governance committee or compliance function at ACC. Compliance will largely refer to various health and safety, food standards and consumer affairs regulations. These can most likely be handled by a combination of human resources and the operations managers through the chief operating officer. Of course, they will also be monitored through the RMC.

Group management should produce a paper articulating ACC’s core values, its culture and its ethics. The paper should be approved by the board and then issued to all employees to explain how ACC requires its employees to behave.

A good culture will be one promoting openness and transparency.

“Risk champions” may be identified in each business area or subsidiary or operational centre.

ACC should start to provide far more detailed reporting to its various stakeholders. It should strive to be as transparent as possible in a competitive environment to demonstrate to all that it is well run and behaving as an upstanding corporate citizen.

Remuneration and personal development processes should be established that encourage and reward appropriate risk-aware behaviours.

Internal audit functions may be established or strengthened.

This part was reasonably well handled by many candidates. Even though this part was relatively generic the answer needs to relate back to the particular case study. The vast majority of candidates made many valid points. Some candidates failed to score more marks because they were unable to make their points relevant to the case study.

- (xi) The credit rating agency rating the bond and the exchange are likely to make suggestions that they feel would help to strengthen the ERM. This may involve changes to the framework. Common changes suggested would include:
- The timeliness of the reporting. They may feel that some information should be available on the company's systems weekly instead of monthly.
 - The detail of the information being reported through to the various risk management committees. They generally feel that more information is better than less information.
 - The centralisation of the ERM. They may feel that the proposed practical structure doesn't have sufficient internal audit style checks and verifications of reported data.

Whilst not a change to the framework, the group risk manager will likely change some of the management information to monitor the credit rating of the bond and the potential for a rating change. A decline in rating will make any replacement issue more expensive.

The credit rating agencies' ERM requirements will likely increase as the rating increases.

This part was reasonably well handled by many candidates. Part (x) stated that the answer had to apply to ACC specifically. Even though part (xi) also applies to ACC specifically the answer is likely to apply equally well to many other companies issuing a rated bond for the first time to be traded on the stock exchange. This is because the drivers of change will be the credit rating agency and the stock market listing authority. For this reason the above answer is quite generic to a particular type of situation and not just specific to ACC.

END OF EXAMINERS' REPORT

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINATION

24 September 2014 (pm)

Subject ST9 – Enterprise Risk Management

Time allowed: Three hours

INSTRUCTIONS TO THE CANDIDATE

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all six questions, beginning your answer to each question on a new page.*
6. *Candidates should show calculations where this is appropriate.*

AT THE END OF THE EXAMINATION

Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.

In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.

- 1** Northern Insurance has separate Risk and Actuarial functions. Southern Insurance has a combined Risk and Actuarial team.

Discuss the relative merits of the two approaches. [5]

- 2** A general insurance company is investigating the correlation of claims arising between two insurance classes: Type A and Type B.

Past total claims experience (in \$000) has been as follows:

	<i>Type A</i>	<i>Type B</i>
2009	164	769
2010	149	463
2011	125	426
2012	211	685
2013	203	500
Overall Total	852	2,843
Mean	170.4	568.6

- (i) Calculate Pearson's rho for these two sets of data. [4]
- (ii) Calculate Kendall's tau for these two sets of data. [3]
- (iii) Outline the relative merits of these two correlation measures. [2]
- (iv) Suggest, with reasons, possible insurance classes that are represented by Type A and Type B. [2]

[Total 11]

3 ABC Life is a small life insurance company. It is currently developing a disaster recovery plan for its operations.

(i) Define operational risk. [1]

(ii) Outline how ABC Life could measure its operational risk exposure. [5]

As part of its operational risk monitoring, the risk management team is carrying out interviews with each of the senior managers in order to categorise the criticality of all the company's processes.

(iii) Outline the advantages and disadvantages of the chosen interview approach. [4]

(iv) Explain the need for a disaster recovery plan for ABC Life. [2]

ABC Life is proposing including disaster risk in the operational risk component of its economic capital model.

(v) Comment on this proposal. [4]

ABC Life is also developing its risk appetite statement.

(vi) Explain what is meant by a risk appetite, including examples of common ways in which it is expressed. [3]

ABC Life considers a definition based on profit to be the most appropriate. However it currently reports profit on three different bases, namely:

- The surplus emerging in its regulatory solvency accounts, which are prepared on a prudent basis.
- The profit before tax in its financial accounts.
- The economic profit arising (or “economic value added”) based on its economic capital calculations.

(vii) Discuss which of these definitions would be most appropriate for the risk appetite statement. [5]

(viii) Outline the potential disadvantages to ABC Life of basing its risk appetite statement primarily on profit. [2]

[Total 26]

- 4 A leading accountancy professional body, APB, has decided to introduce its own ERM professional qualification. It has established the ERM Institute, ERMI, and accredited members will become fellows of the institute or FERMI.

ERMI is a not for profit organisation (i.e. it has no shareholders and does not aim to make or distribute profits). The APB will lend funds to ERMI to establish itself and these funds will need to be repaid in due course.

ERMI will set essay style examinations with some straightforward calculations, coursework and a continuing professional development program. It intends to operate internationally in the future.

- (i) Outline the risks facing ERMI. [6]
- (ii) Suggest ways in which ERMI might mitigate or transfer these risks. [5]

ERMI has now been examining and awarding professional qualifications for two years. In its first year of operations 50% of candidates passed their examinations and in the second year of operations only 25% of candidates passed. The executive board is concerned that examination standards have changed to the detriment of the long run success of ERMI.

The examination process involves setting the examinations, marking the examinations and determining an appropriate pass mark.

- (iii) Describe an examination process designed to minimise the risk that the standard required of candidates could vary from one examination to the next. [5]
- [Total 16]

- 5** Predictable Life is a large life insurance company. It has developed a sophisticated generalised linear model (GLM) to assess mortality risk across a range of biometric, medical and socio-economic factors in order to set premium rates accordingly.

The sophistication of the model is a key source of Predictable Life's competitive advantage. The insurer collects both qualitative and quantitative data to support its model through a rigorous underwriting process.

- (i) List the four main components of mortality risk that Predictable Life's model will assess. [2]
- (ii) Outline the process of GLM modelling as it applies to mortality risk. [4]
- (iii) Explain why Predictable Life may charge a different premium from that suggested by its model. [2]

Penny Saved Bank is a retail bank providing a diversified wealth management service to its clients. It does this by combining banking products with other financial services products provided by subsidiaries that it owns.

The bank's strategy is to maximise customer relationships and to earn a minimum profit per customer. As part of this strategy, it may from time to time use one product as a "loss leader". For example, it may use heavily discounted life insurance policies to secure sales of home loans.

- (iv) Give a possible risk management rationale for this strategy. [2]
- (v) Suggest key indicators that the bank could use in its internal management information to monitor the implementation of its strategy. [2]
- (vi) Contrast the likely life insurance risk exposures of Predictable Life and Penny Saved Bank. [2]

Extreme Life is a niche EU life insurance company providing short term life insurance cover of fixed amounts to extreme sports enthusiasts. The policies are typically sold by travel agents. The cover excludes pre-existing conditions, but there are no other exclusions or underwriting criteria.

Extreme Life is the only insurer operating in this market. To date its pricing approach has been straightforward: it sets premiums for new policies based on the two year average claim cost plus a margin for expenses and profit.

- (vii) Contrast the life insurance risk exposures of Predictable Life and Extreme Life. [3]
- (viii) Explain whether Extreme Life should adopt an internal model under Solvency II. [2]

[Total 19]

- 6 The Association of Independent Lawyers (AIL) is a trade association offering a range of services to its independent member firms.

The supervisory professional body requires that every law firm maintains professional liability insurance (PLI). An entrepreneur has decided to establish a new insurance company, New Insurance Company (NIC), to write PLI. Initially it proposes to offer insurance solely to AIL member firms. It proposes to attract their business by ignoring their past claims experience when underwriting and by offering insurance at a substantial discount to current market rates.

The following information is provided:

AIL Membership Information

- 300 member firms with three or fewer lawyers each.
- 30 member firms with 50 lawyers each.

PLI Policy Terms Information

- No individual or aggregate claim limits per policy.
- No per claim deductible or excess.

PLI Premium Information

- Market premium in each of the past three years was £2,000 per lawyer including a £200 expense loading.
- Current market premium is £4,000 per lawyer including a £200 expense loading.

PLI Claims Information

- 99.5% of claims cost £20,000 on average and 0.5% of claims cost £1m on average.
- On average, a group of 100 lawyers is expected to incur 12 claims in any given year.

Aggregate Claims Cost Distribution Information

- The standard deviation of the distribution is assumed to be 30% of the mean.
- The 99.5th percentile of the distribution is assumed to be 3.5 standard deviations away from the mean.

Market Risk Information

- The portfolio of investments is expected to earn 4% per annum.
- The standard deviation of the distribution of total investment returns is assumed to be 25% of the mean.
- The 0.5th percentile of the distribution of total investment returns is assumed to be 2.2 standard deviations away from the mean.

Credit Risk Information

- The portfolio of investments is expected to incur credit default losses of 0.5% per annum.
- The standard deviation of the distribution of total credit default losses is assumed to be 50% of the mean.
- The 99.5th percentile of the distribution of credit default losses is assumed to be 2.6 standard deviations away from the mean.

Operational Risk Information

- Two operational risks have been identified. They each may happen once over the lifetime of the company.
- Risk A has an estimated cost of £500,000 and a probability of 5% of occurring in any year.
- Risk B has an estimated cost of £1,000,000 and a probability of 0.25% of occurring in any year.

You should assume that:

- 30% of member firms purchase PLI insurance from NIC.
- market risk and credit risk are 100% correlated.
- claims cost, operational risk and combined market/credit risk are independent of each other.

The financial services regulator requires that insurance companies hold regulatory capital in excess of best estimate reserves. The capital is estimated to enable the company to meet all of its liabilities in at least 99.5% of forecast future scenarios, assuming that the company writes business for one year only. The capital requirement is therefore calculated as the amount that would need to be held at outset in order to cover the overall reduction in the year end assets (net of any outstanding claims liabilities) under the 99.5% scenario relative to expected.

- (i) Calculate the initial minimum regulatory capital requirements for NIC, stating your reasons for making the various calculations and any assumptions made. [16]
- (ii) Suggest reasons why the regulator might require NIC to hold more than this minimum amount. [4]

The current market premium is relatively high due to very poor claims experience in the past three years.

- (iii) Describe the additional investigations that should be conducted and the likely main implication for the calculation in part (i). [3]
[Total 23]

END OF PAPER

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

September 2014 examinations

Subject ST9 – Enterprise Risk Management

Introduction

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and using past papers as a revision aid and also those who have previously failed the subject.

The Examiners are charged by Council with examining the published syllabus. The Examiners have access to the Core Reading, which is designed to interpret the syllabus, and will generally base questions around it but are not required to examine the content of Core Reading specifically or exclusively.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report; other valid approaches are given appropriate credit. For essay-style questions, particularly the open-ended questions in the later subjects, the report may contain more points than the Examiners will expect from a solution that scores full marks.

The report is written based on the legislative and regulatory context at the date the examination was set. Candidates should take into account the possibility that circumstances may have changed if using these reports for revision.

F Layton
Chairman of the Board of Examiners

December 2014

General comments on Subject ST9

The ST9 exam generally requires bullet point form or short form essay style answers that apply general principles to directly address specific circumstances. The answers given below are just one possible set of acceptable answers. Candidates are awarded marks for all reasonable answers including different but still reasonable numerical solutions. Marks are awarded for working in the case of numerical answers.

Candidates' answers are made up of a series of points. For example, a point can be stating a valid type of risk, describing the type of risk or (part of) a calculation. Some points are more fundamental to the correct answer but, in the main, candidates earn one-half mark per correct point up to the limit of marks available for the question.

Comments on the September 2014 paper

The paper was made up of three relatively small questions and three relatively large questions. Unusually question 4 was in part about setting exam questions and the answer is instructive. The question addressed the desire to maintain consistent standards from one diet to the next across many diets. The answer suggested that it is important to ensure that the overall paper contains the targeted balance of bookwork and application and the range of content needed to reasonably cover the syllabus. This exam fulfils those objectives.

As is common practice, the large majority of the questions were:

1. based heavily on bookwork;
2. based on simplified case studies or;
3. loosely based on actual and often relatively recent events.

For example, questions 1 and 2 were largely bookwork and the remainder of the questions were loosely based on relatively recent events.

The examiners seek to test the candidate's knowledge of the syllabus. The core reading is an important source for framing questions but not the only source. For this reason, candidates are encouraged to read the financial press and to consider how current news items can be applied to the issues and concepts contained in the core reading.

Well-prepared candidates scored acceptably well across the whole paper. The comments that follow the questions concentrate on areas where candidates could have improved their performance.

1 The advantages of separate functions are the disadvantages of a joint function and vice versa.

Separate:

- One function can provide an independent review of / check on the other.
- It facilitates the independence of the risk function.
- It allows for clear reporting lines.
- It avoids conflicts of interest by separating the risk roles from the front line business operations such as pricing.
- It can encourage more communication between teams and parts of the business on risk issues.
- It achieves a dedicated central risk function which can cover a wider remit than just “actuarial risk”.

Together:

- It reduces the need for specialised / skilled resource in the firm.
- It may therefore also be cheaper.
- Arguably it is the more integrated approach, achieving a better relationship between risk specialists and operational staff.
- May be a more collaborative approach; less likely to try to “hide” problems.
- Decisions may be made and implemented more quickly.
- It could reduce the possibility of duplication of effort, if there is a blurred distinction between some responsibilities.

[5]

The question was handled well by most. Virtually all of the candidates made at least some of the above points. As ever, additional marks were given for other valid answers including that if the functions were together then communication might be easier and the company might need fewer people.

2	(i)	Claims Type A	Claims Type B	$A-\mu_A$	$B-\mu_B$	$(A-\mu_A)^2$	$(B-\mu_B)^2$	$(A-\mu_A)^*$ $(B-\mu_B)$
	2009	164	769	-6.4	200.4	41	40,160	-1,283
	2010	149	463	-21.4	-105.6	458	11,151	2,260
	2011	125	426	-45.4	-142.6	2,061	20,335	6,474
	2012	211	685	40.6	116.4	1,648	13,549	4,726
	2013	203	500	32.6	-68.6	1,063	4,706	-2,236
	Sum	852	2843			5,271	89,901	9,941
	Mean (μ)	170.4	568.6					

The sample standard deviations and covariance, from dividing by $T - 1 = 4$, are thus:

$$\begin{aligned}
 s_A &= 36.3 \\
 s_B &= 149.9 \\
 s_{A,B} &= 2485.2 \\
 \rho &= 0.457 \\
 &= \frac{s_{A,B}}{s_A \cdot s_B}
 \end{aligned}$$

[4]

The question was handled well by most. The statement made in the summary section earlier said that marks were given for working. This is true. It does not however mean that the candidate needs to show working to gain full marks. If, as in this case, the question simply says "Calculate..." without reference to workings or reasoning then simply writing down the answer would gain full marks.

(ii) Kendall's τ

			v2009	v2010	v2011	v2012
2009	164	769				
2010	149	463	c			
2011	125	426	c	c		
2012	211	685	d	c	c	
2013	203	500	d	c	c	c

$$\begin{aligned}
 p_c &= 8 \\
 p_d &= 2 \\
 t_{A,B} &= 0.6 \\
 &= 2(p_c - p_d) / T(T - 1) \text{ where } T = 5
 \end{aligned}$$

[3]

The comments made for part(i) above also apply here.

- (iii) Both methods are fairly simple to calculate.

However Pearson's ρ depends on the distribution of claims being jointly elliptical. If the results are not from elliptical underlying distributions, the results may not be valid.

Kendall's τ depends only on the rank of the data points and so is always valid, irrespective of the underlying distribution of the variables.

Kendall's τ has a simple relationship with the parameters of a number of copula functions.

Pearson's ρ can be used directly in some common multivariate distributions.

[2]

The question was handled well by most. As ever, additional marks were given for other valid answers.

- (iv) The results of both correlation tests are positive, suggesting that the claims move in similar directions and therefore may have important risk factors in common.

However, the correlations are lower than 1 and so there must also be other underlying claims drivers which affect one class more than the other.

Examples could be house insurance contents claims and motor vehicle accident claims (as both increase with bad weather but are also affected independently by other "perils").

[2]

[Total 11]

Marks were given for other examples that are likely to have relatively high but not perfect correlation e.g. buildings and contents insurances.

- 3** (i) Operational risk is the risk of losses resulting from inadequate or failed internal processes, people and systems, or from external events. [1]

Most candidates scored full marks.

- (ii) The company may want to measure its risk exposure as the impact of operational risk events on one or more of:

- Additional short term costs of staffing, property, and systems.
- Fines for failure to comply with regulatory requirements that apply.
- The fall in turnover / the reduction in new business sales.
- The reduction in customer satisfaction scores.
- The increase in lapse rates.
- Overall impact on ABC's embedded or economic value.

- Overall impact on surplus capital or VaR/TVaR.

To model this, the company may be able to source data internally (although unlikely given ABC's small size) or externally through any industry databases that may exist.

By its nature the risk is bespoke and it may be impossible to get sufficient data to model and measure this risk statistically, particularly for low frequency, high severity events.

However it may be possible to get input from experts in this field to help guide the assessment of the exposure.

The experts might be internal or external.

Both severity and frequency need to be considered.

Scenario analysis techniques may be used.

Correlations between operational risk events need to be considered.

The exposure measures should reflect the mitigations or controls that are in place.

It may be necessary to use other losses as a proxy for the exposures to operational risk.

[5]

The question was handled poorly by most. Many candidates made two or three of the above points but no more. Similar questions have been asked in past papers.

(iii) Advantages:

- gets input directly from people who understand the business processes
- assessments will be bespoke to ABC Life and not for an average company in the industry
- the interview process may help build an understanding of how the different teams depend on each other
- interviewing (as opposed to questionnaires or surveys) allows immediate clarity to be sought if the answer is unclear
- interviewing on an individual basis reduces bias or "group think"
- and it ensures that all of the required contributors are engaged

Disadvantages:

- people responsible for the separate processes may not be familiar with the wider risk management / economic capital modelling requirements
- individual senior managers may be biased and overstate the importance of their area
- it is difficult for individuals to estimate impacts in extreme or hypothetical scenarios, which could result in unrealistic impact assessments
- it might be a relatively time-consuming process
- care has to be taken to avoid bias resulting from framing within the questions used or due to using different interviewers

[4]

The question was handled reasonably well by many. Other extra points include:

- *Advantage: that the persons doing the interviews are risk experts.*
- *Disadvantage: could be difficult to aggregate the responses (particularly if done by different interviewers).*

- (iv) Following a disaster ABC Life may not have access to its systems or to its premises.

Staff may not be able to report for work.

The disaster may not have affected ABC Life directly; the impact might be indirect via its suppliers and customers.

A disaster recovery plan would help the company focus on critical processes to the business and proactively set out how it will ensure these are able to continue under these circumstances.

[2]

The question was handled reasonably well by many. Other extra points include that the DRP should increase other stakeholder's confidence in the company e.g. shareholders and regulators.

- (v) The company should hold capital against this risk.

It fits with the definition of operational risk.

It will help to raise the profile of disaster risk (and the need for a disaster recovery plan) within the company.

It allows risk diversification, since operational risk is not perfectly correlated with other risks such as market and credit risk.

It may be difficult, however, to quantify the high severity, low frequency exposures required for economic capital modelling and in particular to obtain sufficient extreme event data with which to calibrate the model.

It may be necessary to use Extreme Value Theory techniques within the economic capital model, which increases the complexity of the modelling.

Correlations with other risks will also be difficult to determine. E.g.1 potential impact on financial markets if the disaster is widespread. E.g. 2 potential positive correlation with insurance risk.

The mitigating actions that can be taken to minimise the impacts in the event of a disaster should be taken into account. This may be difficult to do in an economic capital model as the impact of the actions may not be the same in the high severity, low frequency scenarios as in the lower severity higher frequency scenarios.

[4]

The question was handled reasonably well by many. Other extra points include that the company is small and including disaster risk in this way in the ECM may be a relatively inexpensive and practical way of modelling it.

- (vi) Risk appetite can be interpreted as reflecting the setting of targets and limits across the organisation as a whole, plus the breakdown of these high level statements into more detailed risk tolerances.

Risk appetite is usually presented as a probabilistic statement.

Examples are:

- The solvency level, X, should stay above the threshold Y with 99.5% probability over the next 3 years.
- The probability that the company's credit is reduced from the current AAA to A, or worse, in the next twelve months should be no more than 1%.
- Earnings volatility over the next year should be no more than Y%.
- The company is prepared to lose \$Y with a probability of no more than 0.5% over the next 12 months and \$Z with a probability of 0.1% over the next 5 years.

[3]

The question was handled well by most.

- (vii)
- Since regulatory profit is based on prudent assumptions it will be unrealistic in that the release of margins is materially deferred (profits too low early on).

- Accounting profit is likely to be more realistic than regulatory profit.
- However, it won't fully reflect all the constraints imposed on ABC, e.g. it is unlikely to reflect fully the cost of capital imposed on ABC as a result of the solvency regulations, and is unlikely to be risk-adjusted.
- Economic profit will allow the most realistic assessment of risk-adjusted profit.
- It can take into account regulation and other business constraints.
- However economic profit is not subject to audit, unlike accounting (and potentially also regulatory) profit.
- It is therefore potentially more readily manipulated.
- As it gives the most realistic assessment, economic profit can be considered to be the most appropriate for the risk appetite statement.
- It may also be easier to assign a probabilistic interpretation to economic profit.
- However, accounting profit will be more widely understood by stakeholders and so could lead to more engagement with staff and better integration of risk into the management of the company.

[5]

The question was handled well by most.

- (viii) A focus on profit can lead to short termism amongst the Board and senior management.

Short termism could also encourage profit reporting manipulation.

If the remuneration structures are aligned with the profit focus, they could in turn incentivise management and staff to focus on sales rather than longer term value creation.

There could be a related mis-selling risk.

High sales volumes could jeopardise the solvency of the company.

To reduce profit volatility, the company may prefer to offer products that have more stable profit streams; these less risky products may have lower value to customers which could lead to lower sales and lower ultimate added value to the business.

Basing risk appetite on a balance of different metrics will likely result in relatively less risky (volatile) behaviour for a given targeted return.

[2]

[Total 26]

The question was handled well by most. Extra valid points include that the primary focus on profit ignores many other important targets and risks that other stakeholders will be interested in to a greater or lesser extent than profit e.g. risk of ruin and more particularly the risk of ruin resulting from short-term funding difficulties.

- 4** (i) Business risk and more particularly strategic risk, being the risk of not achieving ERMI's plans and objectives.

This could also have knock-on implications for the wider reputation of the APB (contagion of reputational risk).

Failure to achieve these plans and objectives will likely come from one or more failures, such as:

- Failure to develop clear plans and objectives regarding targeted market, projected numbers of students and fellows, positioning of the perceived status of the fellowship compared with alternatives.
- Failure to develop appropriate syllabus and coursework
- Failure to properly advertise the institute and the fellowship
- Failure to keep up with competition and with ERM developments
- Failure to build the reputation required to attract new students and hold on to existing members
- Failure to meet the expense budget

Reputational risk can also arise from high profile failures of the examination system once it is established, e.g. lost exam scripts, advance leaking of exam papers.

Or the risk that the standard of those passing the exams is not set at the appropriate level (unrealistically high: will deter students from registering for these exams; too low: will diminish the perception of the quality of the qualification).

Risk of financial ruin will most likely be the result of failing to attract a minimum number of students from year to year.

New systems and staff will be required, increasing operational risk (at least until established).

Operational risks may be exacerbated if significantly higher numbers of students register for the exams than expected and the process and staff are unable to cope.

Operational risks may also be increased once it starts to work internationally, as the logistics become more complex.

[6]

The question was handled well by the large majority of candidates. Marks were given for any other valid points including:

- *Regulatory risk: risk of adverse intervention (or changes in approach) of the regulator for the professional body.*
- *Fraud risk: exposure to exam cheating.*
- *Agency risk: conflicts could arise between the objectives of ERMI and APB.*
- *Legal risk: from individuals who do not consider themselves to have been treated fairly in the exams.*
- *FX risk: in relation to costs incurred for any overseas exam centres and/or the relative expense of overseas exam fees.*
- *Market/counterparty risk: in relation to working capital including the initial funds from APB.*
- *Liquidity risk: e.g. in relation to repayment of the loan.*

- (ii) The APB is likely to support ERMI in several different ways (and thus help to reduce many of the above risks) once ERMI can evidence to the APB that it has developed appropriate syllabus, coursework, exam systems and continuing professional development.

To reduce the risk of not attracting enough students:

- Some of APB's members are likely to be interested in ERM and the APB is likely to want to market ERM to them.
- APB will also have relationships with other professional bodies around the world. It will likely promote ERM to them.
- APB is likely to be in regular contact with employers, government and educational bodies. It will likely promote ERM to them.

To reduce the risk of failing to develop appropriate syllabus, coursework and exams:

- ERMI could work with academics and experienced ERM professionals. It could for example hire as consultants a number of recognised ERM experts from universities and management consultancies. It could develop a panel of experienced senior ERM professionals to review and refine the draft syllabus and coursework.

- These same people together with educational consultants should be able to help ERMI to develop an appropriate exam setting and marking system as well as continuing professional development program.
- The syllabus and educational material should be subject to regular review by the expert panel in order to maintain its relevance.
- ERMI could outsource the development and maintenance of the syllabus, coursework, exams and continuing professional development to a suitable university.

To reduce operational risks:

- In the early years ERMI could outsource the bulk of IT and administration.
- For example, it could do this to APB, which would already have its own qualification assessment systems.
- ERMI needs to develop and document robust processes and governance systems.
- And to ensure that it has sufficient resourcing levels and that its staff are well trained.
- And that all qualification support systems undergo thorough testing protocols.
- Tight security measures should be put in place and also rigorously tested.
- ERMI needs to have robust processes and recovery plans in place to deal with adverse operational events e.g. loss of exam papers in transit or leakage of information.
- ERMI also needs to control its expenses.

[5]

The question was handled well by the large majority of candidates. Marks were given for any other valid points including:

- *Regulatory: engage with the regulator and work closely.*
- *Legal: consult lawyers at each stage.*
- *FX: use of derivatives if appropriate.*
- *Market/counterparty: invest working capital in secure assets.*
- *Liquidity: make sure the loan agreement with APB is on flexible terms.*

(iii) Setting the exams

Break the syllabus into sections and seek to examine those sections relatively regularly from diet to diet to test fairly those candidates with different strengths and weaknesses.

Break the questions into categories of difficulty ranging from straightforward to requiring original thought. Endeavour to keep a constant percentage of marks in each level of difficulty from diet to diet.

The exams should pass through a process of review including experienced personnel actually sitting the exams (e.g. those who have recently passed the ERMI exam).

The aim of this review is to maintain consistent language from diet to diet, ensure that the questions are clear and unambiguous and to test that the exam can be answered in the allowed time.

If the exam is being sat by candidates who do not have the language used as their first language, then the papers should also be reviewed by such personnel.

Multiple choice questions, calculation questions and questions requiring a list answer require no or little interpretation to mark and thus can help to ensure consistency if included in a target proportion.

Marking the exams

The examiners will produce draft solutions and a clear and detailed marking schedule.

The draft solutions will be updated by the markers during the marking process as the candidates will collectively make other valid points and take other valid approaches.

All markers can be required to mark the same “test batch” of scripts and these marks can be analysed and discussed to ensure that appropriate and consistent standards of marking are being applied.

It would be reasonable for a team of experienced markers to mark all the papers once and to separate out the clear passes and failures.

A more rigorous approach would be to mark all papers twice before separating out clear passes and failures.

After taking account of marking differences between markers, some or all of the questions on the remaining papers would be remarked – particularly those where the first two markers' marks were significantly different.

Multiple marking of exams would ensure that each candidate receives an appropriate mark.

The markers should be experienced in ERM.

Over time, students who have passed the ERMI exam should be encouraged to become markers.

The group of markers used should not change materially from session to session.

Markers who do not allocate marks within an acceptable tolerance should be removed from the marking pool.

Determining the pass mark

The examiners will set the draft pass mark at the time of setting the exam.

The draft pass mark will be revised if the candidates as a group discover any difficulties in understanding or finishing the exam in time.

The examiners will review scripts above and below the draft pass mark and decide whether the pass mark is set correctly based on the knowledge displayed in the answers compared with the knowledge displayed by prior candidates at the pass mark in previous diets.

Clearly it is important that past examiners are available to review scripts at this stage.

Examiners must be able to provide robust justification for material changes in the pass mark (and pass rate) from diet to diet.

[5]

[Total 16]

The question was handled well by many. Marks were given for any other valid points including:

- *Monitoring the exam process across diets to ensure the various steps are being followed.*
- *Reviewing the governance structure regularly.*

5

(i)

- Level
- Volatility
- Catastrophe
- Trend

[2]

The question was handled poorly by the large majority of candidates. This was a bookwork question.

(ii) Generalised linear modelling will be principally used to model the “level” risk.

Generalised linear modelling requires us to first risk rate the data.

This works as follows:

- Divide the data into homogenous groups
- Derive expressions for the mortality of each group in terms of the risk factors
- Analyse the structure of the group of lives of interest in terms of these risk factors
- Use the risk factor exposures to infer the underlying mortality of the group of interest

Generalised linear modelling usually involves logit or probit regression analysis.

This places the mortality rate as the dependent variable and the risk factors as the independent variables.

[4]

The question was handled poorly by the large majority of candidates. ST9 candidates should have some understanding of GLM.

(iii) The premium rates it charges will load margins for expenses and profit on top of the pure risk premium.

High levels of competition in the market may force Predictable Life to (temporarily) charge lower premium rates than the risk levels its models are suggesting in order to maintain market share.

Alternatively, a lack of competition in the market (or offering niche features on its products) may enable Predictable Life to charge a much higher premium rate and still retain a healthy market share.

[2]

The question was handled well by most candidates.

- (iv) Diversification between different product lines suggests that the “worst case” scenario for one product is not the same as on another product. As a result, combining the two products into a single offering may result in a lower combined economic capital requirement. The benefit of this can be passed on to customers.

[2]

The question was handled well by most candidates.

- (v)
- Number of products/policies per customer.
 - Profit per customer.
 - Risk capital per customer.
 - Customer retention rates.

[2]

The question was handled well by most candidates. Other reasonable suggestions included customer satisfaction ratings and rankings.

- (vi) Penny Saved Bank will most likely have on average:

- Slightly less healthy – more risky – lives because of lower underwriting standards (since any protection products are likely to be purchased specifically to cover a home loan rather than on a standalone basis)
- Slightly wealthier – less risky – lives because of the different target markets the companies operate in: bank customers have at least one other financial services product so on average are likely to have a higher net worth
- Slightly higher sums assured where the policies are sold specifically as part of the collateral on a home loan

This suggests that per policy Penny Saved may have a higher life insurance risk exposure than Predictable Life.

However, Predictable Life will likely have a larger number of policies and so will probably have greater exposure overall.

Although Predictable Life is more likely to have longevity exposures (if it writes immediate annuity business), which might partially offset its mortality risk exposure.

[2]

The question was handled well by many candidates. Most candidates made at least two valid points.

- (vii) There is an element of self-selection at work. People taking part in extreme sports are likely to be younger, fitter and healthier so that the lives insured by Extreme Life are likely to be younger, fitter and healthier on average than those insured by Predictable Life.

This should reduce the frequency of non-extreme sports claims.

However, there will be the additional claims arising directly from participation in extreme sports, the frequency experience under which could be more volatile if the portfolio is relatively small, given the restricted target market.

The fixed sum assured under Extreme Life policies reduces the variability of the claim amounts.

The business written by Extreme Life is short term and therefore it can probably change its pricing more rapidly to reflect changes in expected insurance risk, thus reducing its exposure to this risk.

If sold to small groups of travellers, Extreme Life business might have greater potential aggregation risk.

However, Predictable Life is more likely to have offsetting longevity exposures.

[3]

The question was handled well by most candidates.

- (viii) For:

- Extreme Life is taking a non-standard risk and so a “standard” formula approach is inappropriate.
- Extreme Life is the only player in this market and developing a more sophisticated risk assessment tool could help it ensure a longer term competitive advantage.

Against:

- Noting the simplistic pricing approach, it would appear that the internal model won't have a track record of being used in the business.
- Extreme Life appears to be a relatively small company and hence the cost of developing and implementing an internal model might be too onerous.
- As Extreme Life has a monopoly on this market it is likely to have exposure to the “good” and “bad” risks, and the expected frequency of claims should be relatively low. Hence a simple model could be adequate.

[2]

[Total 19]

The question was handled well by many candidates. Most candidates were able to make at least one point for and one point against an internal model.

6 (i) Exposure: Calculate the number of lawyers taking up the PLI

- The average of 1,2 and 3 is 2. Assume each of the small member firms taking up insurance has 2 lawyers.
- Assume that the most common and best way of pricing the insurance (and calculating the exposure) is per lawyer.
- Since the assumed take-up rate is 30%, the insurance will cover $.3 * 300 * 2 + .3 * 30 * 50 = 630$ lawyers

Calculate the premium income

Assume that in order to entice member firms to switch to NIC, NIC decides to charge each lawyer £3,000 rather than the market price of £4,000.

Hence the total premium income net of expenses of £200 per lawyer equals $630 * 2,800 = £1,764,000$.

This ignores any 99.5% stress of the expense assumption, which is assumed not to be material.

Calculate the claims cost at the 99.5th percentile

- The implied average claim per lawyer equals $.995 * 20,000 + .005 * 1,000,000 = 24,900$
- Assume that all claims are independent from one another.
- The mean aggregate claims cost equals $630 * 24,900 * .12 = 1,882,440$
- The coefficient of variation of the aggregate claims cost distribution equals 0.3 of the mean so that the standard deviation equals $.3 * 1,882,440 = 564,732$
- The 99.5th percentile of the aggregate claims cost distribution equals $3.5 * 564,732 + 1,882,440 = 3,859,002$
- So the additional claims cost (reduces year end assets) under the stressed scenario = $3,859,002 - 1,882,440 = 1,976,562$

Calculate the investment income net of the credit default losses at the 99.5th percentile

- Assume that the 1,764,000 is invested for one year at 4% before the claims are paid out.
- At the 0.5% percentile the investment income will be
 $.04 - .04 * .25 * 2.2 = .018$
- Also the 1,764,000 invested funds are assumed to be subject to one year's credit default losses whilst they are invested.
- At the 99.5% percentile this will be $.005 + .005 * .5 * 2.6 = .0115$
- Investment income and credit risk are stated to be 100% correlated. Hence the net investment income at the 99.5th percentile will be
 $(.018 - .0115) * 1,764,000 = 11,466$
- The mean net investment income will be $(.04 - .005) * 1,764,000 = 61,740$
- So the reduction in investment income earned (reduces year end assets) under the stressed scenario = $61,740 - 11,466 = 50,274$

Calculate the operational risk at the 99.5th percentile

- In the best estimate scenario, neither risk is expected to happen.
- The probability of Risk B occurring is beyond the 99.5th percentile and hence the capital cost is zero.
- Since the probability of Risk A occurring is below the 99.5th percentile, it could be assumed that the capital requirement for it is 500,000.
- Alternatively, assuming that Risk A is relatively uniformly spread in the tail, it could be considered to have a 90% chance of occurring
(= $(.05 - .005) / .05$) at the 99.5th percentile. Hence the capital cost for Risk A can be taken to be $500,000 * (.05 - .005) / .05 = 450,000$
- So the reduction in assets due to operational events under the stressed scenario = (say) 450,000

Calculate the diversification credit

As given in the question, claims cost, operational risks and market/credit risk are independent.

Assume that a normal approximation can be used for the aggregation (although this is less reasonable for operational losses)

Diversification credit formula = { square root of the sum of the squares of the three individual capital amounts, i.e. 1,976,562 and 50,274 and 450,000 }

Gives the required minimum capital requirement = 2,027,764

[16]

The question asked candidates to calculate a capital requirement for a hypothetical company. The question was handled well by some and quite poorly by others. Candidates were given credit for different approaches and particularly where they stated their assumptions. For example the above calculations for investment income could be done on a higher amount to reflect the fact that the start year best estimate liabilities would exceed the premium income under these assumptions and thus additional investment return would be earned on the additional assets that would have to be held to back those liabilities.

- (ii) Whilst theoretically sufficient, initial capital of this amount is unlikely to be acceptable to the regulator on its own because:
- There are no guarantees that the £1,764,000 of net premium will actually be received.
 - Claims might be due to be paid prior to receipt of the bulk of the premiums.
 - There exists a theoretical chance of more than two £1m claims and the total capitalisation of NIC would not support this.
 - In practical terms the regulator is likely to require NIC to hold sufficient capital to cover at least three or more large claims implying a minimum capital requirement of either £3m or more.
 - The actual take-up rate might be far higher than expected, making the capital requirement insufficient (obviously held premium reserves would increase to at least in part compensate).
 - The regulator might not like the model including its construct and its parameters, so it may impose a prudential margin.
 - The capital calculations are predicated on several assumptions, some of which may be incorrect e.g. that the risk categories are fully independent.
 - Similarly the regulator might not be happy with the approach taken to operational risk if Risk B is effectively ignored completely.
 - The regulator might require an additional buffer to be held so that NIC continues to demonstrate sufficient solvency even after an adverse event.
 - The cost of placing long-tailed liabilities into run-off might exceed the best estimate liability implicitly assumed.
 - Additional capital could be required to cover other risk categories.
 - For example, liquidity risk.

- Additional capital could be required to cover an expense stress.

[4]

The question was handled well by some and quite poorly by others. Additional valid points included that the new company is likely to have extra operational risks which were not modelled.

- (iii) Need to investigate the reason for the higher claims and research the extent to which it is likely to continue.

Also would investigate whether the higher claims are resulting from specific law firms only, and if so whether they are linked to the particular strategy or practices of that firm.

The most likely reason for the higher claims is that there have been systemic losses, meaning that the assumption that claims are independent from one another is not correct.

In order to test this assumption it would be necessary to conduct a survey of a random selection of claims to determine whether they are related in any way.

Assuming that the factor of 3.5 standard deviations to reach the 99.5th percentile of the aggregate claims cost distribution was made assuming that claims were independent from one another then it would be necessary to develop the assumption to allow for positive correlation between claims and possibly very strong positive correlation in the extreme cases.

The impact will be to increase the minimum required capital.

[3]

[Total 23]

The question was handled well by many.

END OF EXAMINERS' REPORT