

# INSTITUTE AND FACULTY OF ACTUARIES



## EXAMINATION

12 October 2015 (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 five 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** A leading international accounting and consulting firm has fully functioning enterprise risk management, corporate governance systems, internal audit and compliance functions. It has decided to appoint a Global Ethics Officer.

Describe the firm's likely motivation for the appointment. [Your answer should include reference to aspects of the role that may or may not already be found in other areas of the firm.] [6]

- 2** International Insurance is a multinational insurer headquartered in Europe. It sells all types of life and general insurance across the world in both developed and emerging markets. As part of its Solvency II preparations it is developing a group-wide Own Risk and Solvency Assessment (ORSA) template.

- (i) Describe the role of the ORSA and how it fits into the Solvency II framework. [2]

The sophistication of the markets in which International Insurance operates varies significantly. When introducing a standardised ORSA template across the group, it needs to convince local management about the benefits that this template provides.

- (ii) Outline the advantages of a standardised ORSA template, from the viewpoint of the local managers. [3]

The group ORSA will be built on a common set of risk reports which must be completed by each operating subsidiary on a quarterly basis. For example, one common requirement is a list of each subsidiary's five largest risk exposures.

- (iii) Suggest challenges that International Insurance may face when introducing this reporting requirement across the group. [5]

International Insurance would also like to establish a group-wide scenario testing program as part of its ORSA. The basis for the scenario test will be the local regulatory reporting basis of each subsidiary, rather than the Solvency II Pillar 1 basis.

- (iv) Comment on the appropriateness of this basis. [4]  
[Total 14]

- 3** (i) Outline the main features of the generalised extreme value (GEV) distribution. [Note that statement of cumulative distribution or density functions is not required.] [4]

A team manages a fund of hedge funds. This is an investment vehicle which itself invests in a range of hedge funds. These hedge funds follow a variety of strategies. Every month, each hedge fund in which the team already invests, or is considering investing in, supplies the team's manager with its investment return in the previous month.

The manager is concerned with the risk of extreme adverse events in each of the hedge funds that the team already invests in or is considering buying. The GEV distribution has been proposed to model the extreme investment returns, including the probability, for each hedge fund, of obtaining a monthly return of less than  $-50\%$ .

- (ii) Describe how the GEV distribution could be fitted as part of this analysis. [4]
- (iii) Discuss the extent to which the proposed GEV approach is appropriate for modelling the extreme investment returns. [6]

[Total 14]

- 4** Solvania is a large European country where the government has committed to preventing global warming. In order to reduce its greenhouse gas emissions, three years ago the Solvanian government implemented legislation to encourage the installation of solar panels (i.e. panels which generate electricity from the sun).

Under this legislation any household can install solar panels at their property, typically at a cost of around €5,000. Any power that they do not use can be sold back to the main power grid at a subsidised rate. The subsidised rate is the standard rate, which increases in line with inflation, plus a 25% subsidy. The subsidy is funded by higher electricity bills for other customers, overseen by the electricity regulator, and is guaranteed for 25 years from the date of installation.

As an alternative, the Solvanian Solar Company (“SSC”), offers households the installation of the solar panels for free. Under this arrangement SSC pays for the installation and allows the household to use as much of the electricity generated as they require. Any power that is not used is sold back to the power grid, but SSC receives the subsidised rate for the unused power rather than the household.

Currently, it is not possible to monitor how much power from the solar panels is used by the household. It is therefore assumed that half of the total power generated is unused.

Due to more households installing solar panels than anticipated, the Solvanian government tried to reduce the rate at which unused power can be sold back to the power grid. However, this was prevented by Solvania’s courts. The government was therefore restricted to reducing the subsidy for new installations from 25% to 12½%.

As a result, SSC has decided to suspend offering free installations. In addition, the senior management of SSC has decided to securitise the future revenues for the unused electricity in order to free up capital that it can use to pay a special dividend to shareholders.

The securitised vehicle will issue a 25 year term €100m loan, the first of its kind in Solvania, with the following features:

- The securitised vehicle will purchase the future revenues received in respect of the unused electricity and these will provide the security for the loan. SSC will retain the equity tranche.
- The interest rate payable on the loan is 4% per annum above the yield achievable on Solvanian government index-linked bonds of similar duration.
- The loan to value ratio is 75% with full amortisation over the 25 year term.
- The investment management fees charged by the investment bank intermediating the deal are expected to be 50 bps each year, increasing with inflation.

The Capital Management Director at the Solvanian Life Assurance Society (“SLAL”) is investigating the opportunity to invest in the above loan, noting that a decision on this is required within the next two weeks. Investment in the loan would represent a divergence from its current investment mandate, which specifies investment only in Solvanian government and corporate debt.

- (i) Describe the risks associated with investing in the loan and how these may be mitigated. [17]

Over the years, SLAL has written large portfolios of term assurance and immediate annuity business. Its current investments, i.e. Solvanian government and corporate debt, are typically available for terms up to 15 years.

- (ii) Assess the suitability of the loan as an asset to back SLAL’s liabilities. [6]

SLAL intends to investigate a number of stresses as part of its economic capital assessment and will subsequently combine the capital impacts using a correlation matrix.

- (iii) Describe how such stresses might be set for two of the more material risks relating to this potential investment. [4]  
[Total 27]

Solvania is a large European country with a mature financial services industry. The Solvanian Affluent Retirement Society (“SARS”) writes both immediate annuity and unit-linked savings business. SARS is indirectly exposed to the equity markets, since the annual management charges (“AMCs”) deducted from policyholders’ unit funds are expressed as a percentage of the value of the underlying assets which include equities. SARS has no other exposure to equity risk.

SARS’ Capital Management Director is concerned about the impact of changes in the value of the AMCs on SARS’ capital position.

The regulatory regime requires SARS to assess its capital on the following bases:

- Basis 1 – This involves the market consistent valuation of all “admissible” assets less a 2.5% prudential margin, and the prudent valuation of liabilities. The present value of future profits is not an admissible asset. A “traditional capital” buffer equal to 2.5% of the liabilities must be held. [Some asset types are not deemed to be “admissible” for valuation purposes, which means they are assigned a zero value regardless of the actual market value.]
- Basis 2 – This involves the market consistent valuation of all assets and the best estimate valuation of liabilities (discounted using market consistent rates). Risk-based economic capital must also be held, where this is assessed explicitly and is calibrated to the 99.5th percentile loss over a one year time horizon.

The Capital Management Director is considering the use of derivatives to hedge the equity risk, and wishes to understand better how futures, put options and put spreads could be used.

A put option hedges all equity exposure below a defined exercise price  $E$  (also known as the strike price), while a put spread only hedges the equity exposure between a defined “higher strike”  $E_H$  and a defined “lower strike”  $E_L$ . The put spread is therefore similar to a put option, but the payoff is limited to a maximum of  $E_H - E_L$ .

- (i) (a) Write down an expression for the payoff at maturity for each of the following, all on an equity index:

- the purchaser of a put option
- the purchaser of a put spread
- the seller of a futures contract

- (b) Sketch a graph of these three payoff profiles.

[6]

- (ii) Discuss the advantages and disadvantages of these three financial instruments in terms of managing SARS’ equity risk, taking into consideration the two regulatory capital assessments.

[12]

The following formula can be used for the valuation of a put spread:

$$\begin{aligned}
 PS_t(E_H, E_L) &= P_t(E_H) - P_t(E_L) \\
 &= E_H e^{-r(T-t)} \Phi(-d_2[E_H]) - X_t e^{-q(T-t)} \Phi(-d_1[E_H]) \\
 &\quad - E_L e^{-r(T-t)} \Phi(-d_2[E_L]) + X_t e^{-q(T-t)} \Phi(-d_1[E_L])
 \end{aligned}$$

where:

- $PS_t(E_H, E_L)$  is the price at time  $t$  of a put spread with “higher strike”  $E_H$  and “lower strike”  $E_L$
- $P_t(E)$  is the price at time  $t$  of a put option with exercise price  $E$
- $r$  is the continuously compounded risk-free rate
- $T$  is the time of maturity
- $X_t$  is the price of the underlying asset at time  $t$
- $q$  is the continuously compounded rate of dividend income
- $\Phi(u)$  is the cumulative Normal distribution function at  $u$

and:

$$d_1[E] = [\ln(X_t / E) + (r - q + \sigma^2 / 2) \times (T - t)] / [\sigma \sqrt{(T - t)}]$$

$$d_2[E] = [\ln(X_t / E) + (r - q - \sigma^2 / 2) \times (T - t)] / [\sigma \sqrt{(T - t)}]$$

for the appropriate values of  $E$ .

- (iii) Justify the above valuation formula, with reference to your answer to part (i). [2]

The National Bank of Solvania (“NBS”) has recommended partially hedging SARS’ exposure to equity risk using a put spread with a term of 15 months and a “higher strike” and “lower strike” of 85% and 70% respectively, where these are expressed as a percentage of the current value of the underlying equity index. The Capital Management Director is keen to examine partially hedging SARS’ exposure to equity risk using this put spread.

The NBS has quoted a price for the put spread of 2.3% based on volatilities at the “higher strike” and “lower strike” of 19.8% and 24.3% respectively.

The relevant risk-free rate is 0.5% p.a. and the dividend yield on the benchmark Solvanian equity index is 3.8% p.a. (both are continuously compounded).

- (iv) Verify the price of the put spread quoted by NBS, using the indicated volatilities. [7]

SARS is considering the impact of the put spread on the two regulatory capital assessments. For Basis 2, it can be assumed that the diversified stress that applies to equity prices is a fall of 30% and that stressed equity volatilities are 5% higher.

At SARS' request, NBS has analysed how the value of the put spread would change in a variety of scenarios. Its analysis covered the following scenarios:

- With current equity prices and volatilities unchanged, the value of the put spread at the start of the year is 2.3%.
- With current equity prices stressed down over the course of the year by 30% and equity volatilities stressed up by 5%, the value of the put spread at the end of the year is 11.4%.
- With current equity prices immediately stressed down by 12% and equity volatilities immediately stressed up by 5%, the value of the put spread at the start of the year is 4.7%.
- With current equity prices immediately stressed down by 12% and then further stressed down over the course of the year by 30% and equity volatilities stressed up by 5%, the value of the put spread at the end of the year is 14.1%.

The present value of the AMCs on funds invested in equity markets is approximately €1,000m, and the Capital Management Director wishes to hedge this exposure in full.

- (v) Determine the immediate decrease in the required economic capital upon the purchase of the put spread, and hence also the increase in the surplus capital under the Basis 2 "economic" assessment. [3]
- (vi) Determine the immediate impact on the surplus capital under the Basis 1 "traditional" assessment, upon the purchase of the put spread. [1]

The Capital Management Director would like to understand how the hedge responds to smaller and more likely changes in equity prices and volatilities. A 12% fall in equity prices along with a corresponding increase in equity volatilities of 5% is thought to have a 20% probability.

- (vii) Determine the additional impact on the available and required economic capital and on the surplus capital under Basis 2, assuming that equity prices fall by 12% and equity volatilities increase by 5% the day after the put spread is purchased. [5]
- (viii) Comment on whether SARS should purchase the put spread, including any additional information that would be required. [3]

[Total 39]

**END OF PAPER**