

# **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 15<sup>th</sup>) 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)).

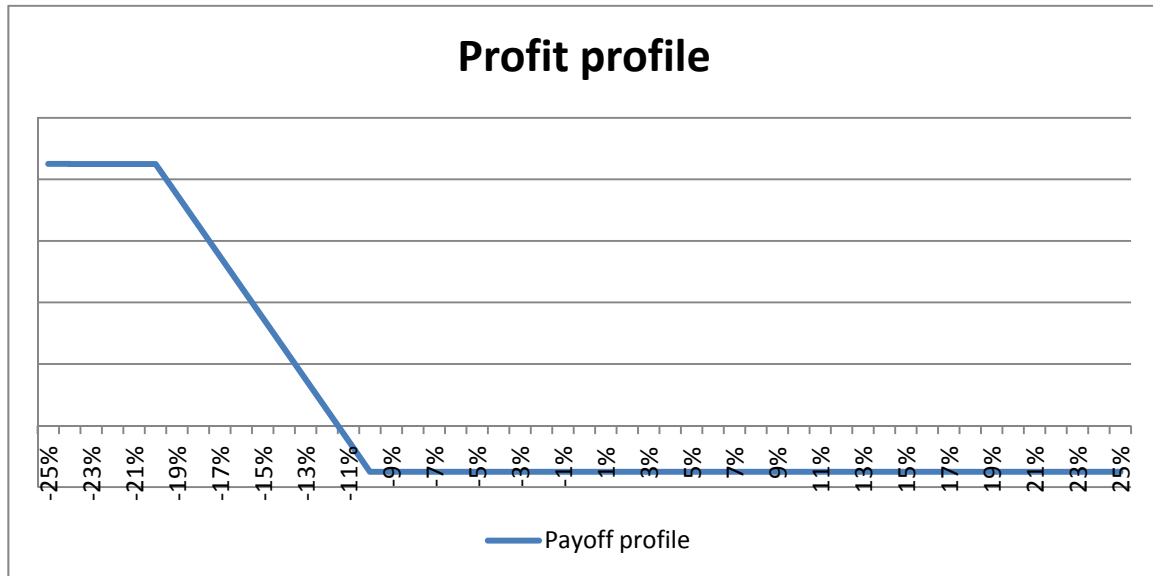
However, given that it underwrites only a small volume of annuity business it may find that significant investment in underwriting models is not cost effective. Further it will not have sufficient own-experience data to support this development and so would have to rely on others' data to do this.

- 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  $\alpha$  was set to 2.5.
- Setting the parameter  $\alpha$  to 1 yields the independence copula. Alternatively, as  $\alpha$  tends to  $\infty$ , it tends to the minimum copula (i.e. co-monotonicity). Assigning a larger value to  $\alpha$  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**