INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

April 2019 Examinations

Subject SP9 – Enterprise Risk Management

Specialist Principles

Introduction

The Examiners' Report is written by the Chief 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

Mike Hammer
Chair of the Board of Examiners
July 2019

A. General comments on the *aims of this subject and how it is marked*

1. The aim of the Enterprise Risk Management (ERM) subject is to instil in successful candidates the key principles underlying the implementation and application of ERM within an organisation, including governance and process as well as quantitative methods of risk measurement and modelling. The student should gain the ability to apply the knowledge and understanding of ERM practices to any type of organisation.

2. The SP9 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.

3. 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.

4. 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.

5. Candidates who give well-reasoned points, not in the marking schedule, are awarded marks for doing so.

B. Comments on *student performance in this diet of the examination.*

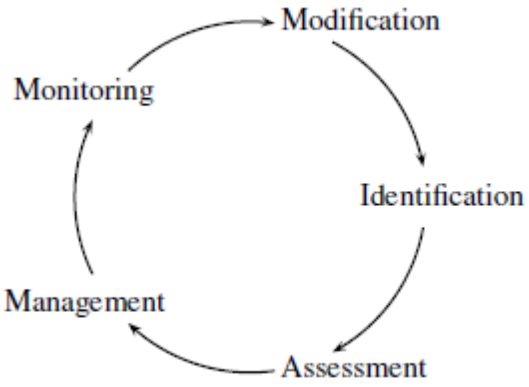
Many students performed well in this diet. Knowledge based questions were generally but not universally well answered. The key challenges seemed to be two areas: First, where a process was to be described, candidates often struggled to outline all of the steps required and apply them to the scenario. Second, where information was available, candidates often struggled to explain how that information could be used in the specific scenario.

C. Pass Mark

The Pass Mark for this exam was 61

Q1

(i)



[½ mark for each element]
Plus external factors: competitive environment, regulation etc. [½]

Alternative words such as measurement instead of assessment are acceptable
If the diagram is not used then some reference to the cycle or that the process is continual… etc instead of the arrows is required – otherwise max 1½

[Total 3]

(ii)
It is wrong to suggest that risk control cycle cannot be adapted to allow for the new analytical technique and operating model. [1]
With more advanced analytics, the firm may be able to increase the efficiency of the risk control cycle. [1]
By not using the control cycle, the firm may miss out on the following benefits
Manage risks systematically with a robust continual process… [½]
- this is important given the operating model's heavy reliance on outsourcing [½]
- and the untested nature of the new analytical technique. [½]

Understanding how risk exposure compares to risk appetite. [½]
The focus on analytics may cause the firm to overlook risks that are difficult to quantify [½]
Ensure that the definition of risks is consistent across the different functions / outsourcing partners … [½]
- and consistent approaches are used regarding risk quantification [½]

Determine its aggregate risk exposure … [½]
- and hence identify any concentrations of risk or diversification benefits [½]

Detect shifts in market dynamics and/or customer preferences on a timely basis and make appropriate adjustments to pricing strategy. [½]
Identify upside risks as well as downside risks in order to optimize them. [½]
Identify emerging risks quickly and react quickly to them. [½]
Build a culture of learning from mistakes and continued improvement. [½]

The company may find it needs to use the ERM control cycle to satisfy regulation/legislation, For example [½]

- Solvency II in Germany and Europe requires companies to carry out an Own Risk and Solvency Assessment (ORSA), which involves the identification and management of risks. [½]
- Sarbanes-Oxley in the US requires companies to produce an Internal Controls Report setting out how risks (in particular fraud) are managed. [½]

The statement talks about pricing and underwriting risks but does not specify how the other risks are managed. [1]

For example

- Operational risk [½]

[11½, Max 6]

(iii)

model risk – the new model may not describe risks correctly. [1]

parameter risk – as this is a new business, there may not be sufficient data to correctly parameterise the model. [1]

market risk – the investment returns on premiums received may be lower than expected [1]

credit risk – risk that premiums are not received. [1]

credit/counterparty risk – risk that outsourcers fail to deliver services. [1]

liquidity risk – risk that investment cannot be liquidated when needed. [1]

insurance/mortality/reserve risk – risk that claims are higher than expected. [1]

operational risk – risk that disruption to internet access. [1]

operational risk – risk that computer centre damaged. [1]

operational risk – risk of fraudulent claims. [1]

operational/regulatory risk – risk of legislative change restricting access to the required data. [1]

regulatory risk – e.g. risk that additional laws for online insurers introduced. [1]

regulatory/political risk – risk that regulations related to outsourcers are changed. [1]

expense/expense inflation risk – risk that expenses are higher than anticipated. [1]

lapse risk – risk of a higher level of policy lapses than anticipated and new business costs are not covered. [1]

lapse risk – risk of selective lapses so that the remaining policies have worse mortality than anticipated. [1]

Anti-selection risk – risk that customers attempt to 'game' the algorithm. [1]

business risk – risk that sales volumes are higher than expected and there are not enough resources to support it e.g. capital, technology resources...*(any reasonable example)* [1]

business risk – risk that sales volumes are lower than expected and expenses are not covered by premiums. [1]

foreign exchange risk – risk that adverse movements in exchange rates cause overseas claims costs to risk more quickly than expected. [1]

catastrophe risk – risk that a single event causes multiple claims e.g. a flu epidemic. [1]

If risks above are listed but not described, ½ mark should be awarded for each risk.
Any other reasonable risks allowed: for other risks, full mark is awarded only if the risk is listed and outlined, otherwise no marks. [1 per risk]

[21, Max 10]

(iv)

The impact of a catastrophe would typically be material enough to cause significant losses. [1]

The firm may choose to only underwrite in areas where catastrophes are extremely rare [½]

Or exclude more common catastrophes from the cover… [½]
… which may make its policies uncompetitive in the marketplace. [½]
The low frequency/high severity nature of these events mean that impossible to model them accurately… [1]
… so the reserve the firm sets up is going to be unused, or insufficient to cover catastrophe losses. [1]
Reinsurers are typically better placed to manage and model these types of risks due to their expertise [½]
…and the diversification benefits of writing these covers around the globe allows them to price competitively. [½]
The firm is based in Germany so must comply with Solvency II regulations. [½]
The firm's capital requirement should allow for the risk of individual rare events… [½]
…So this reserve may not be required for risk management purposes. [½]
The firm's capital requirement should also allow for the counterpart risk of reinsurance [½]
The insurer should compare the size of the reserve and the opportunity cost with the cost of taking an insurance cover [½]
… and consider the impact on the capital requirement from both options. [½]

[8½, Max 4]

(v)

Advantages:
More efficient process, i.e. quicker to achieve sales than a competitor … [1]
… or to implement any pricing changes. [½]
Can react quickly to experience trends… [½]
… due to being able to run experience analysis & forecasting more frequently. [½]
Can deliver unbiased analysis … [½]
… and (largely) human error-free. [½]
Approach forces experts to document and codify as much as possible how decisions in relevant areas are made, thus increasing transparency. [½]
Free up time for humans to focus on innovation. [½]
As a new firm, the situation lends itself easier to adopting such a radical idea than an established firm, given cultural and infrastructural aspects. [1]
Cost reduction from being able to have smaller workforce [½]
..which can be used to reduce premium or increase profits. [½]
Instantaneous recording of new business means more timely financial reporting and risk reporting is possible. [½]
Ensures continuity across the different timezones. [½]

Disadvantage:
Unable to underwrite non-standard policies automatically… [½]
…or allow for new and emerging rating factors… [½]
… which may frustrate potential customers / limit market coverage. [½]
Without manual intervention / checking, may generate unreasonable results [½]
For example

- a risk of model error(s) that go unspotted [½]
- a risk of finalised contracts going out based on incorrect premiums [½]
- a risk of anomalies in the pricing due to random fluctuations in experience / lack of smoothing. [½]

for examples [1½, Max 1]

Such errors may result in financial losses … [½]

… or reputational damage. [½]
Human errors can still exist (in coding the model), which may have a material negative impact. [1]
The model may not be able to perform experience analysis and forecasting as well as humans, due to difficulty in codifying expertise and judgement in these areas. [1]
As a new firm, difficult to obtain sufficient amount of high quality historical data to train model and verify analytical results, though this situation will change over time as the business grows. [1]
Likely to still require some kind of fail-safe mechanism, in case things go badly wrong, so probably not able to truly remove all manual intervention. [½]
The pricing model may not be well understood – it may become a "black box" [½]
For example

- if there is an IT failure manual pricing may not be possible if no-one understands the pricing process. [½]

There is a risk of breaching data protection legislation, for example if the uses of the data have not been made fully clear to customers. [1]

[17½, Max 10]
[Total 33]

This question was generally well answered by candidates. Well prepared candidates were able to apply both principles and knowledge to the scenario described and generate a broad range of relevant points on the longer questions.

Q2

(i) $\rho_{A+B} \leq \rho_A + \rho_B$
Where ρ_X is the risk of X. [1]
Credit to be given for appropriate non-mathematical definition

(ii) $Diversification\ benefit := \rho_A + \rho_B - \rho_{A+B}$
Equal credit given for $\rho_{A+B} - (\rho_A + \rho_B)$ [1]
Credit to be given for appropriate non-mathematical definition

(iii) Value at Risk (VaR)

- Require use of a parameter, $\alpha \in (0,1)$.
- $VaR_\alpha(X) = x\ such\ that\ P(X > x = \alpha)$ over a specified time horizon, where X is loss.
  Credit for equivalent definition

- VaR is not subadditive
- But VaR meets all other criteria for a coherent risk measure
- VaR is relatively stable (unaffected by very low-frequency, high-severity events)
- VaR is widely-used
- VaR is simple to communicate to a non-technical audience.

Tail Value at Risk (TVaR)

- Requires use of a parameter, $\alpha \in (0,1)$.
- $TVaR_\alpha = E(X|X > VaR_\alpha(X))$ over a specified time horizon, where X is loss

Credit for equivalent definition

- TVaR is a coherent risk measure
- TVaR can be materially distorted by very low-frequency, high-severity scenarios
- TVaR is quite commonly used, but not as commonly as VaR
- TVaR can be difficult to communicate to a non-technical audience.

Expected Shortfall (ES)

- $ES = TVaR_\alpha(X)(1 = \alpha)$ over a specified time horizon, where X is loss.

Credit for equivalent definition

- ES is a coherent risk measure
- ES can be distorted by very low-frequency, high-severity scenarios
- Though it is usually more stable than TVaR
- ES is not commonly used
- ES is simple to communicate to a non-technical audience.

Per core reading note that sometimes TVaR is called expected shortfall and ES=E[X/X>0] where X is loss, rather than the alternative definition used here.

Probability of Ruin (PR)

- $PR = Probability(X_t < 0)$ for some t, where X_t is the surplus at time t.

Credit for equivalent definition

- This requires a limit on the maximum t considered
- PR is not a coherent risk measure
- PR is relatively stable: it is not distorted by very low-frequency, high-severity scenarios
- PR is not commonly used
- PR is simple to communicate to a non-technical audience.

for each point [½]
per risk measure [Max 2]
Max of 2 risk measures considered
Any other equivalent definitions accepted
[Max 3]

(iv)

Regulators

- Interested in ensuring the solvency of individual firms.

Policyholders

- Interested in ensuring that their legitimate claims will be paid.

Rating agencies

- Interested in ensuring that they can appropriately assess the creditworthiness of individual counterparties

Competitors
- Interested in understanding the strategy and financial position of their competitors

Creditors
- Interested in ensuring that the payments due to them will be made in full

Investors / shareholders
- Interested in ensuring the ongoing functioning and growth of the company

Company directors
- Responsible for ensuring the accuracy and completeness of the disclosures
- Also interested in understanding what information is available to their competitors

Company employees
- Interested in ensuring the ongoing functioning and growth of the company

Government agencies
- Interested in ensuring that individual companies are fulfilling their obligations (e.g. tax, anti-money laundering, financial conduct etc.)

for each stakeholder [½]
for each explanation [½]
[Max 5]

(v)

Regulators
- Interested in information which threatens their defined objectives

For example
- unrealistic growth targets, trends towards loss-making etc.
- A-FSA's primary objective is threatened by the risk of bankruptcy of market participants, this information would be a leading indicator of these risks.
- Its secondary objective is threatened by the risk of systemic / 'contagion' risks. This information would allow consistent comparison across entities to identify such risks
- And helps determine when regulatory intervention may be needed
- Understanding the security of market participants, and how they might be linked, is useful in assessing these risks
- Can use the information on risk management and governance frameworks to inform recommended 'best practice'
- Can also use the information for warning signs of corruption.

Policyholders
- Interested in information on the financial strength of the company
- Including the liquidity of the company's assets
- And the effectiveness of governance and risk management

- Allows them to assess the likelihood that they can rely on the company to pay claims as they fall due
- Some information may be too complex so of limited value.

Rating agencies

- Financial information informs about the probability of bankruptcy, which risks creditors not being paid
- Will help them to identify trends, either within a company or across the industry
- If this company is not being rated this may be the only information available to the rating agency for benchmarking across the industry
- Contains sufficient information to use as volume measures for the agencies' own risk models
- Governance information informs about the reliability and accuracy of the information provided and of future plans
- Likely to have a relatively short time horizon (e.g. 3-5 years) as the rating can be updated if new information comes to light
- Biographical information gives confidence the directors are fit and proper and free from corruption. [1]

Competitors

- Understanding of the company's future strategy
- Identify particularly profitable / unprofitable lines of business for new opportunities
- Allows them to benchmark their own risk profile and performance against others'
- Allows them to identify best practice in risk management and governance within the industry
- May help to identify opportunities for M&A activities
- Allows them to identify key employees

Creditors

- As rating agencies, but specific to the likelihood of their specific debts not being paid
- .. so the level of gearing, the existence of any prior-ranking, debt and the likelihood of default
- ... and from the market value of assets, the likely recovery rate on default
- Time horizon may differ depending on the type of credit being offered
- Longer-term creditors will be more interested in governance and future projections. Shorter-term creditors will be more interested in current financials and risk profile.

Investors / shareholders

- Financial information allows investors to value the likely future cashflows, in order to value the investment [1]
- Biographical information gives confidence the directors are suitably qualified and experienced to run the company
- ... and indicates if they are likely to be free from corruption

- Governance information gives:
    1. Confidence that the information they are relying on is accurate and complete
    2. Confidence that the plans set out can be achieved
    3. Confidence that the company will react appropriately to future circumstances.

Company directors

- Current financials and current risk profile provide a good understanding of the company's current position [1]
- Whether or not the disclosures are public is not relevant to them
- Planned premiums and loss ratios give an indication of future profitability and hence of remuneration for executive directors
- This allows them to decide what changes should be made to improve the company for the future
- And keep their jobs

Company employees

- Interested in information on the financial strength of the company
- Including the liquidity of the company's assets
- And the effectiveness of governance and risk management
- To assess their job security and remuneration
- ...including long term future items like pensions
- Some information may be too complex so of limited value.

Government agencies

- Use will vary by government agency:
  For example
    - tax authorities will be interested in P&L and balance sheet information.
    - competition authorities will be interested in balance sheet and business plan information.

  for any other valid example [½, Max 1]

- Current financials will provide quantitative information to tax authorities on amounts due
- Governance information will provide qualitative information to competition authorities on how to ensure the market is not being undermined.

unless otherwise stated, for each point [½]
per stakeholder [Max 2]
[Max 10]

(vi)

Require specific licenses for specific lines of business

- Ensures that only those with sufficient expertise, systems and controls operate in specific sectors of the market
- Especially for systemically important products such as reinsurance.

Require independent sign-off / audit of key financials

- Particularly regarding the setting of technical liabilities
- Ensures that the information provided to stakeholders is reliable
- Forces management to really understand the company's risk profile.

Limit the ways in which insurance can be sold to retail customers
- E.G. requiring particular disclosures or cooling-off periods
- Ensures that vulnerable customers are not mis-sold inappropriate products, which would undermine confidence in the market.

Require particular checks to be run on new customers (e.g. Know Your Customer checks)
- Ensures that the insurance market is not used as a 'front' for illegal activity
- Maintains underwriting standards within the industry.

Restrictions on the storage, use or transfer of data
- Ensures that personal data is treated appropriately
- Allows legitimate customers to interact with the industry with confidence.

Requirements on segregation of funds in specific cases
- E.G. with-profits policy funds held separately
- Ensures that individual customers can be sure their funds are available as needed.

Require minimum levels of capitalisation
- Based on risk profile or absolute limits
- Ensures that individual customers can be confident their claims will be paid if needed.

Regulations on the process for transferring liabilities between companies
- Allows failing companies to be taken over by stronger ones, reducing the chance of default
- But requires strict regulations to ensure that policyholders are not disadvantaged.

Require minimum standards around setting of technical liabilities
- Ensures financial soundness of both individual companies and the industry as a whole
- Reducing probability of default
- Or contagion
- Facilitates comparison between companies and across industries.

Require that key individuals are 'fit and proper' to practice
- have the relevant qualifications and experience
  For example
  - that individuals (such as actuaries) in key roles hold practising certificates
  - do not have a criminal record.

Require frequent assessments/reports

- Require that companies assess their own solvency position on an ongoing basis over and/or longer time horizon
- … and identify their risks and their approach to risk management (e.g. an ORSA)
- Require a report on internal controls as part of the reports and accounts …
- … to demonstrate that the company has processes in place to safeguard its financial and other assets (aka SoX)
- Require compliance with Corporate Governance Codes …
- … or require that insurance companies explain in their Report and Accounts why they have not complied ('Comply or Explain' approach)
- Require report on anti-money laundering controls to prevent fraud / corruption
- Require annual assessment from the regulator on these reports.

'Discuss' not 'list'

for a heading and a bullet point [1]
per additional point [½]
[Max 5]

(vii)

Underwriting risk

Gross claims incurred are dominated by motor business

- This business appears to be very stable

Next biggest line of business by gross claims is commercial liability business

- Which is also relatively stable

The two smallest lines of business (commercial property and other) based on gross claims seem to be more volatile.

Reinsurance recoveries are also dominated by motor business

- Which suggests that this may not be risk-based reinsurance
- Possibly a quota share arrangement
- Though material recoveries may be apparent in other lines of business in extreme claims.

'Other' reinsurance recoveries are very stable

- Though the gross claims are very volatile
- So either the limits are being breached regularly
- Or the reinsurance programme only covers particular subsectors of the book
- 'Other' reinsurance reserves are decreasing though
- Which suggests those recoveries are being paid faster.

Reinsurance reserves for 'Commercial property' were very stable

- Though the gross claims ranged from 0 to 25.
- This may be a single historical claim (or event) that is taking a long time to settle
- If so, this may be subject to significant disputes
- So may be very uncertain.

Reinsurance loss ratio is 62.5% / 64.7%.

- Compares to a gross loss ratio of 72% / 76%
- As the RI ratio is close to the gross, this is likely to be lower layers / proportional cover
- Therefore relatively inefficient from a risk/return perspective

- Though reinsurance may be purchased for other reasons.

Underwriting profit was positive, but smaller than investment income in both years.

- Suggests that profit margins are quite fine
- Combined ratios were 97% in both years *[or any other reasonable quantification]*

Expenses have dropped significantly over the year

- There may be an increase in operational risk as a result
- Especially as expenses have dropped alongside increasing premiums
- Expense ratio has dropped from 24.2% to 19.5% in one year
- This is a significant reduction in a single year
- This may reflect a weakening of underwriting standards
- Or this may reflect one-off elevated expenses in 2017.

Reserve risk

- Commercial liability reserves are growing significantly
- By almost as much as the incurred claims
- So very little of the incurred claims are being paid.
- Which suggests that most of the risk is coming from historical business
- Which will not be profit-generating.

'Other' reserves are very stable

- But the incurred claims are not
- Which suggests there is a volatile, short-tailed component to the business
- As well as a more stable, longer-tailed component comprising the reserves
- The reserves for the other lines of business are very stable.

Market risk

Investment income is volatile

- Dropped from 4.5% to 2.9%) *[or any other suitable quantification]*

Overall, the investment portfolio seems to be getting riskier:

- Increase in equity investments
- Increase in overseas investments, particularly corporate bonds
- Although cash holdings increased each year
- In both absolute and relative terms.

Property investments are small

- But may incur costs (e.g. maintenance, voids etc.)
- And may be hard to liquidate as required.

Some asset values (e.g. domestic government bonds and property) have not changed over time

- This may mean that the balance sheet valuations do not reflect the economic value of the assets
- Or it may represent a deliberate re-balancing of the portfolio
- In which case re-balancing costs may be incurred in future.

Significant proportion of assets are domiciled overseas.

- So there is significant foreign exchange risk
- Not holding any derivatives so this won't be hedged.

Corporate bond holdings have increased over time

- So there is risk of credit spreads widening and asset values falling.

Cash holdings are smaller than reserves

- So liquidity may be an issue
- The company is relying on the liquidity of the other invested assets
- Domestic government bonds may not be totally liquid in a developing country
- However, the ratio of cash and equivalent assets to total liabilities has increased, 41.9% (end 2016), 47.6% (end 2017) and 49.7% (end 2018), representing a reduction in liquidity risk over the period.

Credit risk

Reinsurance reserves are decreasing even as gross reserves are increasing

- Which may be luck, or may represent lower levels of coverage.

Unable to assess the soundness of the existing reinsurers

- Though note no impairment charges on the financial statements.

Reinsurance spend is relatively low (around 10% of GWP)

- So this is unlikely to be one of the key risks.

Counterparty risk on the bond holding

- Likely significant given the proportion of assets in corporate bonds.

Operational risk

Legal risk writing liability insurance

- There is the potential that poorly-established legal precedents might give rise to latent liabilities.

Political risk: corruption

- Risk that legislation may change unexpectedly, based on external pressures
- If corruption is common, there may be heightened risk of fraudulent claims.

Lots of other possible operational risk examples: Max 2 for risks not shown here

Overall:

- Unable to comment on the full risk profile from the information [1]
  For example
  - not enough information on operational risks to assess the risk profile
- Underwriting risk comes from a large, stable portfolio with a small amount of riskier business
- Margins are fine and expenses are being cut while premium is growing
- The reinsurance programme appears to be relatively inefficient
- The company seems to be taking on more market risk. The company seems to have historical reserves building up from longer-tailed business
- Profit margins seem to be quite thin
- But the RoE is quite high (22% and 15%)
- Which suggests that the company may not be holding enough capital for its risk profile.

per additional valid point relating question and the data given [½]
[Max 12]
[Total 37]

Candidates generally answered the knowledge elements of parts i to iv well.
Some candidates did not refer to enough of the available information in part v and/or did not explain how the information could be used so could not generate many distinct marks.

Some candidates listed rather than discussed for part vi so missed some available marks
Candidates that were able to interpret the quantitative available information to identify risks, indicate the level of the risk and identify trends in that risk scored well on part vii.

Q3

(i)

WidgetCo is small, so ERM function does not need to be large (e.g. 3 FTEs)
WidgetCo is spread geographically, so ERM staff should be embedded in local teams

- Likely to be part-time roles, possibly using existing staff members
- With split reporting lines to the CRO and their current manager.

Regional office management should explicitly be given responsibility for risk management.
Likely to require a member of staff at head office

- To coordinate and standardise policies across the hubs.

Should be headed by a CRO

- Who should sit on, or report to, the board.

for each point [½]
[Max 3]

(ii)

Risk management should be everyone's responsibility.
The tone should be 'set from the top' e.g. examples of commitment and buy-in from leadership.
A no-blame culture should be established, where people can discuss mistakes without fear of recriminations.
An easy reporting mechanism should be created for employees to report risks and ideas.
Lessons should be learnt from past mistakes.
Training should be provided to encourage knowledge sharing.
All staff encouraged to consider upside risk as well as downside risk.
Staff should be actively encouraged to criticise and raise potential risk problems.
Risk management is built into each employee's objectives and performance measures.
for each point [½]
[Max 2]

(iii)

Deterministic model:

- A model with a single set of inputs ...
- which produces a single result
- the output is therefore a single outcome.

Stochastic model:

- A model that runs many times (often hundreds of thousands), each time with slightly different inputs, giving slightly different results
- The output is therefore a range of possible outcomes.

for each point [½]
[Max 2]

(iv)

Deterministic – pros:

- Provides definite answer
- Usually runs quickly
- ...so can be cheaper
- Possible to understand exactly how the result is derived
- Simple to run scenario tests.

Deterministic – cons:

- Does not provide a range of outcomes
- Some calculations / distributions can't be assessed analytically in a deterministic model
- No indication of the *likelihood* of the output / a particular scenario occurring
- Scenarios are limited to those thought of by the modelling team.

Stochastic – pros:

- Allows a wider range of scenarios to be tested, including those that may not have been considered by the modelling team
- Easier to communicate the uncertainty of the output
- Enables measures of both likelihood and severity to be calculated
- Better modelling of guarantees and options
- Able to provide a range of outcomes
- Can determine compound outputs which cannot be assessed analytically
- Including dependencies.

Stochastic – cons:

- Required more expertise to build
- Can take a long time to run
- Can be very opaque
- Can be hard to run scenario tests
- Can be hard to understand the output
- May result in spurious accuracy, especially if data to set assumptions if scarce.

for each point [½]
[Max 3]

(v)

Recommend deterministic model.

- Simpler to build for a small, newly-established function
- Easier to determine appropriate inputs given limited data as the company is new
- Easier to communicate the results
- Faster to run/ lower computational power.

OR:

Recommend stochastic model.

- Provides a wider range of information for management to use
- In particular, more sophisticated options for allocating capital to the different regions
- Which will provide more options for both strategy setting and allocating limits
- As experience data is limited, a range of outcomes should be considered.

for each point [½]
[Max 2]

(vi)

(a) The model should produce results for each:

- Hub
- Line of business
- Risk type
- Should include expected profit as well as downside risk.

WidgetCo should allocate the overall risk to each of these levels

- There are a number of different ways of doing this
- The methodology used should be selected with reference to the use to which the allocation will be put: in this case, strategic direction.

This can be carried out using selected scenarios with a deterministic model
... or the distributional output from a stochastic model
WidgetCo can then calculate the risk/return ratio at each of these levels. This will allow WidgetCo to identify areas with relatively high or low returns for a given level of risk.
WidgetCo should consider expanding in areas with high relative returns, and contracting in areas of low relative returns

- This will improve the weighted average risk / return ratio for WidgetCo in aggregate
- This will allow WidgetCo to generate a higher return for the same level of risk (or a lower level of risk for the same return).

WidgetCo can therefore design an 'ideal' portfolio.
However, WidgetCo should consider whether there may be other reasons for these areas to look particularly high / low return:

- Choice of risk allocation methodologies
- Inconsistent model parameterisation between hubs
- Choice of expense allocation methodologies
- Strategic / 'loss-leader' products

Any other reasonable example, Max 2.

WidgetCo should therefore sensitivity test different sets of assumptions

- To see if this has an impact on the conclusions drawn

WidgetCo can then use the model to run sensitivity tests for different realistic strategies / portfolios to see what impact they have on the risk/return profile of the business.
WidgetCo should compare results to expectations

- To ensure that deviations from expectations are understood
- This will ensure that the model results are appropriate for use
- Model limitations and simplifications should be understood and allowed for in interpreting results.

In practice, it is hard to drastically change the risk profile of a business every year

- So incremental steps will be required.

Once WidgetCo has identified which areas of the business to expand / contract, and by how much (relatively), it can provide this as guidance to the business.
WidgetCo can put this guidance into effect by charging (or crediting) different parts of the business a hypothetical 'risk premium'.
This transfers reward from one area of the business to another.
This incentivises local management to expand / contract their own areas in response.
The process should be monitored to ensure the impacts are as expected

And the model should be updated with this information

for each point [½]
[Max 5]

(vi)

(b) WidgetCo should set a risk appetite. This should include:

- An outcome
- With a given probability
- Over a specified time horizon for all 3 elements [½]

- E.G. 0.5% probability of bankruptcy over the next 12 months

for a suitable example [½]

WidgetCo runs the internal model using current planned business volumes.
This lets WidgetCo identify whether or not it is within its risk appetite.
WidgetCo can also use this to identify roughly how much 'headroom' there is for it to take on more risk in aggregate without jeopardising its risk appetite.
The model should produce results for each:

- Hub
- Line of business
- Risk type
- Any other areas of particular importance to stakeholders (e.g. specific catastrophe perils).

WidgetCo should allocate the overall risk to each of these levels

- There are a number of different ways of doing this
- The methodology used should be selected with reference to the use to which the allocation will be put: in this case, setting risk limits.

This lets WidgetCo identify how much risk it is currently taking in each of the key areas.
WidgetCo can use the identified 'headroom' to convert its current risk levels to limits beyond which the risk appetite is likely to be breached.

- A 'broad brush' approach is reasonable at this stage, e.g. scaling all risks by the same amount.

This provides an initial view of potential risk limits.
This should be modified by management to reflect:

- Specific risks / areas where management would like to keep risk within other metrics (e.g. percentage of balance sheet exposed to particular perils)
- Management's desire to expand / contract particular areas of the business
- Management's confidence in the controls in place for particular hubs / risks
- Management's desire to retain some future flexibility, i.e. 'unallocated' risk limit which can be used at a later date.

Any other reasonable examples, Max 2

The modified risk limits should then be run through the Internal Model simultaneously to ascertain whether or not the risk appetite is breached if all limits are reached.
This allows WidgetCo to identify roughly how much 'headroom' (if any) remains for it to take on more risk in aggregate without jeopardising its risk appetite.

The process can then iterate, with progressively more accurate risk limits being produced.
Management should then ensure that the limits are suitably explained to the business to ensure suitable buy-in from those managing the risks on a day-to-day basis.

for each point [½]
[Max 5]

(vii)

A Generalised Pareto distribution could be used:

- We are modelling low-frequency, high-severity claims
- We are therefore considering the tails of the distribution
- There is unlikely to be sufficient data to carry out a suitable goodness-of-fit test to identify which is the best distribution to use
- The Generalised Pareto distribution is very flexible as it has two parameters
- The Generalised Pareto distribution is therefore likely to be as good, or better, fit than any other commonly-used distribution.

for each point [½]
[Max 3]

OR:
A Generalised Extreme Value distribution could be used:

- We are modelling low-frequency, high-severity claims
- We are therefore considering the tails of the distribution
- There is unlikely to be sufficient data to carry out a suitable goodness-of-fit test to identify which is the best distribution to use
- The GEV distribution is very flexible as it has three parameters
- Whatever the underlying distribution, in the tail of the distribution, the GEV is a good fit for the largest individual value from a random sample
- The GEV is therefore suitable for very large individual claims.

for each point [½]
[Max 3]

(viii)

Advantages:

- These variables might be linked in real life so a dependence measure is required
- So a dependence measure is required to ensure more reasonable model output
- And better uses of the model
- Using a copula makes it relatively easy to explain / describe where and how the dependency is applied
- Copulas model the dependency structure between the risks explicitly i.e. independently of the marginal distributions used for the recall loss severity in each regional office
- Copulas have the property of invariance, i.e. the copula function is unaffected by the shape of the marginal distribution functions,
- ... as long as the relationships (ranks) between the recall losses in different offices stay the same
- Using a copula also makes it easy to identify the impact of the modelled relationship

Disadvantages:

- This provides no information or insight into the reasons why variables are related
- Copulas are very hard to:
  - select,
  - parameterise
  - explain in detail and
  - validate
- Measured concentrations are likely to increase

[½ mark per point, except where shown otherwise. Max 3]

(ix)

Recommend a Gumbel copula

- A large event may reflect a systemic issue
- But smaller events won't
- We therefore want upper tail dependence but not lower tail dependence
- So a Gumbel copula is appropriate.

Alternatively,

- the independent nature of the manufacturing / quality control
- implies independence of lower tail losses
- so recommend a weaker copula
  For example
  - a Gumbel copula with a low parameter value

for each point [½]
[Max 2]
[Total 30]

[Paper Total 100]

Most parts of this question were answered well by well prepared candidates. However, there was a larger variance of marks on part vi where candidates were required to apply generic processes from different part of the syllabus – ERM cycle, risk identification, risk assessment, risk allocation and so on to a specific scenario. Candidates that did well on this question were able to describe the required outputs, inputs and other considerations that could be appropriate to articulate the strategy and limits in the scenario.

END OF EXAMINERS' REPORT