INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

September 2021

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.

Sarah Hutchinson
Chair of the Board of Examiners
December 2021

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

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 candidate should gain the ability to apply the knowledge and understanding of ERM practices to any type of organisation.

The SP9 examination generally requires bullet-point or short form essay style answers, together with concise mathematical applications. The answers given below are just one possible set of acceptable answers.

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

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

Well-prepared candidates, who were able to apply their knowledge of the core reading to the specific scenarios given in the questions, were successful in this diet.

Candidates who were able to draw upon on a wide range of risks, and who were able to articulate a sophisticated understanding of limitations of risk modelling scored well.

Questions that required idea generation, application of mathematical techniques, and in-depth discussion or expansion of points were not answered well by unsuccessful candidates.

C. Pass Mark

The Pass Mark for this exam was 58
238 presented themselves and 84 passed.

Solutions for Subject SP9 - September 2021

Q1

(i)

Reduces the volatility of OIL's financial performance/business results	[½]
e.g. income, profit	
Enables OIL to better decide trade-off between risk and return	[½]
Enables OIL to assess and set its risk appetite	[½]
Helps OIL to identify upside risks (as well as downside risks)	[½]
Helps OIL to identify interdependencies	[½]
e.g. concentrations of risk, diversification benefits	
Helps OIL to manage and assess risks consistently and holistically	[½]
Facilitates OIL to react quickly to emerging risks	[½]
Helps OIL to make strategic decisions	[½]
e.g. prioritising different risks/business segments	
Helps OIL in making decisions on capital allocation between business segments	[½]
Helps OIL to achieve consistent pricing and adequate margins to take on certain risks	[1]
May have a positive impact on OIL's credit rating	[½]

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May help to improve OIL's operational efficiency through existence of central risk function [½]

[Marks available 6½, maximum 3]

(ii)

Strategic risk. OIL's new business model may not work, i.e. may not be profitable after paying fees and commissions [1]

Market risk: the firm is expected to invest its 'float' and surplus funds, which are subject to movements in the financial market [1]

Interest rate risk. Risk that the cost of funding is higher than expected [1]

Economic risk. The firm's operation and prospects are subject to macroeconomic conditions, for example, inflation and demand to insurance [1]

Foreign exchange risk. The firm's business may be subject to movements in foreign exchange rates [1]

Counterparty risk. The underwriting leader(s) may fail to perform its/their contractual obligations [1]

Liquidity risk. The firm may encounter issues with paying claims if it is not able to raise necessary funds quickly in the financial market by selling asset holdings [1]

Operational risk. Internal processes and systems may fail or turn out to be inadequate [1]

Model risk. Poorly designed algorithms (as developed and signed off very quickly leading to the risk of an inaccurate evaluation of risk / return, portfolio construction and monitoring [1]

Systems risk. Risk of failure of technology / data breaches / cyberattacks [1]

Strategic risk. Over-reliance on technology, lack of human judgement in the decisions [1]

People / process risk. Lack of expertise in launching this business venture meaning that either process errors are made, or costly external expertise must be brought in [1]

Legal risk. Being a new type of insurer may present additional challenges in proper adherence to legislation [1]

Regulatory risk. Changes in legislation or regulation may deem the business venture non-viable / loss-making [1]

Reputational risk. Risk of reputational damage by association (e.g. if another underwriting leader incurs negative publicity) [1]

Agency risk. There may be misalignment in interest between different stakeholders e.g. between shareholders and senior management [1]

[Marks available 16, maximum 9]

(iii)

The insurance risk types being taken by OIL are quantifiable [½]

even though there may be challenges to obtain high quality data [½]

due to lack of occurrence (i.e. data volume and history) [½]

It is not a given that the underwriting leaders will share data willingly [½]

Data quality may be poor [½]

insufficient granularity to enable quantitative analysis [½]

errors, omissions, lack of checks [½]

data format/convention may differ across sources, creating additional challenges [½]

due to differences in underwriting standards [½]

due to differences in target market or distribution channels [½]

due to differences in terms and conditions, level of cover, excesses, exclusions [½]

Modelling requires expertise [½]

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Model could be time consuming to develop [½]
The firm has spent limited time conducting analysis, which calls into question its robustness [½]
On the other hand, OIL may be able to leverage commercially available models and datasets and then apply its own adjustments [½]
or hire experts to conduct the analysis [½]

[Marks available 8, maximum 5]

(iv)
The managing directors should have responsibilities for risk management as well as revenue/profit generation [½]
the bonus structure potentially incentivises premium growth in the first three years at the expense of overall profitability and sound risk management [1]
The bonus strategy may encourage the managing directors to leave after three years [½]
There should be an element of their compensation which is linked to the overall performance of the firm [½]
It would be better if the remuneration were based on a risk-adjusted measure of performance [½]
It will be important to ensure consistency between the two managing directors [½]
in terms of risk taxonomy, risk measurement and reporting [½]
so that the aggregate risk profile of the firm can be assessed [½]
allowing for the interdependencies between the two business segments [½]
The Business Committee's independence is good [½]
though the members of the Committee need to have the appropriate expertise in underwriting and capital/risk management [1]
The central risk function should be led by a CRO, who should sit on the independent business committee to provide expert input on risk [1]
The requirement for the Committee to sign off every deal may not be ideal, as this may delay the response time and reduce the authority of managing directors [½]
The Committee should work closely with the Board, especially regarding setting risk appetite. The Board should also be involved in the risk management processes, including setting risk appetite [1]
It is a good practice to have a central risk function [½]
but its responsibilities are too narrow, leaving a gap on risk management policies and risk control processes [1]
The firm should consider the best model for the risk function to interact with the business segments [½]
and as part of this, mitigate any shortcomings with each model, based on its situation [½]
For example, the Policy and Policing Model might leave the risk function too detached from the business segments [½]
The Partnership Model, which may benefit the firm during its start-up phase, may reduce the risk function's effectiveness as an independent assessor of the risk management approaches carried out by the business segments [1]
The Three Lines of Defence Model may be too costly/time consuming for the firm to set up, while the model may lack the flexibility required by the firm as it starts building its business [½]

[Marks available 13½, maximum 9]

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(v)
The calculation is sensitive to the modelling approach used by OIL [½]
i.e. what statistical distribution is assumed for the (tail of) risks it plans to insure [½]
or the stochastic model(s) used to model the underlying risks [½]
TVaR is potentially less intuitive than other metrics (e.g. probability or ruin) for OIL's management team to understand and manage [½]
Lack of data, as OIL is a new operation, means TVaR may be an unreliable metric [½]
TVaR may not be industry standard, and therefore it will be difficult for OIL to make comparisons with other firms [½]
[Marks available 3, maximum 2]

(vi)
TVaR is a 'coherent' risk measure [½]
and therefore its demonstrates the subadditivity property [½]
which means that the measure can be aggregated to give valuable insight on the aggregation of risk within the firm [1]
OIL can aggregate individual business segment TVaRs to give insight on the upper-bound for the firm-wide TVaR [1]
VaR does not exhibit the subadditivity property, and therefore can give anomalous results when it is aggregated [½]
[Marks available 3½, maximum 3]

(vii)
Allocation using a risk measure [½]
in proportion to reserves or premium income [½]
in proportion to standalone VaR/TVaR [½]
using the Euler principle [½]
or more complex modelling e.g. the use of co-measures or the consideration of capital as a shared asset [½]
Allocation by marginal capital costs [½]
where capital is allocated to the two segments of business in accordance with the marginal additional capital required for writing that business, given that the other segment of business is already in place [½]
Allocation using game theory [½]
for example, the Shapley method allocates capital with reference to an average of the marginal capital requirements, assuming that the segment under consideration is added to the overall portfolio first or second [½]
Standalone capital allocation [½]
where capital is allocated as if each segment were treated in isolation, with any diversification benefit being retained centrally [½]
Do not allocate capital to business units, and instead hold it centrally [½]
[Marks available 6, maximum 3]

(viii)
Allocation using a risk measure
could be very simple to calculate, e.g. overall capital is allocated in proportion to the TVaR of each business segment [1]
could also be complex to calculate and understand [½]

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alternative calculation methods exist, and can generate very different results under these methods [½]
method ensures that total capital is fully allocated (i.e. allowing for the diversification benefit) [½]
Allocation by marginal capital costs
corresponds to the financial principle of marginal pricing, allowing the firm to choose the most profitable policies to write [1]
This approach may not suit the firm due to it being a start-up, i.e. it does not have any existing business [1]
It's difficult for the firm to maintain a fair calculation across the two business segments, due to the dependence on the order of consideration [½]
Allocation by marginal costs does not ensure that total capital is fully allocated (i.e. sum of marginal capital requirements is unlikely to sum to the total capital requirements) [½]
Allocation using game theory
For example, can remove the dependence on order of consideration by taking an average under different orders of consideration [½]
This ensures fairness among the firm's two business segments, regardless of the order in which they are added [½]
Given the firm has a relatively simple business profile, the typical problem of computational intensity does not apply [½]
OIL would probably want to perform calculations under multiple methods, before deciding the final allocation [½]
and potentially switch between them as it grows its business [½]

[Marks available 8, maximum 5]

(ix)
Scenario analysis and stress testing helps to combine the results across OIL's business segments and answer a series of "what-if" questions, which is important and relevant for a start-up [1]
Stress testing will focus on using stressed assumptions, to help OIL to understand the impact of low frequency/high impact events (e.g. heavy rainfall leading to event cancellation and flooding claims) [1]
Scenario analysis will involve testing combinations of assumptions that together will give the firm insight into particular circumstances that may unfold (e.g. external events affecting levels of business, combined with assumptions about internal operational risks) [1]
Scenario analysis and stress testing could be used to effectively supplement the results based on historical data, i.e. to provide a forward-looking view, or to explore worse outcomes than experienced historically [1]
Scenario analysis and stress testing is a good way to engage with individuals in different business segments and functions of the firm [½]
which may help to harmonise processes and risk quantification [½]
and results are likely be easy to interpret and communicate [½]
Scenario and stress-testing may help the firm to prepare actions plans to deal with possible future risks, and risk mitigation techniques [1]
However, the choice of scenarios/stresses is subjective, and may not be exhaustive [½]
and the probability of the scenarios/stresses may not be considered or is difficult to evaluate [½]

[Marks available 7½, maximum 3]

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(x)
Using Kendall's tau to calculate [1]

$$\alpha = \frac{2 \times 0.06}{1 - 0.06} = 0.1277$$

Use the generator function for event cancellation [1]

$$\frac{1}{\alpha} \times (0.04^{-\alpha} - 1) = \frac{1}{0.1277} \times (0.04^{-0.1277} - 1) = 3.9812$$

Use the generator function for commercial building insurance [1]

$$\frac{1}{\alpha} \times (0.16^{-\alpha} - 1) = \frac{1}{0.1277} \times (0.16^{-0.1277} - 1) = 2.0648$$

Reverse the generator function to obtain the joint probability of loss of [1]

$$\left(\frac{3.9812+2.0648}{1/0.1277} + 1\right)^{(1/-0.1277)} = 0.0113$$

Possible Alternative Solution:
Clayton copula (closed form expression):
C(u,v) = {u^-α + v^-α - 1}^(-1/α) where: [½]
u = probability of loss in event cancellation business = 0.04
v = probability of loss in commercial building insurance business = 0.16 [½]
Therefore, probability that both business segments make a loss:
= C(0.04, 0.16) [1]
= {0.04^-0.1277 + 0.16^-0.1277 - 1}^(-1/0.1277) [1]
= 0.0113 [1]

(xi)
The Clayton copula is straightforward to calculate, as it provides a joint probability distribution in a closed form [½]
making it easier for the firm to implement [½]
The Clayton copula exhibits lower tail dependency but zero upper tail dependency [1]
this may or may not be appropriate for capturing the joint risk dynamics of the marginal risks [½]
depending on whether losses are measured as positive or negative values [½]
OIL may want to use a different copula that exhibits upper tail dependency as well (or instead of) lower tail dependency [½]
[Marks available 3½, maximum 2]

(xii)
OIL can try to write a diversified set of policies/risks [½]
so that it brings the capital requirement down [½]
When evaluating opportunities, it should focus on evaluating the marginal capital requirement and pick those which delivers the best "return on marginal capital" [1]
it would even evaluate those based on some level of reinsurance, or not [½]
The firm could use reinsurance to adjust the sizes of the exposure from policies [½]
to create better diversification at the tail/achieve lower overall capital requirement [½]
and this should be selective given the substantial cost of the reinsurance [½]
it can play with the reinsurance parameters to find the best arrangement for each policy [½]
Different types of reinsurance should be considered [½]
(e.g. proportional vs. non-proportional)
also consider retention limits [½]
layering [½]

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The firm should consider which reinsurance counterparties to engage with, as the counterparty default risk may become material and increase capital requirement [1]
It might be useful for OIL to have a strict hurdle rate of return, to keep discipline and avoid writing low return policies [½]
OIL could consider alternatives to traditional reinsurance products [½]
e.g. ART products may be more cost-effective than reinsurance [½]
OIL should consider its investment strategy, and whether it can increase the return generated on premiums invested [½]
e.g. investing in higher return assets such as corporate bonds [½]
OIL should consider the cost of capital, based on different sources of capital it has available [½]

[Marks available 10, maximum 6]

(xiii)
Counterparty risk: OIL will be subject to the reinsurance counterparty defaulting [1]
could arrange collateral with the reinsurance counterparty [½]
purchase credit default swap of the appropriate notional. [½]
Legal risk: may come into dispute with the reinsurer on terms and conditions, which may reduce the pay-out or delay it [1]
tighten wording/review the terms and conditions closely [½]
The firm should consider which reinsurance counterparties to engage [½]
only work with more reputable parties [½]
Model risk: the algorithm may make foolish decisions regarding the need to arrange reinsurance on certain policies or the parameters around the reinsurance arrangement [1]
conduct extensive testing on the algorithm and closely monitor its outputs [½]
ART products may not be as well understood as reinsurance [½]
require expertise [½]
can introduce operational risk [½]
may not be recognised in terms of regulatory capital calculations [½]
ART-related risks mitigated via research [½]
and suitable external expertise/training [½]

[Marks available 8½, maximum 4]

[Total 58]

Candidates in particular performed well on parts (i), (ii), (vii) and (viii), showing good knowledge and application of the course material on the benefits of ERM, risk identification and capital allocation.

Parts (xii) and (xiii) were not well-answered, with almost all candidates failing to identify core capital management techniques and associated risks.

Other question parts were answered reasonably well.

Q2
(i)
NII could use scenario analysis to capture the opinions and expertise of key managers [½]
The firm should consider operational risks related to the IT infrastructure and systems [½]

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and also look into other potential areas of operational risk (e.g. fraud) [½]
The scenario analysis will help with risk identification [½]
as well as understanding the consequences of risk exposure
(e.g. regulatory fines, loss of business) [½]
and the identification of risk responses/mitigation. [½]
Risk maps can be used to help document this process [½]
The scenarios should be reviewed periodically to ensure ongoing relevance [½]
[Marks available 4, maximum 3]

(ii)
Create a mechanism for evaluating and prioritising potential improvements [1]
Establish a cross-functional repaid response team which addresses and focuses on
emerging operational risk issues [½]
Add human resources/experts to the relevant areas, e.g. IT and systems [½]
change organisational structure and incentives [½]
provide relevant training to the existing staff [½]
Add internal controls [½]
e.g. well-documented processes and version control [½]
e.g. expand scope and frequency of monitoring [½]
e.g. implement business continuity and disaster recovery planning [½]
e.g. promote a good risk management culture to encourage transparency of reporting
losses/incidents [½]
Upgrade certain systems or sections of the IT infrastructure to newer technologies [½]
enhance capabilities or add redundancies to the existing infrastructure [½]
Leverage the know-how and relationships of the parent company, where appropriate [½]
Implement business continuity and disaster recovery planning [½]
Consider use of outsourcing to acquire operational expertise in appropriate areas [½]
[Marks available 8, maximum 4]

(iii)
NII should accurately model the terms and cashflow profiles of its assets and liabilities [½]
Asset cashflows will include premiums and investment proceeds [½]
Liability cashflows will include maturity payments, expenses [½]
Consider a wide range of economic and operating scenarios [½]
in particular with respect to credit downgrade/default and market volatility [½]
retention rate and expected sales growth [½]
interest rate changes [½]
distribution costs/expenses [½]
Evaluate the scenarios under various time horizons [½]
e.g. compare positive cashflows with negative cashflows to evaluate whether a
cashflow surplus or shortfall arises at future points in time [½]
Need to pay attention to the interaction between different factors [½]
e.g. interest rate changes potentially impact both the retention rate and the market
value of asset holdings [½]
Need to pay attention to the duration gap between assets and liabilities [½]
e.g. in a scenario where interest rates rise, the value of the assets will fall by more
than the value of the liabilities, exposing NII to losses if the assets need to be sold early [½]
[Marks available 7, maximum 3]

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(iv)

Closely monitor liquidity risk exposure and the movements of its drivers	[½]
including testing key parameters/assumptions, e.g. retention rate	[1]
Ensure there is enough surplus assets/capital to meet unexpected liquidity shortfalls	[½]
Arrange contingent liquidity sources, e.g. credit facilities with a commercial bank.	[½]
Explore contingent liquidity arrangements with the parent company	[½]
need to allow for any potential limits on transfers of assets between legal entities	[½]
Hedge the mark-to-market risk of the credit portfolio	[½]
against reductions in the value of the corporate bonds if credit risk increases, to offset a loss on forced sale	[½]
Reduce the duration gap between the assets and liabilities	[½]
one way to achieve this is to increase cash holdings within the asset portfolio	[½]
Invest in credit with above-average liquidity profiles or government bonds	[½]
could lead to a reduction in expected returns	[½]
Consider modestly increasing the guaranteed rate to attract more fund inflow	[½]

[Marks available 7, maximum 5]

(v)

A measure of the difference between the yield on a risky and a risk-free security	[½]
e.g. a corporate bond vs a government bond	[½]
or a corporate bond vs interest rate swap of appropriate terms	[½]
The credit spread reflects:	
the expected cost of default	[½]
a risk premium relating to the uncertainty of default	[½]
a liquidity premium	[½]

[Marks available 3, maximum 2]

(vi)

The distance to default, DD is calculated as follows [1]

$$DD = \frac{X_0 - \tilde{B}}{X_0 \sigma_X}$$

Where X_0 is the asset value of the firm, σ_X is the asset volatility, and $\tilde{B}$ represents the structure of the firm's debts [1]

(vii)

The Merton model goes straight from the data to a probability of default, whereas KMV takes an indirect route	[½]
The KMV model better represents the structure of a firm's debts	[½]
as it allows for insolvency caused by the failure to repay certain debts	[½]
whereas the Merton model only reflects a firm's level of debt	[½]
The KMV model also derives values for X_0 and σ_X from the quoted value of a firm's equity rather than assuming that they are directly observable	[1]
The KMV model can cater for coupon-paying debt, whereas Merton's model is based on zero-coupon debt	[½]

[Marks available 3½, maximum 3]

(viii)

Expected default rate is 0.16% at the end of Year 1	[½]
Then add up the following for Year 2, which comes to 0.24%	[½]

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The default rate over two years is therefore 0.40% [½]
the proportion of the portfolio being promoted to AAA and then default is:
[0.01%/(1−6.00%)]×[0.00%/(1−3.12%)] = 0.00% [1]
the proportion of the portfolio being promoted to AA and then default is:
[0.09%/(1−6.00%)]×[0.02%/(1−3.92%)] = 0.00% [1]
the proportion of the portfolio being promoted to A and then default is:
[3.37%/(1−6.00%)]×[0.05%/(1−4.40%)] = 0.00% [1]
the proportion of the portfolio remains BBB and then default is:
[86.32%/(1−6.00%)]×[0.16%/(1−6.00%)] = 0.16% [1]
the proportion of the portfolio being demoted to BB and then default is:
[3.51%/(1−6.00%)]×[0.61%/(1−9.60%)] = 0.03% [1]
the proportion of the portfolio being demoted to B and then default is:
[0.44%/(1−6.00%)]×[3.33%/(1−12.41%)] = 0.02% [1]
and the proportion of the portfolio being demoted to CCC-C and then default is:
[0.10%/(1−6.00%)]×[27.08%/(1−15.45%)] = 0.03% [1]

[Marks available 8½, maximum 8]

(ix)
The firm should conduct detailed analysis about its current credit holdings and likely future holdings [½]
and quantify and monitor the credit risk exposure on a timely basis [1]
Carry out appropriate due diligence (e.g. on corporate bond issuers) [½]
It should set clear boundaries on the types of issuer/issuances in which to invest [½]
including concentration limits [½]
There should also be sector and rating limits [½]
Build a credit portfolio so that certain idiosyncratic risks could be (largely) diversified away [½]
The firm should review its investment strategy, and reduce exposure to corporate bonds [½]
e.g. increase holdings in less risky assets, and reduce exposure to risky assets [½]
The firm should assess its (expected) risk exposure and hold sufficient amount of capital [1]
for example, it could request capital injection from the parent company [½]

[Marks available 6½, maximum 4]

(x)
The firm could purchase a Credit Default Swap on certain bonds [½]
whereby it pays a fee to a counterparty, which will make a credit default protection payment if a credit default event on these bonds occurs within the term of the contract [½]
The firm could enter into a Total Rate of Return Swap with a counterparty on certain bonds [½]
which will protect the firm from both default and price risks [½]
The firm could take positions in bond futures or forwards to hedge the pricing risk of its holdings [½]
These are also useful if the firm wants to put on a temporary hedge on the latest holdings before the put option is due to be purchased [½]

[Marks available 3, maximum 2]

(xi)
For its dynamic hedging trades, Bank A will try to achieve delta neutral [½]
by rebalancing the option portfolio using bond forwards and futures [½]

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as well as shorting bonds	[½]
This rebalancing will often occur on a daily basis/It is not practical for Bank A to rebalance its hedge continuously	[1]
Bank A will incur dealing costs for rebalancing its hedge from time to time	[½]
including paying dealers to borrow bonds to short	[½]
A large gamma of the options means more/bigger balancing activities to be conducted by Bank A, for it to maintain delta neutral	[1]
which will increase its dealing costs	[½]
A large vega means Bank A is highly exposed to the volatility of underlying bonds' prices	[½]
Bank A may want to achieve gamma and vega neutral with its hedge, but this may be very difficult	[½]
due to the lack of liquidity with the underlying bonds and the relevant derivatives	[½]
Operational risks may arise due to complex nature of dynamic hedging	[½]
A very large quantity of hedging derivatives may be needed in order to be delta, gamma and vega hedged	[½]
there may be a lack of availability of necessary assets	[½]

[Marks available 8, maximum 6]

[**Total 42**]

This question was generally well-answered overall.

Candidates struggled with parts (viii) and (xi).

The strongest candidates were able to produce a concise and well-explained calculation for part (viii), which allowed marks to be awarded regardless of numerical slips. However, most answers contained unclear numerical working with little or no explanation of the approach being used.

In part (xi), most candidates struggled with generating a sufficient breadth of practical issues linked to dynamic hedging.

[Paper Total 100]

END OF EXAMINERS' REPORT

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