# INSTITUTE OF ACTUARIES OF INDIA

# Subject SP9 - Enterprise Risk Management

# May 2024 Examination

# INDICATIVE SOLUTION

**Introduction**

The indicative solution has been written by the Examiners with the aim of helping candidates. The solutions given are only indicative. It is realized that there could be other points as valid answers and examiner have given credit for any alternative approach or interpretation which they consider to be reasonable.

**Solution 1:**

**i)** Udyamee's enterprise might face the following risks:

Market risks

For a non-financial enterprise like Udyamee's, this might entail market conditions that lead to lower sales or profit margins.

- Sales could be low due to:
  - Lower number of units sold, which in turn might be due to:
    - Demand-side reasons:
      - Lower aggregate demand (e.g. summer not being hot enough, easy availability of alternatives such as ice cream)
      - Lower market share (e.g. opening up of a competing lemonade stall in the vicinity, customers not liking the taste)
    - Supply-side constraints:
      - Shortage of input materials (e.g. disposable cups not being available in the market)
  - Lower sales price per unit (e.g. perhaps needed to clear piled up inventory) than expected
- Profit margins could be low due to:
  - Higher input costs (e.g. sugar or lemon prices rising up drastically) than expected
  - Higher overheads and fixed expenses (e.g. need to hire an assistant to man the stall at a substantial salary) than expected
  - Wastages (e.g. lemonade spilling over, unsold inventory going bad, etc)

Credit and counterparty risks

Since people will usually pay for the lemonade right after consumption and the amount involved per customer will be presumably small, there is negligible credit risk from the customers' side.

As regards counterparty risk, there can be risk of the suppliers failing to meet their obligations (to supply lemons, for example). This could be to varying extents:

- Absolute failure to supply
- Delayed supply, leading to loss of business
- Deficient quality, leading to poorer lemonade

Operational risks

This could be pertaining to:

- Processes – examples include:
  - Non-standard recipe leading to inconsistent produce (taste, flavour)
  - Lack of SOP leading to inconsistent service standards
- People – examples include:
  - Human error (in handling cash payments, for example)
  - Potential fraud by a hired assistant running the stall
- Systems – examples include:
  - Failure of card swiping machine, leading to card payments being infeasible
  - Lack of personnel backup in case of exigencies
- External events – examples include:
  - A pandemic-like outbreak virtually shutting the business

- A sporting event / carnival in a different neighbourhood leading to lack of footfalls at this stall

Other risks

- Legal /regulatory risk – stalls could be outlawed, declaration of no-hawking zone
- Agency risk – especially
  - if production is outsourced or
  - if an employee is manning the stall
- Reputational risk
  - Taste not being up to the mark
  - Customers falling ill due to the consumption

(Max 10)

**ii)** Time horizon and discount rate will depend on Udyamee's view of her enterprise.

If she views this as a temporary venture, merely to keep her occupied during her vacation or to earn some quick bucks,

- The time horizon will just be the few months of summer vacation
- Discount rate for such a short-term venture is likely irrelevant

(1)

On the other hand, if Udyamee has an ambition to perpetuate and grow the stall (perhaps into a wider stall with more offerings and eventually a food joint),

- The time horizon will need to reflect this view and may run into a few years
- Discount rate will be a loading over and above the risk-free rate which will be governed by:
  - Cost of capital (expected returns from investor – her father)
  - Perceived level of risk exposure in enterprise
  - Economic variables like
    - Inflation rates
    - Interest rates
    - Investment returns

(3)

**(4)**

**iii)** The following are the typical challenges in risk quantification:

- Difficulties in assessing possible extreme events
  - E.g., probability of a pandemic-like event
- Imperfect data
  - E.g., historical data of lemon prices may not be easily available to forecast future prices
- Difficulties in assessing interdependence of risks
  - E.g., how the risk of lower demand due to weather conditions correlates with higher cost of inputs (lemon)
- Dealing with unquantifiable risks
  - E.g., risk of potential fraud by an employee

(4)

**iv)** The following are the three common deterministic risk modelling approaches:

- Sensitivity analysis

- This entails varying each input assumption [usually only the key ones] one at a time to quantify the effect it has on the model's output (independent of other aspects).
- Scenario analysis
  - In contrast to the previous one, this entails varying multiple inputs simultaneously, considering scenarios which are plausible and internally-consistent
- Stress testing
  - This is similar to the first two, except that the focus is on very large changes in assumptions or very extreme scenarios.

For the enterprise at hand, for example,

- A sensitivity analysis could be to check the impact of slight change (e.g. 10%) in the sale price on the net profit.
- A scenario analysis could account for a number of variables (e.g. summer temperatures not soaring as expected leading to tepid demand, lemon prices being higher than expected leading to depressed margins, etc.) to assess their impact on the net profit.
- A stress test could assess the impact of two new competitors coming up in the same vicinity leading to a sharp decline in our market share.

(Max 5)

**v)** The usual responses to an identified risk are as follows:

- Risk rejection (removal)
  - E.g., the risk of potential fraud by an employee can be removed by Udyamee manning the stall herself (or recruiting a trustworthy sibling)
- Risk acceptance (retention)
  - E.g., the legal / regulatory risk of the area being declared no-hawking zone might have to be accepted
- Risk transfer
  - E.g., the risk of rising lemon prices can be transferred to the supplier by entering into a forward agreement (a derivative of sorts)
- Risk management (reduction without transfer)
  - E.g., the counterparty risk of supplier failing to provide lemons can be partially mitigated by empanelling multiple suppliers

(4)
**[27]**

**Solution 2:**

**i)** A conglomerate might consider setting up an ERM function in response to:

- A risk management failure having happened in one of its entities
- A near-miss having happened in one of its entities
- A risk management failure in another company (presumably in a similar sector)
- A regulatory requirement
- Pressure from other stakeholders

(2)

**ii)** The main practical benefits of ERM over traditional risk management are:

- Improved reporting of risk leading to
  - improved transparency,
  - clearer understanding and

    - informed decision making
- Improved organizational effectiveness
- Improved business performance

(3)

**iii)** A consistency in the usage of risk terminology and documentation will lead to a clear, shared understanding of risk…
… across the multiple entities within the group…
… reducing the likelihood of confusion or a misunderstanding.

(1)

A common risk language by way of consistent terminology makes ERM accessible to everyone within the group…
… which is likely to lead to greater acceptance by everyone.

(1)

It will also drive efficiencies by way of:

- identifying duplication / redundancies and managing them
- facilitating a more productive discussion on risk throughout the organization from the top (i.e. board) to the bottom

(1)

Consistency in documentation helps preserve organizational knowledge and makes it robust against staff attrition.

(0.5)

It is also essential for a coordinated approach to risk. This helps in:

- accurate accounting of risks (avoiding double-counting or overlooking risks)
- accurate assessment of concentrations / diversifications
- accurate evaluation against stated risk tolerance.

(2)

Further, consistency in risk terminology as well as documentation demonstrating help in regulatory or supervisory compliance relatively easily.

(0.5)
(Max 5)

**iv)** From a risk perspective, it is ideal if CRO has a seat on the Board and have a direct reporting line. They can also lead the risk subcommittee.

(1)

Alternatively, the CRO can report to the CEO or the CFO who in turn report to the Board.

(0.5)

However, in the latter instance, it becomes important for the CRO to have a dotted line to the Board. This will enable them to communicate freely to the Board regarding any issues, say arising out of conflict of interest, which may otherwise go unreported.

(1)

Under extreme circumstances, the dotted line should become a solid line.

(0.5)
**(3)**

**v)** A risk measure is said to be coherent if it satisfies the following properties:

- Monotonicity
- Sub-additivity
- Positive homogeneity
- Translation invariance

VaR is not a coherent risk measure because it is not always sub-additive.

This can be demonstrated by a simple example relevant to the banking entity as follows: Consider two zero-coupon bonds (issued by two independent issuers X and Y) each having otherwise identical characteristics

- a notional of Rs. 1000
- a time horizon of 1 year
- a default probability of 0.8%

Now consider three portfolios.

Portfolio A – one unit of a bond issued by X

Portfolio B – one unit of a bond issued by Y

Portfolio C – Portfolios A and B combined

Now, for a one year time horizon and at a 99% confidence interval,

VaR of Portfolio A = 0, VaR of Portfolio B = 0. But VaR of Portfolio C = 1000.

So VaR of Portfolio C exceeds the sum of VaRs of portfolios A and B. This shows VaR is not sub-additive!

(5)

**vi)** The Merton model

- considers the shareholders as owning a call option on the company's assets
- uses the Black-Scholes options pricing formula to value the shares
- has the advantages of
  - being mathematically tractable,
  - resulting in an intuitive, economic explanation for default, and
  - enabling the calculation of the credit spread (even if bond is unquoted)
- has the disadvantage of making a number of unrealistic assumptions

The KMV model

- estimates the probability of default based on empirical data on company defaults and how these defaults link to a quantity called distance-to-default
- has the advantage of being able to accommodate more realistic liability structures

Both models have the disadvantage of being significantly affected by changes in market sentiment, even without any real change in prospects.

(Max 6)

**vii)** The main advantages of using derivatives to manage market risk are:

- Cost (cheaper compared to trading the underlying)
- Flexibility (can be tailored)
- Speed (of exposure changes)

The main disadvantages arise from the additional associated risks:

- Counterparty
- Settlement

- Aggregation
- Concentration
- Operational
- Liquidity
- Legal
- Reputation
- Basis
- Loss of upside

Given that it is a large conglomerate which will soon have an ERM function which should be able to handle the additional risks, it is recommended to use derivatives where it is more economical to do so (relative to alternatives).

(Max 4)

**viii)** The two key types of derivatives that can be used to transfer credit risk are Credit Default Swaps (CDS) and Total Rate of Return Swaps (TRORS).

CDS:

- A CDS involves payment of a fee by the protection buyer B (seeking to hedge the credit risk) to the protection seller S.
- In return, S will make a credit default protection payment of amount A if a credit default event on the reference asset R occurs during the term of the contract T.
    - A is the difference between original price of R and its recovery value.
- If the credit default event on R doesn't occur during T, B receives no payment.
- The effect of a CDS is to hedge the default risk, without explicitly hedging the price risk.

TRORS:

- In contrast, TRORS are used to hedge both the default (credit) and the price (market) risks.
- This is achieved by swapping the total return on one or more assets with that on another.

Both CDS and TRORS:

- May have better liquidity than that of the underlying asset [advantage]
- Introduce counterparty risk with the other parties to the swaps [disadvantage]

Alternative ways of transferring credit risk include:

- Credit insurance – to mitigate large exposures to (usually incidental) credit risks
- Securitisation – pooling together a group of risky assets, and converting them to structured financial instruments via tranching / SPVs

(Max 7*)*

**ix)** Demographic and other insurance risks can be managed:

- Before the risk is accepted (via underwriting)
    - By applying exclusion clauses (or rejecting application)
    - Increasing the premium / reducing the benefits
    - Imposing excesses
    - By a system of no-claims discount/bonus
- After the risk has been accepted
    - By a regular monitoring of Actual experience v/s Expected

- By transferring risk (e.g. by reinsurance, swaps, securitization, ART)
- By reducing risk concentration (e.g. by growing business)
- By improving diversification (e.g. by business lines)
- By employing implied hedging (e.g. mortality and longevity risks)

(Max 4)

**x)** Capital models can have many different purposes within an organization, such as regulatory capital setting or considering economic capital requirements.

Generic capital model (GCM):

- A generic capital model may be used by capital providers and regulators to produce a consistent view across different companies.
- It ends to be very simple in general, e.g., factor-table approaches.
- However, the trend has been towards increasing complexity for various reasons.

Internal capital model (ICM):

- In contrast, an internal capital model is used to produce a company-specific view of the capital needed.
- The objective is to improve the management's understanding of the dynamics of the business and thereby to improve their decision making.
- As such, it should aim to cover:
  - All (material) risks faced by a company
  - In a consistent manner
  - Allowing for interactions between the various risks
- Subject to regulatory approval, it can also be used to determine regulatory capital.

Therefore, both GCMs and ICMs can and usually do have a place and a purpose in a large conglomerate with diverse interests.

If, however, it is sought to use ICM for regulatory purpose too, there can be some efficiency gains (no need to run GCMs).

However, this benefit has a trade-off with the 'cost' associated with the increased regulatory scrutiny (both upfront and on an ongoing basis).

(Max 5)

**xi)** Required capital at an overall level may have to be allocated at a lower (say, business unit / product / segment) level in a fair way for several reasons such as:

- Performance measurement (return on capital)
- Business planning
- Pricing

Some of the possible allocation methods include:

- Use of a risk measure (such as standard deviation or VaR)
  - E.g., application of Euler's principle to a positively homogenous risk measure
  - Various methods possible which can give very different results
- Marginal approach
  - Capital allocation in accordance with marginal additional capital required in writing that business

- Corresponds to the financial principle of marginal pricing, but can be unfair due to dependence on order of consideration
- Game theory approach
  - E.g., Shapley method which employs an average of marginal capital requirements for the various possible orders of considerations
  - Ensures parity (by removing dependence on order of consideration) but can be computationally intensive
- Pro rata approach
  - Proportionate allocation according to some basis
  - Easy to understand / implement, but not quite risk-sensitive
- Stand-alone basis
  - Each unit's capital is calculated standalone, and any remaining capital retained in the main corporate business line
  - Doesn't account for diversification benefits across business units

(Max 10)

**xii)** Some of the key lessons from the 2008-09 Global Financial Crisis which are relevant to the conglomerate are as follows:

- A failure to fully understand, and accurately quantify the risks inherent in the business activities can be catastrophic.
  - This is even more crucial when the products involved (like CDOs) are overly complex and not well-understood.
- A remuneration structure that promotes short-termism and rewards quick gains rather than sound risk management practices should be avoided, as it can be a big source of agency risk.
  - In particular, use of risk-adjusted returns in performance management is desirable.
- Mathematical elegance should not blind us to the model risks, especially in tail scenarios where dependency structure can be significantly different from that in the usual situations.
- Liquidity can be a key concern, especially when there is a suspicion of contagion. Appropriate scenario analyses and stress tests are essential.

(Max 3)
**[57]**

**Solution 3:**

**i)** Lam's 5-stage ERM maturity model from a life insurers perspective:

1. Definition and planning – Organizing resources to define and scope an ERM programme
   Key initiatives include:
   - Identifying internal and external requirements for ERM programme
   - Obtaining Board and management support
   - Developing overall framework and plan
   - Appointing key personnel such as CRO
2. Early development – Formalizing roles and responsibilities, identifying risks and education
   Key initiatives include:
   - Establishing ERM policies and risk functions

- Identifying key risks such as mortality, longevity, interest rate risks, etc.
- Co-ordinating risk and control processes across the functions
- Educating and training (especially for the Board)

3. Standard practice – Improving risk assessment capabilities and developing risk quantification processes
   Key initiatives include:
   - Establishing risk databases for events and losses (e.g. frauds, operational errors, etc}
   - Developing key risk indicators (KRIs)
   - Establishing risk models for relevant risks such as mortality, longevity, interest rates, credit default, underwriting, fraud, etc.
   - Measuring risk-adjusted performance
4. Business integration – Integrating ERM into business management, operations and remuneration
   Key initiatives include:
   - Evaluating business risks
   - Quantifying the cost of risk to support pricing and risk transfer decisions (e.g. reinsurance, securitization, etc)
   - Automating risk reporting
   - Allocating capital according to risk
   - Using risk triggers to prompt business decisions (e.g. seeking to avoid concentration in a particular geographical / age / occupational sub-segment)
   - Measuring the effectiveness of the ERM processes and linking to executive remuneration
5. Business optimization – Optimizing business performance, integrating ERM into strategy development and enhancing relationships with key stakeholders
   Key initiatives include:
   - Expanding the scope of ERM to include strategic risk
   - Integrating ERM into strategic planning processes (e.g. taking advantage of natural hedging between mortality and longevity)
   - Allocating capital and resources to optimize risk-adjusted performance

(Max 7)

**ii)** The transition from stage 4 to stage 5 happens when ERM is not just integrated with the business (which should have happened by stage 4) but is actively used for driving efficiencies and optimizing the performance of the business. Emerging technologies can propel this transformation in several ways such as the following:

- Risk assessment can be enhanced at the underwriting stage, as well as on an ongoing basis, by use of data from the health-tracking devices.
  - Poor risks can be declined or priced in a risk-consistent manner.
  - Good risks can be incentivized by way of premium discount or enhanced sum insured.
- Pricing and loss cost modelling can be enhanced by using ML/AI based predictive models:
  - These models can handle far more data than what is possible in the traditional factor-based setup.
  - Moreover, such models can also handle well the interactions between the various inputs.

- Natural Language Processing and Generation can be used to deploy interactive chatbots, leading to a quicker customer response (with call centre capacity no longer acting as a barrier) and better customer engagement
- Blockchain technology can be leveraged to decentralize record-keeping (so as to avoid a single point of failure), but with due checks and balanced for data privacy and related concerns.

(Max 3)
**[10]**

**Solution 4:**

1. Gumbel copula
   - Positive upper tail dependency
   - No (=zero) lower tail dependency

   - Suitable where associations increase for extreme high values (but not for extreme low values)
     Practical modelling use-case: Modelling losses from a credit portfolio

2. Frank copula
   - No (=zero) upper tail dependency
   - No (=zero) lower tail dependency

   - Limited applicability given no tail dependency (and symmetric form)
     Practical modelling use-case: Exchange rate movements

3. Clayton copula
   - No (=zero) upper tail dependency
   - Positive lower tail dependency when $\alpha>0$; no lower tail dependency for $\alpha\leq 0$

   - Suitable where associations increase for extreme low values (but not for extreme high values)
     Practical modelling use-case: Modelling returns from a portfolio of investments (as negative returns are likely to occur simultaneously on a number of investments)

**[6]**

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