Module 2 · Risky investment proposals P14 · 2.1–2.4

SM pp. 69–102 (exercise 103–110). **7–12 marks every paper** (expected 10.3): **Q3(a) a risk-analysis sum in all 6 papers** since Dec'23 — ENPV / SD / CV the last three running (J25, D25, J26), payoff table D23, scenario J24, simulation D24, decision tree J23 (and the MQP) — plus **MCQs (ii) sensitivity and (iii) certainty equivalent**.

Paper	Q3(a)	MCQ
Jun'23	decision tree, 2-year project (= SM Illus. 9 type)	least risky by CV
Dec'23	payoff table: expected values + minimax regret	–
Jun'24	best-case and worst-case scenario NPVs	abnormal risk premium via IRR; normal-distribution range
Dec'24	Monte Carlo: five runs, average NPV	–
Jun'25	two projects: ENPV, SD, CV	–
Dec'25	**expected inflows, CV v an industry benchmark CV**	CE coefficient · sensitivity to project cost
Jun'26	joint probabilities, SD from CV, NPV at risk-adjusted rates	CE coefficient · sensitivity of cash flow

HOW IT IS ASKED

- **Q3(a)**: probabilities × cash flows → expected value → SD → CV → "which is less risky / acceptable against the benchmark?" Variants: joint probabilities over two years (decision tree), scenario NPVs, simulation with given random numbers.
- **MCQ (ii)**: the % change in cost / cash flow / life / rate that makes NPV zero. **MCQ (iii)**: certainty-equivalent coefficient or riskless cash flow.

A Formula sheet — when to use

Formula	When to use · notes	SM
CE coefficient α_t = riskless ÷ risky cash flow; NPV = $-CF_0 + \Sigma\ \alpha_t\ CF_t \div (1 + i)^t$	Certainty equivalent: α between 0 and 1; discount at the **risk-free** rate.	[SM 69–70]
RADR = cost of capital (or risk-free) + risk premium	Discount the risky cash flows at the higher rate (Illus. 1: 13% + 2% = 15%).	[SM 71]
Expected CF = $\Sigma\ P_i\ CF_i$; SD = $\sqrt{[\Sigma\ P_i\ (CF_i - \text{mean})^2]}$	Hillier model step 1, year by year.	[SM 71]
ENPV = $\Sigma\ A_t \div (1 + i)^t - I$; perfectly correlated: $\sigma(\text{NPV}) = \Sigma\ \sigma_t \div (1 + i)^t$	Step 2; discount at the risk-free rate. Independent flows: square root of $\Sigma\ \sigma_t^2 \div (1 + i)^{2t}$.	[SM 72]
CV = SD of NPV ÷ expected NPV	Compare projects of different size: the higher CV is the riskier.	[SM 75–76]
Z = (NPV − expected NPV) ÷ SD of NPV	Probability of an NPV range from the normal table.	[SM 76]
Sensitivity: the value of one input that makes NPV = 0, as a % of its estimate	One variable at a time, others held at their estimates.	[SM 83–84]
Decision tree: NPV per path × joint probability = expected NPV	Two-year trees; joint probability = P(year 1) × P(year 2 given year 1).	[SM 77–79]

B ENPV, SD, CV and decision trees · Q3(a) 2.1

1 · Expected cash flow
Σ probability × cash flow (per year / per project)

↓

2 · SD
√ Σ P (CF − mean)^2 (or given / from CV × mean)

↓

3 · Expected NPV
PV of expected flows − outlay

↓

4 · CV and decide
lower CV = less risk; compare with the benchmark CV

ICMAI layout: table Probability · Cash flow · P × CF · (CF − mean)^2 × P for each project, then a CV line and the advice.

- Three decision situations: complete certainty, complete uncertainty, risk. [SM 69]
- Techniques: certainty equivalent, RADR, expected NPV and SD, decision tree; advanced: sensitivity, scenario, simulation. [SM 69]
- **CE coefficient** falls as risk rises (inverse relationship). [SM 70]
- **Hillier model**: risk = SD of the expected cash flows; ENPV and σ(NPV) depend on whether the flows are perfectly correlated, independent or moderately correlated. [SM 71–72]
- **Decision tree**: analyses proposals with sequential decisions and project flexibility; each path is one outcome. [SM 77–78]

⚠ SM SLIP · ILLUSTRATION 7
It says "refer to Illustration 6" but uses Illustration 5's ENPV ₹16,215.75 and SD ₹34,268, and prints P(Z ≥ 0.11) = 1 − (0.5 + 0.4602) = 3.98%. For Z = 0.11 the table area is 0.0438, so P = 0.4562 (45.6%). Learn the method from Illustration 8.

PROBLEMS BOX · RISK ANALYSIS (Q3(a) — RECOMPUTED BY SCRIPT m02_patterns.py)

WORKED PATTERN · SM ILLUSTRATION 2 (EXPECTED CF AND SD)

Project M (₹'000)	P × X	(X − 16)^2 × P
0.10 × 12 · 0.20 × 14 · 0.40 × 16 · 0.20 × 18 · 0.10 × 20	16.0	4.8
SD = √4.8		**2.19**
Project N: 8, 12, 16, 20, 24 (0.10, 0.25, 0.30, 0.25, 0.10)	16.0	20.8 → **4.56**

Same mean, N has the larger SD. [SM 71–72] CV: M 0.137, N 0.285 → N is riskier.

CV · SM ILLUSTRATION 6

X: 4,800 ÷ 12,000 = **0.4**; Y: 5,800 ÷ 14,000 = **0.414** → Y riskier; prefer X. [SM 75–76]

DECISION TREE · SM ILLUSTRATION 9 (= J23 Q3(a) TYPE)

Outlay ₹40,000; year 1 ₹25,000 or ₹30,000; three year-2 outcomes each; 12%. Six paths: worst −8,111 (joint probability 0.08), best 10,703 (0.06); expected NPV **₹2,045.40** → accept. [SM 78–80]

NORMAL DISTRIBUTION · SM ILLUSTRATION 8

ENPV ₹800, SD ₹400: P(NPV ≤ 0) = P(Z ≤ −2) = 1 − (0.50 + 0.4772) = **0.0228**. [SM 76]

DEC'25 Q3(a) ARON (OUR WORKING), ₹ LAKH

- E(A) = 7 × 0.2 + 9.5 × 0.5 + 12 × 0.3 = **9.75**; E(B) = 5 × 0.3 + 10 × 0.4 + 14 × 0.3 = **9.70**.
- CV A = 1.8 ÷ 9.75 = **0.1846**; CV B = 2.5 ÷ 9.70 = **0.2577**.
- Benchmark = average of 1.6/8, 2.2/10, 1.8/9 = **0.2067** → A is below the benchmark, B above: **choose A**.

OTHER Q3(a) VARIANTS — WHAT TO DO

- **Joint probabilities** (J26): tree of year-1 × year-2 outcomes; SD from CV = CV × mean.
- **Payoff table** (D23): expected value per act; regret = best in that state − payoff; choose the smallest maximum regret.
- **Scenario** (J24): NPV with all-best inputs and all-worst inputs (SM Illus. 12).
- **Simulation** (D24): cumulative probabilities → random-number ranges → read the given random numbers → NPV per run → average.

PRACTISE THESE (MOST LIKELY FIRST)

D25, J25, J26 Q3(a) · MQP Q3(a) (decision tree), PTP Q3(a) · J23 Q3(a) · D23 Q3(a) · J24 Q3(a), postal Q2(a) (scenario) · D24 Q3(a) (simulation) · MCQs J23 Q1(ii), J24 Q1(i), Q1(iv), D25 Q1(iii), J26 Q1(iii), MQP / PTP Q1(ii)–(iii) · SM Illus. 1–10, 12 · SM exercise sums 1–4 (SM 106–107) · **ICMAI Practice Workbook Ch1 illus. 3, 12, 13; Ch2 illus. 2, 3, 6–14** · MCQ bank Q16, Q19–Q21, Q23, Q178.

C Sensitivity, scenario, simulation · MCQ (ii) 2.2–2.4

WORKED PATTERN · SM ILLUSTRATION 11 (SENSITIVITY — RECOMPUTED)

- Investment ₹1,00,000; 3 years; inflows ₹2,00,000, outflows ₹1,50,000; 10%: ENPV = −1,00,000 + 50,000 × (0.909 + 0.826 + 0.751) = **₹24,300**.
- Investment can rise to ₹1,24,300 → **24.30%**; NCF can fall to ₹40,225 → **19.55%**; life to 2.35 years → **21.67%**; rate to **23.4%**. [SM 83–84]

The **lowest** % is the most sensitive variable (here net cash inflow).

PRACTISE

D25, J26 Q1(ii), MQP Q1(ii) · SM Illus. 11, exercise sum 5, solved case 1 (SM 107–108) · **WB Ch2 illus. 1, 4, 5** · MCQ bank Q17, Q22, Q175.

- **Sensitivity**: each estimate in turn, others held constant, to see how far it may move before the decision changes. [SM 83]
- **Scenario analysis**: base case (most likely inputs), best case (lowest rate, highest flows), worst case (highest rate, lowest flows) → a range of NPVs. [SM 85]
- **Simulation steps**: determine the probabilistic variables; define their distributions; check correlation; run the simulation; decide. [SM 87]
- Simulation allocates **random-number ranges** to cash flows by cumulative probability. [SM 99–100]

Item	Rule	SM
CE	riskless ÷ risky; risk-free rate	[SM 69–70]
CV	SD ÷ expected NPV	[SM 75]
Z	(X − ENPV) ÷ SD	[SM 76]
Sensitivity	change to NPV = 0 ÷ estimate	[SM 84]

TRAPS

- CE flows are discounted at the **risk-free** rate; RADR flows at the risk-adjusted rate — never both adjustments.
- CV decides when means differ; SD alone only when means are equal.
- Joint probability = product along the path; the path probabilities must add to 1.