Module 4 Summary: The Risk Problem

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Digital Finance — BSc Course

Module 4: Prerequisites

Theme: Risk (market, derivatives, institutional, new-risk landscape) **From prior modules:**

- **M1L3:** BNPL credit risk transfer
- **M2L2:** credit scoring as a probability estimate
- **M3L4:** stablecoin peg risk and DeFi liquidation

External knowledge assumed:

- Probability distributions (normal, Student-t, fat-tail intuition)
- Expected value and variance
- Basic calculus for partial derivatives in option Greeks

Will be introduced this module: We introduce Value-at-Risk and Expected Shortfall, Black-Scholes intuition (with the PDE primer flagged as a forward reference), institutional-risk frameworks, and the new-risk landscape including DeFi-style liquidations.

Prerequisites are advisory; lessons remain self-contained where feasible. Forward references inside lessons flag any concept used before its canonical introduction.

Key Concepts by Lesson

L1: Measuring Market Risk

- Value-at-Risk (VaR): maximum loss at a given confidence level
- Three methods: historical simulation, variance-covariance, Monte Carlo
- Expected Shortfall (ES/CVaR): average loss beyond VaR

L2: Derivatives & Options

- Options: calls, puts, payoff diagrams
- Greeks: Delta (Δ), Gamma (Γ), Vega, Theta (Θ)
- Greeks are sensitivities read from tables, not derived by hand

L3: Institutional Risk Management

- Basel I $\rightarrow$ II $\rightarrow$ III $\rightarrow$ III.1/IV evolution
- Three pillars: minimum capital, supervisory review, market discipline
- Liquidity rules: LCR (Liquidity Coverage Ratio), NSFR

L4: New Risk Landscape

- Cyber risk violates stationarity assumptions
- Flash crashes: intraday losses exceed daily VaR
- Algorithmic/model risk: cascading failures from correlated models

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Module 4 answers: How do we measure, price, and manage financial risk — and where do traditional models break down?

Key Formulas and Definitions

Value-at-Risk (VaR)

$$\text{VaR}_\alpha = -\inf\{x : P(L \leq x) > \alpha\}$$

Intuition: sort 1,000 returns worst-to-best; the 50th worst is your 95% VaR.

Expected Shortfall (ES / CVaR)

$$\text{ES}_\alpha = E[L \mid L > \text{VaR}_\alpha]$$

Average of all losses in the tail beyond VaR. Always $\geq$ VaR. Basel III requires ES at 97.5%.

The Greeks

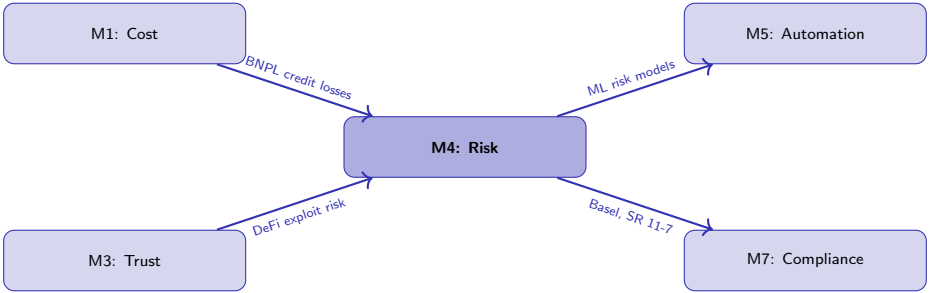
$\Delta = \frac{\partial V}{\partial S}$	stock exposure	$\Gamma = \frac{\partial^2 V}{\partial S^2}$	convexity
$\mathcal{V} = \frac{\partial V}{\partial \sigma}$	volatility exposure	$\Theta = \frac{\partial V}{\partial t}$	time decay

Basel III Capital Requirement

$$\text{CET1 Ratio} = \frac{\text{Common Equity Tier 1 Capital}}{\text{Risk-Weighted Assets}} \geq 4.5\%$$

VaR tells you the door of the tail; ES tells you what is behind it.

Connections to Other Modules



- **Cost → Risk (M1):** BNPL providers bear credit risk funded by MDR revenue — thin margins amplify default losses
- **Trust → Risk (M3):** Smart contract exploits, oracle manipulation, and impermanent loss are risk categories absent from traditional frameworks
- **Risk → Automation (M5):** ML models predict default, detect fraud, and estimate VaR — but introduce model risk and overfitting
- **Risk → Compliance (M7):** Basel III/IV mandates capital buffers; SR 11-7 governs model risk; each Basel version responded to a financial crisis

Risk is the bridge between theory and regulation: measure it (M4), model it (M5), regulate it (M7).

Module 4: Integrative Questions

Two questions that need more than one lesson to answer:

1. M4L1 VaR assumes a normal-ish distribution; M4L4 new-risk frontier breaks that assumption. Name two new-risk lessons that cannot be measured with VaR and why.
2. Combine M4L2 (option Greeks) with M4L3 (institutional risk) to explain why a portfolio that hedges delta but not vega can still blow up under stress.

Use these as study prompts before the module exam; each integrates concepts that span lessons.

Module 4: Worked Multi-Lesson Example

Worked example: walk a leveraged trader through M4L1 (VaR + ES on the position), M4L2 (delta + gamma + vega Greeks of the option overlay), M4L3 (counterparty + concentration + Basel CAR impact), M4L4 (DeFi liquidation engine + on-chain margin call). **Pedagogical pattern:** the example is intentionally end-to-end. Solve it lesson-by-lesson, then step back and identify the lesson whose assumption was the binding constraint.

The exam-style version of this example appears in extttv4/exam_prep/exam_bank.tex for module 4.

Module 4: Forward-Pointing Dependency Map

Concepts from Module 4 that later modules will use:

- **M5L4:** M4L3 stress testing is the operational analogue of the M5L4 MLOps drift monitor
- **M7L4:** Basel CAR (M4L3) is the regulatory floor; M7L4 model-risk governance covers the methodology behind it
- **M8L3:** Climate-finance scenarios (M8L3) extend M4L3 stress testing with physical + transition risks

Forward-pointing dependencies; concepts not in this map are local to Module 4.