PART II SCHWESER'S QuickSheet

CRITICAL CONCEPTS FOR THE 2020 FRM® EXAM

MARKET RISK MEASUREMENT AND MANAGEMENT

Value at Risk (VaR)

VaR for a given confidence level occurs at the cutoff point that separates the tail losses from the remaining distribution.

Historical simulation approach: order return observations and find the observation that corresponds to the VaR loss level.

Parametric estimation approach: assumes a distribution for the underlying observations.

- Normal distribution assumption:

$$VaR = (-\mu_r + \sigma_r \times z_\alpha)$$

- Lognormal distribution assumption:

$$VaR = (1 - e^{\mu_r - \sigma_r \times z_\alpha})$$

Expected Shortfall

Provides an estimate of tail loss by averaging the VaRs for increasing confidence levels in the tail.

Weighted Historical Simulation Approaches

- *Age-weighted:* adjusts the most recent (distant) observations to be more (less) heavily weighted.
- *Volatility-weighted:* replaces historic returns with volatility-adjusted returns; actual procedure of estimating VaR is unchanged.
- *Correlation-weighted:* updates the variance-covariance matrix between assets in the portfolio.
- *Filtered historical simulation:* relies on bootstrapping of standardized returns based on volatility forecasts; able to capture conditional volatility, volatility clustering, and/or data asymmetry.

Peaks-Over-Threshold (POT)

Application of extreme value theory (EVT) to the distribution of excess losses over a high threshold. The POT approach can be used to compute VaR. From estimates of VaR, we can derive the expected shortfall (ES).

Backtesting VaR

- Compares the number of instances when losses exceed the VaR level (exceptions) with the number predicted by the model at the chosen level of confidence.
- *Failure rate:* number of exceptions/number of observations.
- The Basel Committee requires backtesting at the 99% confidence level over one year; establishes zones for the number of exceptions with corresponding penalties (increases in the capital multiplier).

Mapping

Mapping involves finding common risk factors among positions in a given portfolio. It may be difficult and time consuming to manage the risk of each individual position. One can evaluate the value of portfolio positions by mapping them onto common risk factors.

Mean Reversion

- Implies that over time variables or returns regress back to the mean or average return.
- Mean reversion rate, a, is expressed as:

$$S_t - S_{t-1} = a(\mu - S_{t-1})$$

- The β coefficient of a regression is equal to the negative of the mean reversion rate.

Autocorrelation

- Measures the degree that a variable's current value is correlated to past values.
- Has the exact opposite properties of mean reversion.
- The sum of the mean reversion rate and the one-period autocorrelation rate will always equal one.

Correlation Swap

- Used to trade a fixed correlation between two or more assets with a realized correlation.
- Realized correlation for a portfolio of *n* assets:

$$\rho_{realized} = \frac{2}{n^2 - n}\sum_{i>j}\rho_{i,j}$$

- Payoff for correlation swap buyer:

notional amount × $(\rho_{realized} - \rho_{fixed})$

Gaussian Copula

- Indirectly defines a correlation relationship between two variables.
- Maps the marginal distribution of each variable to a standard normal distribution (done on percentile-to-percentile basis).
- The new joint distribution is a multivariate standard normal distribution.
- A Gaussian default time copula can be used for measuring the joint probability of default between two assets.

Regression-Based Hedge

$$F^R = F^N \times \left(\frac{DV01^N}{DV01^R}\right) \times \beta$$

where:

F^R = face amount of hedging instrument

F^N = face amount of initial position

Bond Valuation Using Binomial Tree

Using backward induction, the value of a bond at a given node in a binomial tree is the average of the present values of the two possible values from the next period. The appropriate discount rate is the forward rate associated with the node under analysis.

There are three basic steps to valuing an option on a fixed-income instrument using a binomial tree:

Step 1: Price the bond value at each node using the projected interest rates.

Step 2: Calculate the intrinsic value of the derivative at each node at maturity.

Step 3: Calculate the expected discounted value of the derivative at each node using the risk-neutral probabilities and work backward through the tree.

Interest Rate Expectations

Expectations play an important role in determining the shape of the yield curve and can be illustrated by examining yield curves that are flat, upward-sloping, and downward-sloping. If expected 1-year spot rates for the next three years are r_1, r_2, and r_3, then the 2-year and 3-year spot rates are computed as follows.

$$\hat{r}(2) = \sqrt{(1+r_1)(1+r_2)} - 1$$

$$\hat{r}(3) = \sqrt[3]{(1+r_1)(1+r_2)(1+r_3)} - 1$$

Convexity Effect

All else held equal, the value of convexity increases with maturity and volatility.

Term Structure Models

Model 1: assumes no drift and that interest rates are normally distributed:

$dr = \sigma dw$

Model 2: adds a positive drift term to Model 1 that can be interpreted as a positive risk premium associated with longer time horizons:

$dr = \lambda dt + \sigma dw$

where:

λ = interest rate drift

Ho-Lee Model: generalizes drift to incorporate time-dependency:

$dr = \lambda(t)dt + \sigma dw$

Vasicek Model: assumes a mean-reverting process for short-term interest rates:

$dr = k(\theta - r)dt + \sigma dw$

where:

k = a parameter that measures the speed of reversion adjustment

θ = long-run value of the short-term rate assuming risk neutrality

r = current interest rate level

Model 3: assigns a specific parameterization of time-dependent volatility:

$dr = \lambda(t)dt + \sigma e^{-\alpha t}dw$

where:

σ = volatility at t = 0, which decreases exponentially to 0 for $\alpha > 0$

Cox-Ingersoll-Ross (CIR) model: mean-reverting model with constant volatility, σ, and basis-point volatility, $\sigma\sqrt{r}$, that increases at a decreasing rate:

$$dr = k(\theta - r)dt + \sigma\sqrt{r}dw$$

Model 4 (lognormal model): yield volatility, σ, is constant, but basis-point volatility, σr, increases with the level of the short-term rate. There are two lognormal models of importance: (1) lognormal with deterministic drift and (2) lognormal with mean reversion.

Put-Call Parity

$c - p = S - Xe^{-rT}$

where:

c = price of a call

p = price of a put

S = price of the underlying security

r = risk-free rate

T = time left to expiration expressed in years

Volatility Smiles

Currency options: implied volatility is lower for at-the-money options than it is for away-from-the-money options. If the implied volatilities for actual currency options are greater for away-from-the-money than at-the-money options, currency traders must think there is a greater chance of extreme price movements than predicted by a lognormal distribution.

Equity options: higher implied volatility for low strike price options. The volatility smirk (half-smile) exhibited by equity options translates into a left-skewed implied distribution of equity price changes. This indicates that traders believe the probability of large down movements in price is greater than large up movements in price, as compared with a lognormal distribution.

CREDIT RISK MEASUREMENT AND MANAGEMENT

Credit Risk

- *Credit risk* is the risk of economic loss from default or changes in credit events/ratings.
- Types of credit risky securities include: corporate and sovereign debt, credit derivatives, and structured credit products. Their interest rates include a credit spread above credit risk-free securities.

Expected Loss (EL)

Expected value of a credit loss:

$$EL = EA \times PD \times LR$$

Exposure amount (EA): amount of money the lender can lose in the event of a borrower's default.

Probability of default (PD): likelihood that a borrower will default within a specified time horizon.

Loss rate (LR) or *loss given default* (LGD): amount of creditor loss in the event of a default. In percent terms, it is equal to 1 minus the recovery rate (i.e., 1 – RR).

Unexpected Loss

Unexpected loss represents the variability of potential losses and can be modeled using the definition of standard deviation.

$$UL = EA \times \sqrt{PD \times \sigma_{LR}^2 + LR^2 \times \sigma_{PD}^2}$$

Rating Assignment Methodologies

Experts-based approaches rely on experienced individuals who can provide valuable inputs into the models.

Statistical-based models use both quantitative and qualitative data to describe the real world in a controlled environment.

Numerical-based models are designed to derive optimal solutions using trained algorithms.

Linear discriminant analysis (LDA) is used to develop scoring models (e.g., Altman's *z*-score) to provide accept/reject decisions.

LOGIT models are used to predict default based on understanding the relationships between dependent and independent variables.

Cluster analysis aggregates and segments borrowers based on the profiles of their variables.

Principal component analysis takes original data and transforms it into a new derived data set, which is used to determine the primary drivers of a firm's profile and potential default.

Cash flow analysis is useful for assigning ratings to companies that don't have meaningful historical data for predicting potential default.

The Merton Model

- A value-based model where the value of the firm's outstanding debt (D) plus equity (E) is equal to the value of the firm (V).
- The value of the debt can serve as an indicator of firm default risk.
- Since E and D are contingent claims, option pricing can be used to determine their values as follows:
  payment to shareholders: $\max(V_M - D_M, 0)$
  payment to debtholders:
  $$D_M - \max(D_M - V_M, 0)$$
- Equity is similar to a long call option on the value of a firm's assets where face value of debt is the strike price of the option.
- Debt is similar to a risk-free bond and short put option on the value of a firm's assets where face value of debt is the strike price of the option.

Credit Spread

Difference between the yield on a risky bond (e.g., corporate bond) and the yield on a risk-free bond (e.g., T-bond) given that the two instruments have the same maturity.

$$CS = -\left[\frac{1}{(T-t)}\right] \times \ln\left(\frac{D}{F}\right) - R_F$$

where:

D = current value of debt

F = face value of debt

Credit Risk Portfolio Models

These models attempt to estimate a portfolio's credit value at risk. Credit VaR differs from market VaR in that it measures losses that are due specifically to default risk and credit deterioration risk.

CreditRisk+: determines default probability correlations and default probabilities by using a set of common risk factors for each obligor.

CreditMetrics: uses historical data to estimate the probability of a bond being upgraded or downgraded using historical transition matrices.

KMV Portfolio Manager: default probability is a function of firm asset growth and the level of debt. The higher the growth and lower the debt level, the lower the default probability.

CreditPortfolio View: multifactor model for simulating joint conditional distributions of credit migration and default probabilities that incorporates macroeconomic factors.

Credit Derivatives

A credit derivative is a contract with payoffs contingent on a specified credit event. Credit events include:

- Failure to make required payments.
- Restructuring that harms the creditor.
- Invocation of cross-default clause.
- Bankruptcy.

Credit default swap (CDS): like insurance; party selling the protection receives a fee, pays based on swap's notional amount in the case of default.

First-to-default put: CDS variation where a party pays an insurance premium in exchange for being made whole for the first default from a basket of assets. More cost effective option than CDS if assets have uncorrelated default risks.

Total return swap: total return on an asset (bond) is exchanged for a fixed (or variable) payment; total return receiver gets any appreciation (capital gains and cash flows), pays any depreciation; payments take place whether or not a credit event occurs. Buyer exchanges credit risk of issuer defaulting for the combined risk of the issuer and the derivative counterparty.

Vulnerable option: option with default risk; holder receives promised payment only if seller of the option is able to make the payment.

Asset-backed credit-linked note: embeds a default swap into a debt issuance. It is a debt instrument with its coupon and principal risk tied to an underlying debt instrument (e.g., bond or loan).

Spread Conventions

Yield spread: YTM risky bond – YTM benchmark government bond

i-spread: YTM risky bond – linearly interpolated YTM on benchmark government bond

z-spread: basis points added to each spot rate on a benchmark curve

CDS spread: market premium of CDS of issuer bond

Hazard Rates

The hazard rate (default intensity) is represented by the (constant) parameter λ and the probability of default over the next, small time interval, dt, is λdt.

Cumulative PD

If the time of the default event is denoted t*, the cumulative default time distribution F(t) represents the probability of default over (0, t):

$$P(t^* < t) = F(t) = 1 - e^{-\lambda t}$$

The survival distribution is:

$$P(t^* \geq t) = 1 - F(t) = e^{-\lambda t}$$

Collateralized Debt Obligation (CDO)

- General term for an asset-backed security that issues securities that pay principal and interest from a collateral pool of debt instruments.
- In order to create a CDO, the issuer packages a series of debt instruments and splits the package into several classes of securities called tranches.
- The largest part of a CDO is typically the senior tranche, which usually carries an AA or AAA credit rating, regardless of the quality of the underlying assets in the pool.

Synthetic CDO: originator retains reference assets on balance sheet but transfers credit risk to an SPV, which then creates the tradable synthetic CDO. This product bets on the default of a pool of assets, not on the assets themselves.

Securitization

Transforms the illiquid assets of a financial institution into a package of asset-backed securities (ABSs) or mortgage-backed securities (MBSs). A third party uses credit enhancements, liquidity enhancements, and structuring to issue securities backed by the pooled cash flows (of the same underlying assets).

- Credit enhancements include overcollateralization, subordinating note classes, margin step-up, and excess spread.
- The first-loss piece (equity piece) absorbs initial losses and is often held by the originator.

ABS/MBS Performance Tools

Auto loans: loss curves, absolute prepayment speed.

Credit card debt: delinquency ratio, default ratio, monthly payment rate.

Mortgages: debt service coverage ratio, weighted average coupon, weighted average maturity, weighted average life, single monthly mortality, constant prepayment rate, Public Securities Association.

Subprime Mortgage Market

- Subprime borrowers have a history of either default or strong indicators of possible future default.
- Indicators of future default: past delinquencies, judgments, foreclosures, repossessions, charge-offs, and bankruptcy filings; low FICO scores; high debt service ratio of 50% or more.
- The vast majority of subprime loans are adjustable rate mortgages.

Counterparty Risk

The risk that a counterparty is unable or unwilling to live up to its contractual obligations.

Credit exposure: loss that is "conditional" on the counterparty defaulting.

Recovery: measured by the recovery rate, which is the portion of the outstanding claim actually recovered after default.

Wrong-way exposures: exposures that are negatively correlated with the counterparty's credit quality. They increase expected credit losses.

Mark-to-market (MtM): accrual accounting measure that is equal to the sum of the MtM values of all contracts with a given counterparty.

Credit Exposure Metrics

Expected MtM: forward or expected value of a transaction at a given point in the future.

Expected exposure (EE): amount that is expected to be lost (positive MtM only) if the counterparty defaults.

Potential future exposure (PFE): worst exposure that could occur at a given time in the future at a given confidence level.

Expected positive exposure (EPE): average EE through time.

Effective EE: equal to non-decreasing EE.

Effective EPE: average of effective EE.

Maximum PFE: highest PFE value over a stated time frame.

Credit Mitigation Techniques

Netting: a legally binding agreement that enables counterparties with multiple derivative contracts to net their obligations (e.g., Party A owes Party B \$50 million; Party B owes Party A \$40 million, so Party A pays a net \$10 million to Party B).

Collateralization: if the value of derivative contracts is above a stated threshold, collateral must equal the difference between the value of the contracts and the threshold level.

Modeling Collateral

Certain parameters impact the effectiveness of collateral in lessening credit exposure. These parameters are as follows.

Remargin period: the time between the call for collateral and its receipt.

Threshold: an exposure level below which collateral is not called. It represents an amount of uncollateralized exposure.

Minimum transfer amount: the minimum quantity or block in which collateral may be transferred. Quantities below this amount represent uncollateralized exposure.

Initial margin: an amount posted independently of any subsequent collateralization. This is also referred to as the independent amount.

Rounding: the process by which a collateral call amount will be adjusted (rounded) to a certain increment.

Central Counterparties (CCPs)

CCPs step in the middle of a bilateral counterparty relationship between member firms and offset risk with loss mutualization, collateral posting, and multilateral trade netting. They utilize a loss waterfall to mutualize losses among all member firms. Losses are first absorbed by the defaulted members' initial margin and default funds. If losses are greater, CCP equity and surviving members' default funds are used.

Credit Value Adjustment (CVA)

Expected value or price of counterparty credit risk. A positive value represents a cost to the counterparty that bears a greater propensity to default. The CVA should account for the counterparty's default probability, the transaction in question, netting, collateral, and hedging.

$$CVA = LGD \times \sum_{i=1}^{m} \times EE(t_i) \times PD(t_{i-1}, t_i)$$

where:

EE = discounted expected exposure

Debt Value Adjustment (DVA)

Financial institutions should incorporate the value of their option to default to a counterparty through the bilateral CVA (BCVA), also known as the DVA.

Unlike the CVA formula, the BCVA incorporates negative expected exposure and the probability of the counterparty's survival.

Wrong-Way Risk vs. Right-Way Risk

Wrong-way risk: increases counterparty risk (increases CVA and decreases DVA).

Right-way risk: decreases counterparty risk (decreases CVA and increases DVA).

OPERATIONAL RISK AND RESILIENCY

Operational Risk Governance

The Basel Committee on Banking Supervision defines operational risk as "the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events."

Lines of defense to control operational risks include (1) risk management in each business unit, (2) independent operational risk management function, and (3) independent reviews of operational risks and risk management (internal and/or external reviews).

Enterprise Risk Management (ERM)

In developing an ERM system, management should follow the following framework:

- Determine the firm's acceptable level of risk.
- Based on the firm's target debt rating, estimate the capital (buffer) required to support the current level of risk in the firm's operations.
- Determine the ideal mix of capital and risk that will achieve the appropriate debt rating.
- Give individual managers the information and the incentive they need to make decisions appropriate to maintain the risk/capital tradeoff.

The implementation steps of ERM are as follows:

- Identify the risks of the firm.
- Develop a consistent method to evaluate the firm's exposure to the identified risks.

Firm-Wide VaR

- Firms that use VaR to assess potential loss amounts will have multiple VaR measures to manage.
- Market risk, credit risk, and operational risk will each produce its own VaR measures.
- Due to diversification effects, firm-wide VaR will be less than the sum of the VaRs from each risk category.

Risk Appetite Framework (RAF)

- Sets in place a clear, future-oriented perspective of the firm's target risk profile in a number of different scenarios and maps out a strategy for achieving that risk profile.
- Should start with a risk appetite statement that is essentially a mission statement from a risk perspective.
- Benefits include assisting firms in preparing for the unexpected and greatly improving a firm's strategic planning and tactical decision-making.

Risk Culture

Integrates risk awareness, risk-taking, and risk management activities. Methods to improve risk culture include:

- Encourage positive employee behavior and conduct consistent with firm values.
- Increase governance by boards focusing on firm values, conduct, and culture.
- Realign incentives for compensation and promotion.
- Create an effective three lines of defense.
- Assess conduct at all levels of supervisory roles.

Basel II Operational Risk Event Types

- Internal Fraud.
- External Fraud.
- Employment Practices and Workplace Safety.
- Clients, Products, and Business Practices.
- Damage to Physical Assets.
- Business Disruption and System Failures.
- Execution, Delivery, and Process Management.

Model Risk

Model risk raises the possibility of (negative) outcomes resulting from inaccurate model outputs. It can arise in two ways: (1) model has significant errors and produces faulty outputs, and (2) model is used out of context or is not used properly for its intended purposes.

Rating Model Validation

Qualitative validation: (1) obtaining probabilities of default, (2) completeness, (3) objectivity, (4) acceptance, and (5) consistency.

Quantitative validation: (1) sample representativeness, (2) discriminatory power, (3) dynamic properties, and (4) calibration.

Risk-Adjusted Return on Capital

The RAROC measure is essential to successful integrated risk management. Its main function is to relate the return on capital to the riskiness of firm investments. The RAROC is risk-adjusted return divided by risk-adjusted capital (i.e., economic capital).

$$\text{RAROC} = \frac{\begin{pmatrix}\text{revenues} - \text{costs} - \text{EL} - \text{taxes} + \\ \text{return on economic capital} \pm \text{transfers}\end{pmatrix}}{\text{economic capital}}$$

An adjusted RAROC (ARAROC) measure better aligns the risk of the business with the risk of the firm's equity.

$$\text{Adjusted RAROC} = \text{RAROC} - \beta_E(R_M - R_F)$$

Capital Plan Rule

- Mandates that bank holding companies develop a capital plan and evaluate capital adequacy.
- Capital adequacy process includes: risk management foundation, resource and loss estimation methods, impact on capital adequacy, capital planning and internal controls policies, and governance oversight.

Money Laundering and the Financing of Terrorism (ML/FT)

Banks must determine which customers pose a low or high risk of ML/FT using customer due diligence (CDD). Lines of defense to mitigate ML/FT risks include (1) business units (e.g., customer facing activities), (2) the chief ML/FT officer, and (3) internal and external audits.

Basel II: Three Pillars

Pillar 1: Minimum capital requirements. Banks should maintain a minimum level of capital to cover credit, market, and operational risks.

Pillar 2: Supervisory review process. Banks should assess the adequacy of capital relative to risk, and supervisors should review and take corrective action if problems occur.

Pillar 3: Market discipline. Risks should be adequately disclosed in order to allow market participants to assess a bank's risk profile and the adequacy of its capital.

Market Risk Capital Requirements

Standardized method: determines capital charges associated with various market risk exposures (equity risk, interest rate risk, foreign exchange risk, commodity risk, and option risk). The market risk capital charge for each market risk is computed as 8% of its market-risky assets.

Internal models approach: allows a bank to use its own risk management systems to determine its market risk capital charge. The market risk charge is the higher of (1) the previous day's VaR or (2) the average VaR over the last 60 business days adjusted by a multiplicative factor (subject to a floor of 3).

Backtesting VaR

An exception occurs if the day's change in value exceeded the VaR estimate of the previous day. When backtesting VaR, the number of exceptions is determined for a 250-day testing period. Based on the number of exceptions, the bank's exposure is categorized into one of three zones and VaR is scaled up by the appropriate multiplier (subject to a floor of 3).

- Green zone: 0–4 exceptions, increase in exposure multiplier is 0.
- Yellow zone: 5–9 exceptions, exposure multiplier increases between 0.4 and 0.85.
- Red zone: Greater than or equal to 10 exceptions, multiplier increases by 1.

Credit Risk Capital Requirements

The *standardized approach* incorporates risk weights based on external credit rating assessments. The amount of capital that a bank must hold is specific to the risk of credit-risky assets, the type of institution the claim is written on, and the maturity of those assets.

The *internal ratings-based* (IRB) approaches (foundation and advanced) use a bank's own internal estimates of creditworthiness to determine the risk weightings in the capital calculation.

- *Foundation approach*: bank estimates PD.
- *Advanced approach*: bank estimates not only PD, but also LGD, exposure at default (EAD), and effective maturity (M).

Operational Risk Capital Requirements

Basic indicator approach: measures the capital charge on a firm-wide basis. Banks will hold capital for operational risk equal to a fixed percentage of the bank's average annual gross income over the prior three years. The Basel Committee has proposed a fixed percentage equal to 15%.

Standardized approach: allows banks to divide activities along standardized business lines. Within each business line, gross income will be multiplied by a fixed beta factor. The capital charge for operational risk is the sum of each business line's charges.

Advanced measurement approach (AMA): If a bank can meet more rigorous supervisory standards, it may use the AMA for operational risk capital calculations. The capital charge for AMA is calculated as the bank's operational value at risk (OpVaR) with a 1-year horizon and a 99.9% confidence level. Having insurance can reduce this capital charge by as much as 20%.

Solvency II

Establishes capital requirements for the operational, investment, and underwriting risks of insurance companies.

- Specifies minimum capital requirements (MCR) and solvency capital requirements (SCR).
- *Standardized approach:* Intended for less sophisticated insurance firms; captures the risk profile of the average insurance firm.
- *Internal models approach:* Similar to the IRB approach under Basel II. A VaR is calculated with a one-year time horizon and a 99.5% confidence level.

Stressed Value at Risk (SVaR)

SVaR is calculated by combining current portfolio performance data with the firm's historical data from a significantly financial stressed period in the same portfolio:

$$\max\left(\text{SVaR}_{t-1},\ \text{multiplicative factor} \times \text{SVaR}_{\text{avg}}\right)$$

Basel III Changes

- Raise capital standards (both quality and quantity).
- Strengthen risk coverage of capital framework.
- Require leverage ratio to supplement capital requirements.
- Promote countercyclical buffers during financial shocks.
- Institute policies to address systemic risk and interconnectedness.
- Institute global liquidity standard (liquidity, funding, and monitoring metrics).

Liquidity Coverage Ratio (LCR)

Goal: ensure banks have adequate, high-quality liquid assets to survive short-term stress scenario.

LCR = (stock of high-quality liquid assets / total net cash outflows over next 30 calendar days) $\geq$ 100

Net Stable Funding Ratio (NSFR)

Goal: protect banks over a longer time horizon than LCR.

NSFR = (available amount of stable funding / required amount of stable funding) $\geq$ 100

Standardized Measurement Approach (SMA)

The SMA for operational risk includes both a business indicator (BI) component accounting for operational risk exposure and an internal loss multiplier (and loss component) accounting for operational losses unique to an individual bank. The BI component impact will vary depending on where the bank is classified from buckets 1–3.

Cyber Resilience

An effective cyber-resilience framework consists of the following elements: (1) identify, (2) protect, (3) detect, (4) respond, and (5) recover. Organizations can improve cyber resilience with adaptive response, analytic monitoring, coordinated defense, deception, privilege restriction, random changes, redundancy, segmentation, and substantiated integrity.

Operational Resilience

Process of preventing, responding to, and recovering from operational threats and disruptions in business services. Benefits of having an effective operational resilience program include (1) lowering risk exposures and gaining better insight into the risks, (2) focusing on the most crucial business services, (3) improving innovation abilities, and (4) increasing operational efficiency. Challenges and threats include technical innovation, changing behaviors, technology gaps, dynamic environments, and complexity of systems.

LIQUIDITY AND TREASURY RISK MEASUREMENT AND MANAGEMENT

Liquidity Risk

The lack of a market for a security to prevent it from being traded quickly enough to prevent or minimize a loss.

Trading liquidity risk: risk that the act of buying or selling an asset will result in an adverse price move.

Funding liquidity risk: results when a borrower's credit position is either deteriorating or perceived by market participants to be deteriorating.

Bid-Offer (or Bid-Ask) Spread

$$s = \frac{\text{offer price} - \text{bid price}}{\text{mid-market price}}$$

Liquidity-Adjusted VaR (LVaR)

LVaR = VaR + cost of liquidation

where:

$$\text{cost of liquidation} = \sum_{i=1}^{n} \frac{s_i \alpha_i}{2}$$

α = mid-market value

Leverage Ratio

A firm's leverage ratio is equal to its assets divided by equity:

$$L = \frac{A}{E} = \frac{(E + D)}{E} = 1 + \frac{D}{E}$$

Leverage Effect

Return on equity (ROE) is higher as leverage increases, as long as the firm's return on assets (ROA) exceeds the cost of borrowing funds. The leverage effect can be expressed as:

ROE = (leverage ratio × ROA) – [(leverage ratio – 1) × cost of debt]

Transaction Cost

The 99% confidence interval on transaction cost is:

$+/- P \times ½(s + 2.33\sigma_S)$

where:

P = estimate of the next day asset midprice

s = bid-ask spread

$½(s + 2.33\sigma_S)$ = 99% spread risk factor

Early Warning Indicators (EWIs)

EWIs are changes in key metrics that could signal a pending liquidity problem. They should contain both internal and external measures, be leading indicators and granular, provide warning of any potential worsening of a bank's financial position, identify whether the bank has sufficient liquid resources to handle a stress scenario, and consider different time horizons.

Net Liquidity Position

supplies of liquidity – demands for liquidity

where:

supplies of liquidity = incoming deposits (inflows) + customer loan repayments + asset sales + revenue from nondeposit services + money market borrowings

demands for liquidity = deposit withdrawals (outflows) + borrowing repayments + dividend payments + loan requests + other operating expenses

Liquidity Requirements

Methods for estimating liquidity needs include (1) the sources and uses of funds approach, (2) the structure of funds approach, (3) the liquidity indicator approach, and (4) the market signals (discipline) approach.

Intraday Liquidity

Uses: outgoing wire transfers, payment clearing and settlement (PCS) systems, funding of foreign accounts, collateral pledging, and asset purchases/funding.

Sources: cash balances, payment inflows, intraday credit, liquid assets, and overnight borrowings.

Deterministic and Stochastic Cash Flows

In terms of time, cash flows can be deterministic (occurring at known times) or stochastic (occurring randomly). Similarly, cash flows with known amounts are deterministic (i.e., fixed), while cash flows with unknown amounts are stochastic (e.g., credit related, behavioral).

Contingent Liquidity

Comprised of the (very high quality) liquid assets and credit facilities that are meant to satisfy general liabilities in stressed situations. Contingent liquidity is estimated using the liquid asset buffer, which includes assets that typically have little or no credit and market risk, are easy to value, and are actively traded. The stressed liquidity asset buffer is estimated as:

(normal) liquidity asset buffer – stressed cash outflows + stressed cash inflows

Contingency Funding Plans (CFPs)

Design considerations of CFPs include:

- Alignment to business and risk profiles.
- Integration with broader risk management frameworks.
- Operational, actionable, and flexible playbooks.
- Inclusive of appropriate stakeholder groups.
- Communication plan support.

Methods for Pricing Deposits

Cost-plus pricing: prices the deposit service such that the amount covers the direct and overhead costs associated with providing the service, as well as a profit margin.

Marginal cost pricing: compares the cost of raising additional funds with the yield the financial institution earns on the assets with which it invests the additional funds.

Conditional pricing: bases deposit fees on a condition, such as a minimum balance to be maintained in an account.

Available Funds Gap (AFG)

The difference between the current and projected inflows and outflows of bank funds:

AFG = current and projected loans and other investments – current and expected deposit inflows and other available funds

Repurchase Agreements (Repos)

- Bilateral contracts where one party sells a security at a specified price with a commitment to buy back the security at a future date at a higher price.
- From the perspective of the *borrower*: repos offer relatively cheap sources of short-term funds.
- From the perspective of the *lender*: reverse repos are used for either investing or financing purposes.

Liquidity Transfer Pricing (LTP)

LTP is the process of attributing the costs, benefits, and risks associated with liquidity to appropriate business units of the bank. Approaches used in LTP include zero cost, pooled average cost, separate average cost, and marginal cost. LTP best practice is to use the marginal cost approach, which incorporates actual market costs of funding to calculate liquidity spread.

Covered Interest Parity (CIP)

The cross-currency swap basis (b) is the amount by which the USD interest rate must be adjusted so that CIP holds (assuming F – S is too wide):

$$F - S = S\left(\frac{1 + r_{USD} + b}{1 + r_{FC}}\right) - 1$$

Factors that can cause deviations in CIP and cross-currency swap basis include (1) the lack of market liquidity and (2) increases in the risk of the underlying instruments that gives rise to risk premiums.

Net Interest Margin (NIM)

Measure of bank performance: (interest income – interest expense) / bank assets that earn income

Interest-Sensitive (IS) Gap

Meaure of interest rate risk: interest-sensitive assets – interest-sensitive liabilities

Duration Gap

Measure of the market (price) risk on assets relative to the market (price) risk on liabilities. The *leverage-adjusted duration gap* measures the effect of interest rate changes on the balance sheet:

$$D_A - D_L \times \frac{\text{total liabilites}}{\text{total assets}}$$

Illiquid Asset Return Biases

Biases that impact reported illiquid asset returns:

- *Survivorship bias*: Poor performing funds often quit reporting results, ultimately fail, or never begin reporting returns because performance is weak.
- *Selection bias*: Asset values and returns tend to be reported when they are high.
- *Infrequent trading*: Betas, volatilities, and correlations are too low when they are computed using the reported returns of infrequently traded assets.

RISK MANAGEMENT AND INVESTMENT MANAGEMENT

Factor Risks

Represent exposures to bad times; must be compensated for with risk premiums. Factor risk principles:

- It is not exposure to the specific asset that matters, rather the exposure to the underlying risk factors.
- Assets represent bundles of factors, and assets' risk premiums reflect these risk factors.
- Investors have different optimal exposures to risk factors, including volatility.

Fama-French Model

Explains asset returns based on:

- Traditional capital asset pricing model (CAPM) market risk factor.
- Factor that captures size effect (SMB or small cap minus big cap).
- Factor that captures value/growth effect (HML or high book-to-market value minus low book-to-market value).

Momentum effect: long winners and short losers (WML or winners minus losers). This strategy has outperformed both size and value/growth effects; however, it is subject to crashes.

Fundamental Law of Active Management

Tradeoff between required degree of forecasting accuracy [information coefficient (IC)] and number of investment bets placed [breadth (BR)]. IR stands for information ratio.

$$IR \approx IC \times \sqrt{BR}$$

Portfolio Construction Techniques

- *Screens* simply choose assets by ranking alpha.
- *Stratification* chooses stocks based on screens; includes assets from all asset classes.
- *Linear programming* attempts to construct a portfolio that closely resembles the benchmark.
- *Quadratic programming* explicitly considers alpha, risk, and transaction costs.

Portfolio Risk

Diversified VaR:

$$\text{VaR}_P = Z_c \times P \times \sqrt{w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2w_1w_2\sigma_1\sigma_2\rho_{1,2}}$$

Undiversified VaR:

$$\text{VaR}_P = \sqrt{\text{VaR}_1^2 + \text{VaR}_2^2 + 2\text{VaR}_1\text{VaR}_2} = \text{VaR}_1 + \text{VaR}_2$$

VaR for Uncorrelated Positions:

$$\text{VaR}_P = \sqrt{\text{VaR}_1^2 + \text{VaR}_2^2}$$

Marginal VaR: per dollar change in portfolio VaR that occurs from an additional investment in a position.

$$\text{MVaR}_i = \frac{\text{VaR}_P}{\text{portfolio value}} \times \beta_i$$

How to use MVaR:

- Obtain the optimal portfolio: equate the excess return/MVaR ratios of all portfolio positions.
- Obtain the lowest portfolio VaR: equate just the MVaRs of all portfolio positions.

Incremental VaR: change in VaR from the addition of a new position in a portfolio.

Component VaR: amount of risk a particular fund contributes to a portfolio of funds.

$$\text{CVaR}_i = \text{MVaR}_i \times w_i \times P = \text{VaR} \times \beta_i \times w_i$$

Risk Budgeting

Manager establishes a risk budget for the entire portfolio and then allocates risk to individual positions based on a predetermined fund risk level. The risk budgeting process differs from market value allocation since it involves the allocation of risk.

Budgeting risk across asset classes: selecting assets whose combined VaRs are less than the total allowed.

Budgeting risk across active managers: the optimal allocation is achieved with the following formula:

$$\text{weight of portfolio managed by manager } i = \frac{\text{IR}_i \times \text{portfolio's tracking error}}{\text{IR}_P \times \text{manager's tracking error}}$$

Liquidity Duration

Approximation of the number of days necessary to dispose of a portfolio's holdings without a significant market impact.

$$\text{LD} = \frac{\text{number of shares of a security}}{[\text{desired max daily volume } (\%) \times \text{daily volume}]}$$

Time-Weighted and Dollar-Weighted Returns

Dollar-weighted rate of return: the internal rate of return (IRR) on a portfolio taking into account all cash inflows and outflows.

Time-weighted rate of return: measures compound growth. It is the rate at which $1 compounds over a specified time horizon.

Measures of Performance

The *Sharpe ratio* calculates the amount of excess return (over the risk-free rate) earned per unit of total risk. It uses standard deviation as the relevant measure of risk.

$$S_A = \frac{\overline{R}_A - \overline{R}_F}{\sigma_A}$$

where:

$\overline{R}_A$ = average account return
$\overline{R}_F$ = average risk-free return
σ_A = standard deviation of account returns

The *Treynor measure* is very similar to the Sharpe ratio except that it uses beta (systematic risk) as the measure of risk. It shows excess return (over the risk-free rate) earned per unit of systematic risk.

$$T_A = \frac{\overline{R}_A - \overline{R}_F}{\beta_A}$$

where:

β_A = average beta

Jensen's alpha is the difference between actual return and return required to compensate for systematic risk. To calculate the measure, subtract the return calculated by the capital asset pricing model (CAPM) from the account return.

$$\alpha_A = R_A - E(R_A)$$

where:

α_A = alpha
$E(R_A) = R_F + \beta_A[E(R_M) - R_F]$

The *information ratio* is the ratio of surplus return (in a particular period) to its standard deviation. It indicates the amount of risk undertaken (denominator) to achieve a certain level of return above the benchmark (numerator).

$$\text{IR}_A = \frac{\overline{R}_A - \overline{R}_B}{\sigma_{A-B}}$$

where:

σ_{A-B} = standard deviation of excess returns measured as the difference between account and benchmark returns

The *M-squared (M^2) measure* compares return earned on the managed portfolio against the market return, after adjusting for differences in standard deviations between the two portfolios. It can be illustrated by comparing the CML for the market index and the CAL for the managed portfolio. The difference in return between the two portfolios equals the M^2 measure.

Performance Attribution

Asset allocation attribution equals the difference in returns attributable to active asset allocation decisions of the portfolio manager.

Selection attribution equals the difference in returns attributable to superior individual security selection (correct selection of mispriced securities) and sector allocation (correct over- and underweighting of sectors within asset classes).

Low-Risk Anomaly

Stocks with higher risk, measured by high standard deviation or high beta, produce lower risk-adjusted returns than stocks with lower risk.

Explanation: data mining, leverage and manager constraints, and investor preferences.

CURRENT ISSUES IN FINANCIAL MARKETS

Blockchain Technology

In finance, transaction history can be recorded in a blockchain. This information can be kept in multiple locations in the chain indefinitely, which creates a highly secure record of transactions. Bitcoin is a P2P payment system that uses blockchain technology.

Fintech and Market Structure

Fintech refers to firms focused on financial innovation through the application of technology.

Bigtech refers to large, established technology companies.

Market structure refers to factors benefiting financial markets as well as factors that determine risks. Drivers of market structure are APIs, mobile banking, cloud computing, the EU's revised Payment Services Directive (PSD2).

Digital Money

Types of money or payment include (1) central bank money (issued by a central bank), (2) cryptocurrency (issued on the blockchain by nonbanks), (3) b-money (issued by banks), (4) e-money (electronic money offered by the private sector), and (5) i-money (investment money issued by private investment funds).

E-money characteristics that encourage widespread adoption are convenience, ubiquity, complementarity, low transaction costs, trust, and network effects.

Big Data

Large datasets require tools that are more advanced than simple spreadsheet analysis. Overfitting and variable selection are ongoing challenges. Tools for analyzing big datasets include (1) classification and regression trees, (2) cross-validation, (3) conditional inference trees, (4) random forests, and (5) penalized regression.

Machine Learning (ML)

Uses algorithms that allow computers to learn without programming. *Supervised ML* predicts outcomes based on specific inputs, whereas *unsupervised ML* analyzes data to identify patterns without estimating a dependent variable.

ML can be applied to three classes of statistical problems: (1) regression, (2) classification, and (3) clustering.

Artificial Intelligence (AI)

The growing use of fintech, including AI and ML, is driven by cost savings and increased revenue. Firms use AI and ML to evaluate credit quality, optimize capital allocation, assess trading impacts, predict changes in securities prices and price volatility, and perform regulatory functions in financial markets.

Climate-Related Risks

Climate change generates (1) *physical risks*, which result from the physical impacts of climate change (e.g., fires, floods, heatwaves), and (2) *transition risks*, which result from the migration of energy and industry transitions in response to climate change risk (e.g., policy and reputational risks).

ISBN: 978-1-07-880190-4

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