Solution to Problem Set 6
MFE 409: Financial Risk Management

Cohort 1 Group 8
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Abstract

This report addresses both analytical and conceptual components of Problem Set 6 for MFE 409: Financial Risk Management. The first section presents a detailed case study of Bank of America's risk management practices, focusing on the evolution of risk frameworks from 2009 to the present day, and the bank's alignment with Basel regulations post-2008 financial crisis. The second section answers a set of interview-style theoretical questions covering value-at-risk estimation for nonlinear instruments, forward pricing, and key risk factors in quanto options. Together, the solutions demonstrate a practical and theoretical understanding of modern financial risk management tools and regulatory standards.

Contents

1. Risk Management and Regulation after the 2008 Financial Crisis

1.1 Overview of Bank of America's Risk Management Strategy (2009 vs. 2023/2024)

In 2009, in the immediate aftermath of the financial crisis, Bank of America's risk management strategy was primarily reactive, focusing on stabilizing exposures, managing distressed legacy assets (especially post-Merrill Lynch and Countrywide acquisitions), and increasing capital buffers. The bank's disclosures emphasized Value-at-Risk (VaR), stress testing, and capital adequacy, with heightened attention to credit losses and market dislocations. Risk management was siloed across divisions, and regulatory compliance was driven by Basel II frameworks.

In contrast, the 2023 and 2024 filings reflect a matured and more integrated approach to risk management, deeply embedded into the bank's strategic planning and operations. Bank of America now employs a unified Enterprise Risk and Compliance (ERC) framework, which encompasses risk identification, measurement, monitoring, and control across credit, market, liquidity, operational, and compliance domains. The reports highlight continued alignment with Basel III standards, including Liquidity Coverage Ratio (LCR), Net Stable Funding Ratio (NSFR), and standardized and advanced internal ratings-based approaches for credit risk.

Key developments from 2009 to 2024 include:

- A shift from VaR-centric risk quantification to a more diversified set of tools including scenario analysis, stress testing under CCAR/DFAST, and internal economic capital models.

- Enhanced governance via the Board's Risk Committee and Chief Risk Officer (CRO) structure.

- Real-time risk data infrastructure supporting risk-adjusted performance metrics at business-line levels.

- Increased emphasis on climate risk, cyber risk, and conduct risk, which were not central themes in 2009.

Overall, the transformation reflects both regulatory pressure and strategic realignment. Risk is now viewed not merely as a compliance necessity but as a central factor in pricing, product design, and customer relationship management.

1.2 Basel Framework Compliance

Bank of America's approach to Basel compliance has evolved significantly from 2009 to 2024, reflecting regulatory developments and increased internal sophistication.

In **2009**, the bank operated primarily under the Basel II framework, with an emphasis on the three-pillar approach: minimum capital requirements, supervisory review, and market discipline. At that time, Bank of America reported its Tier 1 and Total Capital ratios based on standardized risk-weighted assets (RWAs), with limited internal modeling. The risk-weighting was focused heavily on credit risk, and market and operational risk were

integrated using simpler approaches (e.g., the Basic Indicator Approach for operational risk). The financial crisis prompted early efforts to strengthen capital reserves and disclosures, particularly around legacy mortgage assets and counterparty exposures.

By **2023 and 2024**, Bank of America reports comprehensive compliance with the Basel III regulatory framework. The key components of its alignment include:

- **Capital Adequacy:** The bank discloses its Common Equity Tier 1 (CET1), Tier 1, and Total Capital ratios under both the Standardized and Advanced Approaches. It consistently exceeds the minimum regulatory thresholds set by the Federal Reserve and Basel III.

- **Risk-Weighted Assets (RWAs):** RWAs are computed with more granular internal models, particularly for wholesale credit risk, retail exposures, counterparty credit risk, and securitizations. This reflects a shift toward the Advanced Internal Ratings-Based (AIRB) approach.

- **Leverage and Liquidity:** BofA reports the Basel III Leverage Ratio, Liquidity Coverage Ratio (LCR), and Net Stable Funding Ratio (NSFR), demonstrating robust liquidity management. For instance, LCR levels have consistently remained above the 100% minimum threshold, ensuring adequate short-term liquidity under stress scenarios.

- **Capital Planning:** Stress testing under the Federal Reserve's CCAR (Comprehensive Capital Analysis and Review) process is integrated into the bank's capital management framework, consistent with Pillar 2 requirements.

- **Pillar 3 Disclosures:** Detailed qualitative and quantitative disclosures are provided to promote market discipline. These include sensitivity analyses, credit risk migration patterns, and breakdowns of RWA by exposure class.

Bank of America's current compliance strategy aligns not only with minimum Basel III standards but also anticipates emerging Basel IV enhancements. This evolution demonstrates a shift from a compliance-driven posture to a proactive, integrated risk-capital management system supporting long-term financial stability.

1.3 Risk Quantification Methods

Bank of America employs a multi-dimensional approach to risk quantification, focusing on three primary categories: credit risk, market risk, and operational risk. The sophistication of these methodologies has increased markedly between 2009 and 2024.

Credit Risk

2009: Credit risk was assessed largely through standardized risk weights under Basel II. The bank relied on internal credit ratings and historical default data to monitor portfolio quality, but internal models were not yet central to regulatory capital calculation.

2023/2024: Credit risk is now measured using both the Standardized and Advanced Internal Ratings-Based (AIRB) approaches. For wholesale exposures, BofA uses internally modeled Probability of Default (PD), Loss Given Default (LGD), and Exposure at Default (EAD) to determine capital requirements. Retail portfolios use segmentation and scoring models based on borrower behavior and external bureau data. Expected credit losses (ECL) under CECL accounting standards are also incorporated for financial reporting and stress testing.

Market Risk

2009: Market risk was primarily captured through Value-at-Risk (VaR) models, with a 99% confidence level over a one-day horizon. Stress testing was rudimentary and scenario-specific.

2023/2024: Market risk is assessed using a suite of tools:

- **VaR and SVaR:** VaR continues to be used for daily risk management, supplemented by Stressed VaR (SVaR) to reflect tail risk conditions under regulatory capital requirements.

- **Incremental Risk Charge (IRC):** Captures default and migration risk in trading book exposures over a one-year horizon.

- **Comprehensive Risk Measure (CRM):** Applied to complex structured products such as correlation trading portfolios.

- **Stress Testing:** Scenario analysis under both internal and regulatory (CCAR/DFAST) assumptions is central to market risk assessment.

Operational Risk

2009: Operational risk capital was calculated using the Basic Indicator Approach, applying a fixed percentage to gross income as a proxy.

2023/2024: BofA now uses a hybrid approach combining the Standardized Measurement Approach (SMA) with internal event data, scenario analysis, and key risk indicators (KRIs). Loss event databases and risk-control self-assessments (RCSAs) are used to quantify and manage exposure to legal, cyber, compliance, and reputational risks. While regulatory capital is calculated using standardized methods, internal tools enable dynamic and forward-looking operational risk management.

In all three categories, Bank of America integrates risk quantification into business-line performance metrics, capital allocation decisions, and strategic planning, signaling a high level of model integration and governance maturity.

1.4 Capital and Liquidity Buffers

Bank of America's capital and liquidity buffer strategies have undergone a significant transformation over the past decade, evolving from crisis recovery in 2009 to strategic resilience and optimization by 2023–2024.

Capital Planning and Capital Buffers

2009: In the aftermath of the global financial crisis, Bank of America was under pressure to shore up capital. The focus was primarily on increasing Tier 1 capital ratios, bolstered by government support programs such as TARP. Capital planning was short-term and reactive, with limited scenario-based modeling. Internal capital assessments relied heavily on regulatory minimums without dynamic internal allocation tools.

2023/2024: The bank now maintains robust capital buffers well above regulatory thresholds. These include:

- **Common Equity Tier 1 (CET1) capital buffer** to meet both the Basel III minimum and the U.S. GSIB surcharge.

- **Stress Capital Buffer (SCB):** Derived from the Federal Reserve's CCAR stress testing results, this buffer is incorporated into minimum capital requirements.

- **Countercyclical Capital Buffer (CCyB):** Monitored and reported, though not actively binding in recent years.

- **Internal Capital Adequacy Assessment Process (ICAAP):** Used to assess capital under a variety of stressed macroeconomic and idiosyncratic scenarios.

Capital planning is integrated with risk appetite statements and business strategy, with oversight from the Risk and Capital Committees of the Board. The firm also engages in capital optimization via dividends and share repurchases, constrained by supervisory approvals and stress performance.

Liquidity Coverage and Stress Testing

2009: Liquidity risk management was focused on maintaining large cash reserves and central bank access. However, formal regulatory liquidity standards such as the Liquidity Coverage Ratio (LCR) and Net Stable Funding Ratio (NSFR) were not yet in place.

2023/2024: BofA actively manages liquidity using forward-looking cash flow forecasting, contingent funding plans, and internal stress models. It complies with:

- **Liquidity Coverage Ratio (LCR):** Measures the ability to withstand 30-day net outflows under stress. The bank maintains LCR consistently above 100%.

- **Net Stable Funding Ratio (NSFR):** Ensures stable funding for one-year horizon needs. The ratio remains above regulatory minimums.

- **Internal Liquidity Stress Testing:** Encompasses both idiosyncratic and market-wide shocks, with multiple time horizons and currency-specific analyses.

High-quality liquid assets (HQLA) are held across jurisdictions to meet both global and local requirements. Liquidity management is centralized and subject to daily monitoring and escalation procedures.

The bank's capital and liquidity resilience reflect a shift from regulatory compliance to strategic and integrated balance sheet management.

1.5 Critical Reflection

Bank of America's transformation in risk management since the 2008 financial crisis reflects not only compliance with evolving global regulations but also a deeper philosophical shift in how the institution perceives and internalizes risk.

One of the most notable improvements is the transition from siloed risk functions in 2009 to a unified enterprise-wide risk framework by 2023–2024. This shift has allowed the bank to better align capital allocation, strategic planning, and regulatory compliance. Additionally, BofA's integration of forward-looking stress testing, enhanced data infrastructure, and dynamic risk dashboards demonstrates a maturity in its risk governance culture.

However, several areas warrant reflection:

- **Model risk and complexity:** As the bank has adopted more advanced internal models (e.g., AIRB for credit, IRC and CRM for market), it becomes increasingly exposed to model risk. The reliance on complex quantitative tools introduces opacity, which—if unchecked—can recreate systemic vulnerabilities under extreme scenarios.

- **Overemphasis on compliance:** While Basel III metrics are met or exceeded, there is a risk of treating regulatory ratios as performance goals rather than minimum safeguards. This can lead to regulatory arbitrage behavior or complacency in risk culture, especially during periods of benign macroeconomic conditions.

- **Emerging risks:** Climate risk, cyber risk, and geopolitical volatility are increasingly relevant but still difficult to quantify with precision. Though Bank of America has acknowledged these risks and taken steps toward scenario analysis and disclosures (e.g., TCFD reporting), integration into core capital and risk metrics remains nascent.

- **Liquidity assumptions:** Despite robust LCR and NSFR metrics, actual liquidity crises often stem from behavioral factors such as depositor panic or funding market freezes. These are not always captured in mechanical regulatory stress models.

In sum, while Bank of America's current risk framework is materially more resilient and forward-looking than in 2009, it remains a living system requiring continuous skepticism, adaptation, and a balance between quantitative precision and qualitative judgment.

2. Interview Questions

2.1 1. Delta-VaR for a Squared Payoff Option

The option in question has a payoff of $S^2_{t+3 \text{ months}}$, meaning the value of the option at time t is $V(S) = S^2$. The first derivative (Delta) is $\Delta = \frac{dV}{dS} = 2S$, and the second derivative (Gamma) is constant at $\Gamma = \frac{d^2V}{dS^2} = 2$.

The Delta-VaR approach uses a first-order Taylor approximation:

$$\Delta V \approx \Delta \cdot \Delta S$$

This linear approximation does not account for curvature in the payoff function. Since the payoff function S^2 is convex, the Delta-VaR significantly underestimates risk for large

downward movements in the stock price. The actual loss will be greater than that predicted by Delta alone.

Moreover, convexity implies that for negative shocks in S, the reduction in portfolio value is more severe than a linear model would suggest. Since VaR measures tail risk, ignoring Gamma leads to underestimation of potential losses in adverse scenarios.

Conclusion: The Delta-only VaR approach *underestimates* risk in this case due to the convex (nonlinear) nature of the payoff.

2.2 2. Forward Price Estimation for a Trending Stock

To compute the three-month forward price of the stock, we use the standard cost-of-carry formula under the assumption of no dividends:

$$F = S_0 e^{rT}$$

where:

- S_0 is the current stock price

- r is the continuously compounded risk-free rate

- $T = \frac{3}{12} = 0.25$ is the time in years

Since the question states the stock has been growing at 10% annually for the past three years and no other rate is provided, we assume this 10% reflects the implied risk-free rate (for estimation purposes). Then:

$$F = S_0 e^{0.10 \cdot 0.25} = S_0 \cdot e^{0.025} \approx S_0 \cdot 1.0253$$

Thus, the three-month forward price is approximately 2.53% higher than today's spot price.

2.3 3. Risk Factors in Quanto Options

Quanto options are exotic derivatives whose underlying asset is denominated in a foreign currency, but the payoff is settled in the investor's domestic currency at a fixed exchange rate. While this eliminates direct foreign exchange (FX) exposure in the payoff, several important risk factors remain:

- **Underlying Asset Risk:** The option is sensitive to the price and volatility of the foreign asset, requiring delta and vega hedging just like standard options.

- **Correlation Risk:** The value of a quanto option depends critically on the correlation between the underlying asset and the exchange rate. This correlation affects the drift adjustment in the pricing model:

$$\text{Drift adjustment} \propto \rho \cdot \sigma_{\text{asset}} \cdot \sigma_{\text{FX}}$$

A misestimate of this correlation leads to significant pricing and hedging errors.

- **FX Volatility Risk:** Although the exchange rate is fixed in the payoff, its volatility affects the pricing model via the quanto adjustment. Therefore, volatility in the FX market indirectly impacts the value of the option.

- **Model Risk:** Quanto options require sophisticated models involving change of measure (e.g., Girsanov's theorem). Errors in calibration or assumptions (e.g., constant vol, normality) introduce model risk.

- **Basis Risk:** If the underlying is an index or basket that cannot be perfectly replicated, basis risk may arise between the theoretical hedge and available instruments.

- **Liquidity Risk:** Quanto options are often traded over-the-counter and may be illiquid, especially in emerging market currencies, limiting the ability to execute hedges or unwind positions.

- **Regulatory and Operational Risk:** Cross-currency exotic derivatives can involve added complexity in terms of legal documentation, settlement mechanics, and capital treatment.

Proper risk management for quanto options thus requires dynamic hedging of multiple greeks, robust estimation of cross-asset correlations, and stress testing for model misspecification and liquidity shocks.

Acknowledgements

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