The following is a review of the Operational and Integrated Risk Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Range of Practices and Issues in Economic Capital Frameworks

Topic 50

Exam Focus

This topic requires an understanding of many risk management concepts that you have already covered at FRM Part I, as well as in earlier readings in the FRM Part II curriculum. Specifically, this topic expands on the concept of economic capital, which is the capital required to absorb unexpected losses for a given time horizon and confidence interval. For the exam, pay attention to the terminology and attempt to integrate this material to the sections pertaining to market risk and credit risk so as to reinforce your understanding.

Economic Capital Implementation Framework

LO 50.1: Within the economic capital implementation framework describe the challenges that appear in:
- **Defining risk measures**
- **Risk aggregation**
- **Validation of models**
- **Dependency modeling in credit risk**
- **Evaluating counterparty credit risk**
- **Assessing interest rate risk in the banking book**

For this LO, it would be helpful to recall the properties of a **coherent risk measure** from the Part I curriculum. The properties are as follows:

1. **Monotonicity:** A portfolio with greater future returns will likely have less risk.
2. **Subadditivity:** The risk of a portfolio is at most equal to the risk of the assets within the portfolio.
3. **Positive homogeneity:** The size of a portfolio will impact the size of its risk.
4. **Translation invariance:** The risk of a portfolio is dependent on the assets within the portfolio.

Defining Risk Measures

It is not always apparent how risk should be quantified for a given bank, especially when there are many different possible risk measures to consider. Prior to defining specific measures, one should be aware of the general characteristics of ideal risk measures. They

should be: intuitive, stable, easy to compute, easy to understand, coherent, and interpretable in economic terms. In addition, the risk decomposition process must be simple and meaningful for a given risk measure.

Standard deviation, value at risk (VaR), expected shortfall (ES), as well as spectral (i.e., coherent) and distorted risk measures could be considered, each with their respective pros and cons. Obviously, no one measure would perfectly consider all of the necessary elements in measuring risk. In practice, VaR and ES are the most commonly used measures. The following section is a summary of challenges encountered when considering the appropriateness of each risk measure.

Standard deviation

- Not stable because it depends on assumptions about the loss distribution.
- Not coherent because it violates the monotonicity condition.
- Simple, but not very meaningful in the risk decomposition process.

VaR (the most commonly used measure)

- Not stable because it depends on assumptions about the loss distribution.
- Not coherent because it violates the subadditivity condition (could cause problems in internal capital allocation and limit setting for sub-portfolios).

Expected shortfall

- May or may not be stable, depending on the loss distribution.
- Not easy to interpret, and the link to the bank's desired target rating is not clear.

Spectral and distorted risk measures

- Not intuitive nor easily understood (and rarely used in practice).
- May or may not be stable, depending on the loss distribution.

In defining or using such risk measures, banks often consider several of them and for different purposes. For example, absolute risk and capital allocation within the bank are most commonly measured using VaR, but increasingly, the latter is being measured using ES. The VaR measure of absolute risk tends to be easier to communicate to senior management than ES, but ES is a more stable measure than VaR for allocating total portfolio capital. The challenge for the bank is to determine if and when one or the other, or both, should be used.

Amongst the commonly used measures to calculate economic capital, regulators do not have a clear preference for one over another. If different risk measures are implemented by a bank for external versus internal purposes, then there must be a logical connection between the two risk measures. For regulators, merely comparing a bank's internal and regulatory capital amounts is insufficient when determining the underlying risks in its portfolio. Therefore, such a task presents an analytical challenge to regulators.

Risk Aggregation

Risk aggregation involves identifying the individual risk types and making certain choices in aggregating those risk types. Classification by risk types (market, credit, operational, and business) may be approximate and prone to error. For example, the definitions of risk types may differ across banks or within a given bank, which complicates the aggregation process.

Even though one or more of the previously mentioned four risk types may be found at the same time within a given bank portfolio, the portfolio will often be represented by one risk type for the bank's classifications purposes. Such a simplistic distinction may result in inaccurate measurements of the risk types and this may bias the aggregation process.

Most banks begin by aggregating risk into silos by risk-type across the entire bank. Other banks prefer using business unit silos, while others combine both approaches. There is no one unanimously accepted method, as each approach has its specific advantages.

Before risk types can be aggregated into a single measure, they must be expressed in comparable units. There are three items to consider: risk metric, confidence level, and time horizon.

1. **Risk metric:** Relies on the metrics used in the quantification of different risk types. Must consider whether the metric satisfies the subadditivity condition.

2. **Confidence level:** Loss distributions for different types of risk are assumed to have different shapes, which implies differences in confidence intervals. The lack of consistency in choosing confidence levels creates additional complexity in the aggregation process.

3. **Time horizon:** Choosing the risk measurement time horizon is one of the most challenging tasks in risk measurement. For example, combining risk measures that have been determined using different time horizons creates problems irrespective of actual measurement methods used. Specifically, there will be inaccurate comparisons between risk types.

A common belief is that combining two portfolios will result in lower risk per investment unit in the combined portfolio versus the weighted average of the two separate portfolios. However, when we consider risk aggregations across different portfolios or business units, such a belief does not hold up with VaR because it does not necessarily satisfy the subadditivity condition. Also, there may be a false assumption that covariance always fully takes into account the dependencies between risks. Specifically, there could be times where the risk interactions are such that the resulting combinations represent higher, not lower, risk. These points highlight an additional challenge in the computation of risk.

There are five commonly used aggregation methodologies. The following is a brief description of them, as well as the challenges associated with using them.

1. Simple summation
   - Adding together individual capital components.

- Does not differentiate between risk types and therefore assumes equal weighting. Also, does not take into account the underlying interactions between risk types or for differences in the way the risk types may create diversification benefits. In addition, complications arising from using different confidence levels are ignored.

2. Constant diversification
   - Same process as simple summation except that it subtracts a fixed diversification percentage from the overall amount.
   - Similar challenges as simple summation.

3. Variance-covariance matrix
   - Summarizes the interdependencies across risk types and provides a flexible framework for recognizing diversification benefits.
   - Estimates of inter-risk correlations (a bank-specific characteristic) are difficult and costly to obtain, and the matrix does not adequately capture non-linearities and skewed distributions.

4. Copulas
   - Combines marginal probability distributions into a joint probability distribution through copula functions.
   - More demanding input requirements and parameterization is very difficult to validate. In addition, building a joint distribution is very difficult.

5. Full modeling/simulation
   - Simulate the impact of common risk drivers on all risk types and construct the joint distribution of losses.
   - The most demanding method in terms of required inputs. Also, there are high information technology demands, the process is time consuming, and it may provide a false sense of security.

The variance-covariance approach is commonly used by banks. Frequently, however, bank-specific data is not available or is of poor quality. As a result, the items in the variance-covariance matrix are completed on the basis of expert judgment. On a related note, banks often use a "conservative" variance-covariance matrix where the correlations are reported to be approximate and biased upward. In order to reduce the need for expert judgment, banks may end up limiting the dimensionality of the matrix and aggregating risk categories so that there are only a few of them, not recognizing that such aggregations embed correlation assumptions. Clearly, a disadvantage of such a practice is that each category becomes less homogenous and therefore, more challenging to quantify.

One potential disadvantage of the more sophisticated methodologies is that they often lead to greater confidence in the accuracy of the output. It is important to consider robustness checks and estimates of specification and measurement error so as to prevent misleading results.

Validation of Models

Validation is the "proof" that a model works as intended. As an example, while it is a useful tool to test a model's risk sensitivity, it is less useful for testing the accuracy of high quantiles in a loss distribution.

The validation of economic capital models differs from the valuation of an IRB (internal-ratings based) model because the output of economic capital models is a distribution rather than a single predicted forecast against which actual outcomes may be compared. Also, economic capital models are quite similar to VaR models despite the longer time horizons, higher confidence levels, and greater lack of data.

There are six *qualitative* validation processes to consider. The following is a brief description of them, as well as the challenges associated with using them (where applicable).

1. Use test
   - If a bank uses its measurement systems for internal purposes, then regulators could place more reliance on the outputs for regulatory capital.
   - The challenge is for regulators to obtain a detailed understanding of which model's properties are being used and which are not.

2. Qualitative review
   - Must examine documentation and development work, have discussions with the model's developers, test and derive algorithms, and compare with other practices and known information.
   - The challenge is to ensure that the model works in theory and takes into account the correct risk drivers. Also, confirmation of the accuracy of the mathematics behind the model is necessary.

3. Systems implementation
   - For example, user acceptance testing and checking of code should be done prior to implementation to ensure implementation of the model is done properly.

4. Management oversight
   - It is necessary to have involvement of senior management in examining the output data from the model and knowing how to use the data to make business decisions.
   - The challenge is ensuring that senior management is aware of how the model is used and how the model outputs are interpreted.

5. Data quality checks
   - Processes to ensure completeness, accuracy, and relevance of data used in the model. Examples include: qualitative review, identifying errors, and verification of transaction data.

6. Examination of assumptions—sensitivity testing
   - Assumptions include: correlations, recovery rates, and shape of tail distributions. The process involves reviewing the assumptions and examining the impact on model outputs.

There are also six *quantitative* validation processes to consider. The following is a brief description of them, as well as the challenges associated with using them (where applicable).

1. Validation of inputs and parameters
   - Validating input parameters for economic capital models requires validation of those parameters not included in the IRB approach, such as correlations.

- The challenge is that checking model inputs is not likely to be fully effective because every model is based on underlying assumptions. Therefore, the more complex the model, the more likely there will be model error. Simply examining input parameters will not prevent the problem.

2. Model replication
   - Attempts to replicate the model results obtained by the bank.
   - The challenge is that the process is rarely enough to validate models and in practice, there is little evidence of it being used by banks. Specifically, replication simply by re-running a set of algorithms to produce the same set of results is not considered enough model validation.

3. Benchmarking and hypothetical portfolio testing
   - The process is commonly used and involves determining whether the model produces results comparable to a standard model or comparing models on a set of reference portfolios.
   - The challenge is that the process can only compare one model against another and may provide little comfort that the model reflects "reality." All that the process is able to do is provide broad comparisons confirming that input parameters or model outputs are broadly comparable.

4. Backtesting
   - Considers how well the model forecasts the distribution of outcomes—comparison of outcomes to forecasts.
   - The challenge is that the process can really only be used for models whose outputs can be characterized by a quantifiable metric with which to compare an outcome. Obviously, there will be risk measurement systems whose outputs cannot be interpreted this way. Also, backtesting is not yet a major part of banks' validation practices for economic purposes.

5. Profit and loss attribution
   - Involves regular analysis of profit and loss—comparison between causes of actual profit and loss versus the model's risk drivers.
   - The challenge is that the process is not widely used except for market risk pricing models.

6. Stress testing
   - Involves stressing the model and comparing model outputs to stress losses.

Overall, although these validation processes may be highly effective in areas such as risk sensitivity, they may not be effective in areas such as overall absolute accuracy.

Additionally, there is difficulty in validating the conceptual soundness of a capital model. The development of a model almost always requires assumptions to be made. However, some of the assumptions may not be testable, so it could be impossible to be absolutely certain of the conceptual soundness of a model. Even though the underlying points may appear reasonable and logical, that may not be the case in practice.

From a regulator's perspective, some industry validation practices are weak, especially for total capital adequacy of the bank and the overall calibration of models. Such a

validation project is challenging because it usually requires evaluation of high quantiles of loss distributions over long periods of time. In addition, there are data scarcity problems plus technical difficulties, such as tail estimation. Therefore, it is important for senior management and model users to understand the limitations of models and the risks of using models that have not been fully validated.

Dependency Modeling in Credit Risk

Modeling the dependency structure between borrowers is crucial, yet challenging. Both linear and nonlinear dependency relationships between obligors need to be considered.

In general, dependencies can be modeled using: credit risk portfolio models, models using copulas, and models based on the asymptotic single-risk factor (ASRF) model. With the ASRF approach, banks may use their own estimates of correlations or may use multiple systematic risk factors to address concentrations. Such an approach would result in questioning the method used to calibrate the correlations and the ways in which the bank addressed the infinite granularity and single-factor structure of the ASRF model.

There are many issues to consider regarding the challenges in coming up with reliable dependency assumptions used in credit risk portfolio models. Regulators may need to test the accuracy and strength of correlation estimates used by banks given their heavy reliance on model assumptions and the significant impact on economic capital calculations.

In the past, the validity of the following assumptions have been questioned: (1) the ASRF Gaussian copula approach, (2) the normal distribution for the variables driving default, (3) the stability of correlations over time, and (4) the joint assumptions of correctly specified default probabilities and doubly-stochastic processes, which suggest that default correlation is sufficiently captured by common risk factors.

Doubts have been raised about the ability of some models using such assumptions in terms of their ability to explain the time-clustering of defaults that is seen in certain markets. Insufficiently integrating the correlation between probability of default (PD) and loss given default (LGD) in the models, coupled with insufficiently modeling LGD variability, may lead to underestimating the necessary economic capital. Furthermore, it will create challenges in identifying the different sources of correlations and the clustering of defaults and losses.

Rating changes are greatly impacted by the business cycle and are explained by different models during expansionary and recessionary periods. As a result, the sample period and approach used to calibrate the dependency structure could be important in assessing whether correlation estimates are overestimated or underestimated. Furthermore, some models assume that unobservable asset returns may be approximated by changes in equity prices but fail to consider that the relationship between asset returns and equity prices are unobservable and may be non-linear. Also, the use of equity prices to estimate credit default probability is problematic because such prices may include information that is irrelevant for credit risk purposes. As a result, using equity prices may result in some inaccuracy in the correlation estimates.

In contrast, when banks use a regulatory-type approach, the assumptions of such an approach create other challenges for both banks and regulators:

- Correlation estimates need to be estimated, but there may be limited historical data on which to base the correlation estimates. Also, the assumptions used to generate the correlations may not be consistent with the underlying assumptions of the Basel II credit risk model.
- A bank's use of the Basel II risk weight model requires concentration risk to be accounted for by other measures and/or management methods. It will also require regulators to evaluate such measures/methods.

A key challenge to overcome is the use of misspecified or incorrectly calibrated correlations and the use of a normal distribution (which does not replicate the details of the distribution of asset returns). This may lead to large errors in measuring portfolio credit risk and economic capital.

Evaluating Counterparty Credit Risk

Such a task is a significant challenge because it requires: obtaining data from multiple systems, measuring exposures from an enormous number of transactions (including many that exhibit optionality) spanning a wide range of time periods, monitoring collateral and netting arrangements, and categorizing exposures across many counterparties. As a result, banks need to have well-developed processes and trained staff to deal with these challenges.

Market-risk-related challenges to counterparty exposure at default (EAD) estimation.

- Counterparty credit exposure requires simulation of market risk factors and the revaluation of counterparty positions under simulated risk factor shocks, similar to VaR models. Consider the following two challenges that occur when attempting to use VaR model technology to measure counterparty credit exposure.
  - Market risk VaR models combine all positions in a portfolio into a single simulation. Therefore, gains from one position may fully offset the losses in another position in the same simulation run. However, counterparty credit risk exposure measurement does not allow netting across counterparties. As a result, it is necessary to compute amounts at the netting set level (on each set of transactions that form the basis of a legally enforceable netting agreement), which increases computational complexity.
  - Market risk VaR calculations are usually performed for a single short-term holding period. However, counterparty credit exposure measurement must be performed for multiple holding periods into the future. Therefore, market risk factors need to be simulated over much longer time periods than in VaR calculations, and the revaluation of the potential exposure in the future must be done for the entire portfolio at certain points in the future.

Credit-risk-related challenges to PD and LGD estimation.

- Some material transactions are performed with counterparties with which the bank does not have any other exposures. Therefore, the bank must calculate a probability of default (PD) and loss given default (LGD) for the counterparty and transaction.
- For hedge funds, the measurement challenge occurs when there is little information provided on underlying fund volatility, leverage, or types of investment strategies employed.
- Even for counterparties with which the bank has other credit exposures, the bank still needs to calculate a specific LGD for the transaction.

Interaction between market risk and credit risk—wrong-way risk.

- Identifying and accounting for wrong-way risk (exposures that are negatively correlated with the counterparty's credit quality) is a significant challenge because it requires an understanding of the market risk factors to which the counterparty is exposed. That would be difficult to do in the case of a hedge fund, for example, which would be less transparent.
- It also requires a comparison of those factor sensitivities to the factor sensitivities of the bank's own exposures to the counterparty.
- The magnitude of wrong-way risk is difficult to quantify in an economic capital model since it requires a long time horizon at a high confidence level.

Operational-risk-related challenges in managing counterparty credit risk.

- The challenge is that managing such risk requires specialized computer systems and people. Complicated transactions, such as daily limit monitoring, marking-to-market, collateral management, and intraday liquidity and credit extensions, increase the risk of measurement errors.
- The quantification of operational risks is a significant challenge, especially when it pertains to new or rapidly growing businesses, new products or processes, intraday extensions of credit, and infrequently occurring but severe events.

Differences in risk profiles between margined and non-margined counterparties.

- The modeling difference between the two types of counterparties is primarily concerned with the future forecasting period. For margined counterparties, the forecasting period is short, and for non-margined counterparties, it is usually much longer.
- As a result of the difference in time periods, the aggregation of risk between these two types of counterparties is a challenge because the usual procedure is to use a single time period for all positions.

Aggregation challenges.

- In general, the challenges are increased significantly when moving from measuring credit risk of one counterparty to measuring credit risk of the firm in general for economic capital purposes.
- When counterparties have both derivatives and securities financing activities, the problem is especially challenging because the systems in place may not be able to handle such aggregation.
- Further aggregation challenges exist when high-level credit risk measures are required to be aggregated with high-level market risk and operational risk measures in order to calculate economic capital.
- Breaking down counterparty credit risk into detailed component parts (as is often done with market risk) is another challenge. The sheer computational complexities and enormous amounts of data required would generally be cost prohibitive to perform on a frequent basis. The challenge still remains for many banks due to outdated or ineffective computer systems.

Assessing Interest Rate Risk in the Banking Book

The computation challenge arises from the long holding period assumed for a bank's balance sheet and the need to model indeterminate cash flows on both the asset and liability side due to the embedded optionality of many banking book items.

Optionality in the banking book.

- A major measurement challenge is found with non-linear risk from long-term fixed-income obligations with embedded options for the borrower to prepay and from embedded options in non-maturity deposits.
- In considering the asset side of the balance sheet, prepayment risk options (i.e., mortgages, mortgage-backed securities, and consumer loans) are the main form of embedded options. The prepayment option results in uncertain cash flows and makes interest rate risk measurement a difficult task.
- In considering the liability side, there are two embedded options in non-maturity deposits: (1) the bank has an option to determine the interest rate paid to depositors and when to amend the rate, and (2) the depositor has the option to withdraw up to the entire balance with no penalty. The interaction between these two embedded options creates significant valuation and interest rate sensitivity measurement problems.
- Sufficiently modeling optionality exposures requires very complex stochastic-path evaluation techniques.

Banks' pricing behavior.

- This factor contributes to the challenges in measuring the interest rate risk of banking book items. For example, it would require a model to analyze the persistence of the many different non-maturity banking products, as well as a model to determine bank interest rates that consider general market conditions, customer relationships, bank commercial power, and optimal commercial policies.
- Determining bank interest rates would require the pricing of credit risk. The price of credit risk applied to different banking products creates a challenge because it would require a pricing rule that links the credit spread to changes in macroeconomic conditions and interest rate changes. Also, it means that interest rate stress scenarios should consider the dependence between interest rate and credit risk factors.

The choice of stress scenarios.

- The drawbacks of using simple interest rate shocks pose interest rate measurement challenges because the shocks:
  - Are not based on probabilities and, therefore, are difficult to integrate into economic capital models based on VaR.
  - Are not necessarily sensitive to the current rate or economic environment.
  - Do not take into account changes in the slope or curvature of the yield curve.
  - Do not allow for an integrated analysis of interest rate and credit risks on banking book items.

BIS Recommendations for Supervisors

LO 50.2: Describe the BIS recommendations that supervisors should consider to make effective use of risk measures not designed for regulatory purposes.

There are ten Bank for International Settlements (BIS) recommendations to consider:

1. **Use of economic capital models in assessing capital adequacy.** The bank should show how such models are used in the corporate decision-making process so as to assess the model's impact on which risks the bank chooses to accept. In addition, the board should have a basic understanding of the difference between gross (stand alone) and net (diversified) enterprise-wide risk in assessing the bank's net risk tolerance.

2. **Senior management.** The economic capital processes absolutely require a significant commitment from senior management. They should understand its importance in the corporate planning process and should ensure that there is a strong infrastructure in place to support the processes.

3. **Transparency and integration into decision-making.** Economic capital results need to be easy to trace and understand in order to be useful. Careful attention must be given to obtaining reliable estimates on an absolute basis in addition to developing the flexibility to conduct firm-wide stress testing.

4. **Risk identification.** This is the crucial starting point in risk measurement. The risk measurement process must be very thorough to ensure that the proper risk drivers, positions, and exposures are taken into account in measuring economic capital. That will ensure that there is little variance between inherent (actual) and measured risk. For example, risks that are difficult to quantify should be considered through sensitivity analysis, stress testing, or scenario analysis.

5. **Risk measures.** No given risk measure is perfect, and a bank must understand the strengths and weaknesses of its chosen risk measures. No one risk measure for economic capital is universally preferred.

6. **Risk aggregation.** The reliability of the aggregation process is determined by the quality of the measurement risk components, plus the interrelationships between such risks. The aggregation process usually requires consistency in the risk measurement parameters. The aggregation methodologies used should mirror the bank's business composition and risk profile.

7. **Validation.** The validation process for economic capital models must be thorough and corroborating evidence from various tests must show that the model "works" as intended. In other words, within an agreed upon confidence interval and time period, the capital level determined must be enough to absorb the (unexpected) losses.

8. **Dependency modeling in credit risk.** Banks must consider the appropriateness of the dependency structures used within their credit portfolio. Specifically, credit models need to be assessed for their limitations, and such limitations need to be dealt with via appropriate supplementary risk management approaches, such as sensitivity or scenario analysis.

9. **Counterparty credit risk.** There are trade-offs to be considered in deciding between the available methods of measuring counterparty credit risk. Additional methods, such as stress testing need to be used to help cover all exposures. Measuring such risk is complicated and challenging. Specifically, the aggregation process needs to be vetted prior to a bank having a big picture perspective of counterparty credit risk.

10. **Interest rate risk in the banking book.** Specifically, financial instruments with embedded options need to be examined closely in order to control risk levels. Certainly, there are trade-offs between using earnings-based versus economic value-based models to measuring interest rate risk. For example, the former has aggregation problems because other risks are measured using economic value. Also, using economic value-based models could be inconsistent with business practices.

Economic Capital Constraints and Opportunities

LO 50.3: Describe the constraints imposed and the opportunities offered by economic capital within the following areas:
- **Credit portfolio management**
- **Risk based pricing**
- **Customer profitability analysis**
- **Management incentives**

Credit Portfolio Management

Constraints imposed:

- Credit quality of each borrower is determined in a portfolio context, not on a stand-alone basis.
- A loan's incremental risk contribution is used to determine the concentration of the loan portfolio.

Opportunities offered:

- The process allows one to determine appropriate hedging strategies to use in reducing portfolio concentration.
- Credit portfolio management becomes a means for protecting against risk deterioration.

Risk-Based Pricing

Constraints imposed:

- Pricing decisions are based on expected risk-adjusted return on capital (RAROC), so deals will be rejected if they are lower than a specific RAROC. The proposed interest rate is determined by the amount of economic capital allocated to the deal.

- Pricing decisions include: (1) cost of funding, (2) expected loss, (3) allocated economic capital, and (4) additional return required by shareholders. Therefore, a minimum interest rate is determined that will increase shareholder value.

Opportunities offered:

- Can be used to maximize the bank's profitability. For example, some pricing decisions may need to be overridden because certain customer relationships are more profitable (at a lower price/interest rate) or desirable from a reputational point of view. Of course, such overrides are not taken lightly and require upper management approval, as well as rigorous subsequent monitoring.

Customer Profitability Analysis

Constraints imposed:

- The analysis is complicated in that many risks need to be aggregated at the customer level.
- Customers need to be segmented in terms of ranges of (net) return per unit of risk; the underlying information is difficult to measure and allocate.

Opportunities offered:

- Assuming that the measurement obstacles have been overcome, the analysis can be easily used to determine unprofitable or only slightly profitable customers. Such customers could be dropped and economic capital allocated to the more profitable customers.
- Economic capital is used in maximizing the risk-return trade-off (through relative risk-adjusted profitability analysis of customers).

Management Incentives

Constraints imposed:

- Studies show that compensation schemes are a minor consideration in terms of the actual uses of economic capital measures at the business unit level.

Opportunities offered:

- It is suggested that management incentives is the issue that motivates bank managers to participate in the technical aspects of the economic capital allocation process.

Key Concepts

LO 50.1

A multitude of challenges exist within the economic capital framework that involve: (1) defining risk measures, (2) risk aggregation, (3) validation of models, (4) dependency modeling in credit risk, (5) evaluating counterparty credit risk, and (6) assessing interest rate risk in the banking book.

LO 50.2

There are ten BIS recommendations that supervisors should consider to make effective use of risk measures.

LO 50.3

A number of specific constraints imposed and opportunities offered by economic capital exist within the areas of credit portfolio management, risk based pricing, customer profitability analysis, and management incentives.

Concept Checkers

1. Which of the following risk measures is the least commonly used measure in the practice of risk management?
   A. Value at risk.
   B. Standard deviation.
   C. Expected shortfall.
   D. Spectral risk measures.

2. Which of the following aggregation methodologies is characterized by great difficulty in validating parameterization and building a joint distribution?
   A. Copulas.
   B. Constant diversification.
   C. Variance-covariance matrix.
   D. Full modeling/simulation.

3. Which of the following model validation processes is specifically characterized by the limitation that it provides little comfort that the model actually reflects reality?
   A. Backtesting.
   B. Benchmarking.
   C. Stress testing.
   D. Qualitative review.

4. Which of the following categories of BIS recommendations specifically refers to the need to consider using additional methods, such as stress testing, to help cover all exposures?
   A. Risk aggregation.
   B. Counterparty credit risk.
   C. Dependency modeling in credit risk.
   D. Interest rate risk in the banking book.

5. The use of which of the following items is meant more for protecting against risk deterioration?
   A. Risk based pricing.
   B. Management incentives.
   C. Credit portfolio management.
   D. Customer profitability analysis.

Concept Checker Answers

1. **D** Spectral and distorted risk measures are the least used of the four measures and are mainly of academic interest only.

2. **A** Copulas have two notable disadvantages: (1) parameterization is very difficult to validate, and (2) building a joint distribution is very difficult.

3. **B** With benchmarking and hypothetical portfolio testing, the process has its limitations because it can only compare one model against another and may provide little comfort that the model actually reflects "reality." All that the process is able to do is provide broad comparisons confirming that input parameters or model outputs are broadly comparable.

4. **B** There are trade-offs to be considered when deciding between the available methods of measuring counterparty credit risk. Additional methods, such as stress testing, need to be used to help cover all exposures.

5. **C** Credit portfolio management is used as a means to protect against risk deterioration. In contrast, risk based pricing is used to maximize the bank's profitability; customer profitability analysis is used to determine unprofitable or only slightly profitable customers; and management incentives are used to motivate managers to participate in the technical aspects of the economic capital allocation process.

The following is a review of the Operational and Integrated Risk Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Capital Planning at Large Bank Holding Companies: Supervisory Expectations and Range of Current Practice

Topic 51

Exam Focus

To protect the smooth functioning of bank holding companies (BHCs), the Federal Reserve's Capital Plan Rule requires BHCs to implement an ongoing internal capital plan for thoroughly assessing and enhancing their capital adequacy under stress scenarios on a firm-wide basis. For the exam, know the fundamental principles and key practices to develop and implement an effective internal control plan, including: risk identifications, model valuation and review, oversight and governance, contingency planning, stress testing and scenario designing, loss estimation and projections methodologies, and evaluating the impact of capital adequacy, including risk-weighted assets and balance sheet projections.

Capital Plan Rule

LO 51.1: Describe the Federal Reserve's Capital Plan Rule and explain the seven principles of an effective capital adequacy process for bank holding companies (BHCs) subject to the Capital Plan Rule.

Bank holding companies (BHCs) must have adequate and sufficient capital for their survival and growth. Capital provides a cushion against unexpected losses and allows BHCs to continue to operate. The failure of BHCs (i.e., liabilities exceed assets, resulting in negative capital) would most likely be a burden on taxpayers and deposit insurance funds. An effective and sound capital management policy is critical for the health of BHCs, as well as the smooth functioning and stability of the entire financial system.

The Federal Reserve maintains its interest in survivability and smooth functioning BHCs through its **Capital Plan Rule** and the annual Comprehensive Capital Analysis and Review (CCAR). The CCAR is the Federal Reserve's supervisory program for evaluating capital plans.

The Capital Plan Rule mandates that BHCs develop and put in place a capital plan and a process to evaluate and monitor their capital adequacy. The capital plan covers all U.S. domiciled BHCs with total consolidated assets equal to $50 billion or more.

The Capital Plan Rule lists the principles that the Federal Reserve uses to evaluate the adequacy and appropriateness of a BHC's internal capital planning processes and practices.

The principles on which the Federal Reserve assesses BHCs for managing and allocating their capital resources is referred to as the **capital adequacy process** (CAP). The seven principles of the CAP are as follows:

1. **Risk management foundation.** A BHC has an effective capital risk management plan to encompass all key risk exposures on a firm-wide basis in terms of identification, evaluation, measurement, and control.

2. **Resource estimation methods.** A BHC has a capital resource estimation plan to clearly define and estimate available capital resources over a stress scenario time horizon.

3. **Loss estimation methods.** A BHC has a process for estimating potential losses and aggregating them on a firm-wide basis over a given stress scenario time horizon.

4. **Impact on capital adequacy.** A BHC has a process to evaluate the combined impact on capital adequacy—given loss estimates and capital resources combined—in light of the stated goals with respect to capital level and composition.

5. **Capital planning policy.** A BHC has a sound capital policy to develop capital goals, determine appropriate capital levels and composition as well as capital distributions (actions) and contingency plans.

6. **Internal controls.** A BHC has a vigorous internal controls policy in place for independent review, model validation, documentation, and internal audit of the capital adequacy process.

7. **Effective oversight.** A BHC has a board and senior management responsible for an effective and thorough oversight of multiple dimensions of the internal capital risk plan, including methods, processes, assessments, validations, reviews, documentation, infrastructure, resources, goals, limitations, and approval of capital decisions.

Capital Adequacy Process

LO 51.2: Describe practices that can result in a strong and effective capital adequacy process for a BHC in the following areas:

- **Risk identification**
- **Internal controls, including model review and valuation**
- **Corporate governance**
- **Capital policy, including setting of goals and targets and contingency planning**
- **Stress testing and stress scenario design**
- **Estimating losses, revenues, and expenses, including quantitative and qualitative methodologies**
- **Assessing the impact of capital adequacy, including RWA and balance sheet projections**

For this LO, we detail the seven key practices that can result in a strong and effective capital adequacy process for a BHC.

Risk Identification

BHCs should have a process in place to identify all risk exposures stemming from numerous sources, including stress conditions, changing economic and financial environments, on-and-off balance sheet items, and their impact on capital adequacy. In addition, BHCs should critically scrutinize underlying assumptions regarding risk reduction through risk mitigation or risk transfer techniques. Senior management should regularly update and review the risk identification plan with special consideration for how their risk profiles might change under stress scenarios. Risk identification techniques should be able to detect the changes in the overall risk profile as well as the signs of capital inadequacy in the early stages.

BHCs should integrate the identified risk exposures into their internal capital planning processes. Scenario-based stress testing may not capture all potential risks faced by BHCs, some risks are difficult to quantify or they do not fall into the integrated firm-wide scenarios. However, such risks must be included and accounted for in the capital planning processes. These risks are categorized as "other risks," and their examples include compliance, reputational, and strategic risks. There are a variety of methods which BHCs can employ, including internal capital targets to incorporate such risks.

Internal Controls

An internal audit team should carefully scrutinize the internal control data for accuracy before submitting to senior management and the board. BHCs should have efficiently running management information systems (MIS) for collecting and analyzing pertinent information set quickly and accurately.

In addition, BHCs should put in place a detailed and organized documentation system fully encompassing all dimensions of capital planning processes, including risk identification, loss estimation techniques, capital adequacy, and capital decision processes.

There must be a thorough, independent, and regular review and validation of all models used for internal capital planning purposes, including assessment of conceptual soundness of models and verification of processes. A validation team should have a required technical skill set as well as complete independence from all business areas of the BHC and model developers. Such independence is crucial for the validation team to offer an unbiased, independent, and valuable verdict.

BHCs should maintain and update a list of all inputs, assumptions, and adjustments for the models used to generate final projections and estimates, such as income, loss expenses, and capital. These models should be validated for their effective use, not only under normal conditions, but also under stress conditions. BHCs should make full disclosure of their validation process and outcome, and should restrict the use of models which are not validated.

Governance

BHCs should have boards with sufficient expertise and involvement to fully understand and evaluate the information provided to them by senior management regarding their capital planning processes. The board should be furnished with comprehensive information with respect to risk exposures, loss estimates, determinants of revenues and losses, underlying models and assumptions, and weaknesses and strengths of capital planning processes. Also, the boards should be informed about the stress scenarios and any corrective measures undertaken as a result of stress testing outcomes.

Under the Capital Plan Rule, the management of BHCs is required to furnish key information to the board for its approval of internal capital adequacy plans. Such information should include underlying assumptions and results of stress testing and the outcome of internal audits, as well as model review and validation checks.

Senior management should evaluate the internal capital plan on an ongoing basis, focusing on key weaknesses, strengths, assumptions, scenarios, estimates, and models. In addition, senior management should make appropriate adjustments and remediation to the capital plan if the review process reveals shortcomings in the plan.

BHCs should maintain detailed minutes of board meetings, describing the issues raised and discussed, as well as the information used and the recommendations made in these meetings.

Capital Policy

A capital policy should clearly define the principles and guidelines for capital goals, issuance, usage, and distributions. The policy should also fully spell out the details of the BHC's capital planning processes, including the decision rules of capital usage and distribution, financing, and other policies. The capital policy should focus on the unique needs and financial situation of BHCs while taking into consideration the supervisory

expectations. Policies regarding common stock dividends and repurchase agreements should include the following:

- Key metrics influencing the size, timing, and form of capital distributions.
- Materials used in making capital distribution decisions.
- Specific scenarios that would cause a distribution to be reduced or suspended.
- Situations that would cause the BHC to consider replacing common equity with other forms of capital.
- Key roles and responsibilities of individuals or groups for producing reference materials, making distribution recommendations and decisions, and reviewing analysis.

Capital goals developed by BHCs should be compatible with their risk tolerance, risk profile, regulatory requirements, and expectations of various stakeholders (e.g., shareholders, creditors, supervisors, and rating agencies). BHCs should establish specific goals for both the level and composition of capital under normal as well as stress conditions. Capital targets, which need to be set above the capital goals for capital adequacy under stress conditions, should take into consideration future economic outlooks, stress scenarios, and market conditions.

While setting capital distribution levels, BHCs must take into consideration numerous factors, including future growth plans (including acquisitions) and associated risk, current and future general economic conditions, in particular the impact of macroeconomic and global events during stress conditions, on their capital adequacy. Capital distribution decisions must be connected to capital goals or capital adequacy requirements.

BHCs should develop strong contingency planning offering numerous options to deal with contingency situations as well as their effectiveness under stress conditions. Contingency plans should be based on realistic assumptions and contain futuristic outlooks, rather than overly relying on history. Contingency actions should be feasible and realistic in the sense that they should be easy to implement when or if the contingency warrants. Capital triggers flagging the early warning of capital deterioration should be based on the projected results, regulatory requirements, and the expectations of various stakeholders, including creditors, shareholders, regulators, investors, and counterparties.

Stress Testing and Stress Scenario Design

Scenario design and stress testing should focus on unique situations of BHCs, their asset and liability mix, portfolio composition, business lines, geographical territory, and revenue and loss factors, while taking into consideration the impact of macroeconomic and firm-specific vulnerabilities and risks. That is, the stress test designing should go above and beyond the general guidelines established by the supervisory authority. Also, a BHC's scenario designing and testing should not employ optimistic assumptions benefiting the BHC.

BHCs should employ both an internal model and expert judgment, an outside expert's opinion. If only a third-party model is used, it must be tailored to the unique risk profile and business model of a BHC. The designed scenarios should assume a strong strain on the revenue and income of BHCs.

Stress testing models should be based on multiple variables encompassing all the risk exposures faced by BHCs on a firm-wide basis. For example, BHCs concentrated in a region, business, or industry should include relevant region, business, or industry-related variables. In addition, the scenarios should clearly spell out how they address specific risks faced by BHCs. The description should also provide explanations of how a scenario stresses specific BHC weaknesses and how variables are related to each other.

Estimating Losses, Revenues, and Expenses

Quantitative and Qualitative Basis

BHCs should prefer using internal data to estimate losses, revenues, and expenses. However, in certain situations, it may be more appropriate to use external data. In these instances, it should be ensured that the external data reflects the underlying risk profile of their business lines, and necessary adjustments should be made to data input or output to make the analysis reflect a true picture of the BHC's unique characteristics.

A range of quantitative methods are available to BHCs for estimating losses, revenues, and expenses. Regardless of which method they use, the final outcome should be identification of key risk factors and impact of changing macro and financial conditions under normal and stress conditions on a firm-wide basis.

In addition, BHCs should segment their line of businesses and portfolios utilizing common risk characteristics showing marked differences in past performances. For example, a borrower's risk characteristics can be segmented by criteria such as credit score ranges. However, each risk segment should have sufficient data observations on losses, revenues, and expenses, (and underlying factors impacting losses, revenues, and expenses) in order to generate meaningful model estimates.

Past relationships between losses, revenues, expenses, and underlying driving factors, and their interrelationships may not hold in the future, thus, necessitating employment of sensitivity analysis (to answer "what if" questions) when using models based on historical underlying interactions.

BHCs sometimes use qualitative methodologies, like expert judgment or management overlay, as a substitute or a complement to quantitative methods. Qualitative techniques should be based on sound assumptions, and an external reviewer should find these approaches logical, reasonable, and clearly spelled out. A sensitivity analysis should be used for a qualitative approach as well. From a supervisory standpoint, BHCs are expected to use conservative assumptions, not favorable to BHCs, for estimating losses, revenues, and expenses under normal and stress conditions.

Loss Estimation Methods

BHCs should employ loss estimation methods, which offer theoretical soundness and empirical validity. In addition to using general macroeconomic explanatory variables, the loss estimation models should use specific variables exhibiting a direct link to particular exposures and portfolios.

BHCs should use uniform, reputable methods to aggregate losses across various lines of business and portfolios for firm-wide scenario analysis. They should also use automated processes, without manual intervention or managerial adjustments showing clear linkage from data sources to loss estimation and aggregation. For estimating retail loan losses, BHCs often use internal data, but for wholesale loss estimation, internal data is supplemented with external data. In the case using external data, BHCs should demonstrate that the data reflects their risk exposures, encompassing geographic, industry, and other key dimensions. Risk segmentation should be supported by the data capturing the unique characteristics of each risk pool.

BHCs can use either an economic loss approach (i.e., expected losses) or an accounting-based loss approach (i.e., charge-off and recovery) to estimate credit losses. For the expected loss approach, BHCs should categorize losses into probability of default (PD), loss given default (LGD), or exposure at default (EAD) and then identify the determinants of each component. Long run averages for PDs, LGDs, and EADs should not be used, as these averages reflect economic downturn and upturn periods not necessarily suitable for scenario testing under stress conditions. LGD should be linked to underlying risk factors, such as a fall in the value of collateralized assets under stress conditions, and it should be estimated at some level of segmentation, such as lending product or type of collateral. EADs should be modeled to exhibit variation depending on changes in macroeconomic conditions.

If BHCs are using rating systems as a key input to estimate expected losses under stress (e.g., on their wholesale portfolios), they should recognize the limitations in rating systems and their data and make necessary adjustments.

BHCs should utilize a robust time series with sufficient granularity while employing role-rate models to estimate the rate at which delinquent and non-delinquent accounts in the current quarter are expected to roll over into default or delinquent status in the next quarter.

If using charge-off models (i.e., accounting models), BHCs should include variables which represent the risk characteristics of an underlying portfolio while estimating the statistical relationship between charge-off rates and macroeconomic variables at the portfolio level.

Operational Risk

In order to determine operational risk, many BHCs estimate correlation between operational risk and macroeconomic factors. If they do not discover a statistically significant relationship between the variables, they employ other methods, including scenario analysis utilizing historical data and management input. BHCs should employ a combination of techniques to develop strong loss estimates under stress conditions, including past loss records, future expected events, macro conditions, and firm-specific risks.

BHCs using regression models to estimate loss frequency and loss severity under stress scenarios should provide statistical support for the period chosen for estimation purposes instead of arbitrary and judgmental selection.

A modified loss distribution approach (LDA) is also used by BHCs to estimate value at risk (VaR) to estimate operational risk losses at a chosen confidence interval (e.g., 90% or 95%).

To generate a strong and effective process, BHCs should offer a sound justification for their choice and perform a sensitivity analysis around the chosen interval.

Some BHCs use scenario analyses in case they encounter model or data limitations in order to incorporate a wide range of risks (which is not possible otherwise due to data or model limitations). In such events, BHCs should provide a rationale for the chosen scenario in their loss estimation process.

Market Risk and Counterparty Credit Risk

BHCs, which are involved in trading, are subject to counterparty credit risk from changes in the value of risk exposure and creditworthiness of the counterparty due to changing macroeconomic conditions.

In order to estimate the potential loss resulting from market credit interaction, BHCs use probabilistic approaches (which produce a probability distribution of expected portfolio losses) and deterministic approaches (which yield point estimates of an expected portfolio loss).

BHCs using probabilistic approaches should clearly offer evidence that such methods can yield more severe risk scenarios compared to historical scenarios. BHCs should also explain how they utilize tail loss scenarios to detect and address firm-specific risks.

BHCs using deterministic approaches should demonstrate that they have employed a wide range of scenarios, adequately covering their key risk exposures, including mark-to-market positions in the event of firm-specific or market-wide stress conditions. In addition, BHCs should clearly spell out the underlying assumptions employed in stress testing scenarios for risk measurement purposes and corrective measures to fix the identified deficiencies.

Market shock scenarios do not directly incorporate the default of the counterparty. Some BHCs explicitly incorporate the scenario of default of key counterparties (including key customers) while using some sort of probabilistic approach involving some estimates of the PD, LGD, and EAD of counterparties. This method allows BHCs to focus exclusively on the defaults of counterparties to which BHCs have large risk exposure.

BHCs also use assumptions about risk mitigation in the future. Such assumptions, if used, should be conservative in nature. In stress scenarios, the ability of BHCs to take desired actions may be limited.

PPNR Projection Methodologies

PPNR is pre-provision net revenue (i.e., net revenue before adjusting for loss provisions). While estimating revenues and expenses over a planning horizon under stressed conditions (the Capital Plan Rule requires forecasts over the next nine quarters), BHCs should not only take into consideration their current situation, but also the possible future paths of business activities and operational environments related to their on- and off-balance sheet risk exposures, underlying assumptions, and assets and liabilities.

BHCs should also take into consideration the impact of regulatory changes on their performance and ability to achieve their stated targets and goals. Projections should be based on coherent and clearly defined relationships among numerous, relevant variables, such as revenues, expenses, and balance sheet items within a given scenario. For example, assumptions related to origination should be the same for projections related to loans, fees, costs, and losses.

Underlying assumptions for revenues, expenses, and loss estimates should be theoretically and empirically sound, and the central planning group as well as the corporate planning group should be engaged in aggregating projections on an enterprise-wide basis. In the case of limited data, BHCs should employ external data in conjunction with internal data.

Net interest income projections are not isolated projections; rather, they are entrenched with other items of a capital adequacy plan. Balance sheet assumptions should be consistent while projecting net interest income. For example, balance sheet assumptions for projecting net interest income should be the same when estimating loss. Methods employed for projecting net interest income should incorporate ongoing changes in current and projected balance sheet positions.

BHC projections under various scenarios, based on product characteristics (e.g., a change in deposit mix due to increased demand for time deposits), underlying assumptions, and rationale by product should be carefully explained.

BHCs linking loss projections to net interest income projections should clearly establish this link while using modeling approaches, which incorporate the behavioral characteristics of the loan portfolio.

Net interest income projections should be based on methodologies that incorporate discount or premium amortization adjustments for assets not held at par value that would materialize under different scenarios.

New business pricing projections and underlying assumptions, such as constant add-ons to a designated index value, should be compatible with past data, scenario conditions, and BHCs' balance sheet projections.

BHCs should project non-interest income in light of stated scenarios and business strategies. Projection methods should fully encompass underlying major risk exposures and characteristics of a specific business line. For example, an asset management group should project non-interest income using various methods, including brokerage as well as money management revenues.

Additionally, BHCs with trading portfolios should establish a clear link between trading revenue projections to trading assets and liabilities and the compatibility of all the elements of stress scenario conditions.

BHCs with off-balance sheet business items should demonstrate the linkage between revenue projections and changes in on- and off-balance sheet items.

BHCs should not assume perfect correlation between revenues (generated from trading or private equity activity) and broad indices. BHCs should estimate the sensitivity coefficients for changes in revenue as a result of changes in broad index movements.

Furthermore, BHCs holding mortgage servicing rights assets (MSRAs) should carefully design assumptions regarding default, prepayment, and delinquency rates, ensuring that these assumptions are robust and scenario specific. In addition, BHCs that hedge MSRA risk exposure should generate scenario specific assumptions.

For BHCs, projecting volume increases in mortgage loans while ignoring market saturation or other key factors would be an ineffective and weak process, whereas consideration of individual business models, client profiles, and capacity constraint (while projecting mortgage loan volume) would be an effective and strong capital adequacy process.

Macroeconomic relationships should be based on sound theoretical construct and supported by empirical evidence. For example, BHCs may experience a steep decline in credit card fee revenues in a strong recessionary period because of a decline in consumer spending. An example of a weaker practice of a capital planning process is if a BHC does not show a sufficient decline in revenue in stressed conditions despite obvious macro relationships.

In addition, BHCs should utilize a wide set of explanatory variables to develop statistical relationships. BHCs should take into consideration the impact of macroeconomic conditions, such as an economic downturn, on their non-interest expense projections. Non-interest expense projections, like all other projections, should be consistent with revenue and balance sheet estimates and should generate the same underlying strategic assumptions. If projections assume that a decline in revenue (e.g., due to an increase in credit collection costs in an economic downturn) can be offset by some mitigating strategies, BHCs should then clearly demonstrate the feasibility of such actions. Mitigation actions should not be supported by past relationships and actions only because future financial, macro, and global environments may not be as favorable to execute such strategies, as was the case in the past.

Estimation methods to project non-interest expense should focus on uncovering determinants (factors) of individual expense items and how sensitive those factors are to changing macro conditions and business strategies.

Assessing the Impact of Capital Adequacy

BHCs should have a well-defined and well-documented process of generating projections with respect to size and composition of on- and off-balance sheet items and risk-weighted assets (RWA) over a stress horizon period.

Projecting balance sheet items, such as changes in assets and funding, directly without consideration of underlying drivers (of such changes), would be a weak practice. BHCs should identify the impact of changes in key factors on changes in asset and liabilities. Projections should take into consideration these vital relationships.

BHCs should incorporate relationships between revenues, expenses, and balance sheet items into their scenario analyses. Projections about losses, revenues, expenses, and on- and

off-balance sheet items should not be based on favorable underlying assumptions. These assumptions may not stand the trial of uncertain market conditions under stress conditions.

Projections for RWA should be consistent with the projections for risk exposures of on- and off-balance sheet items. All underlying assumptions used for balance sheet and RWA projections should be clearly documented and critically reviewed and validated.

BHCs with a strong process of implementation should form a centralized group responsible for aggregating loss, revenue, expense, on- and off-balance sheets, and RWA projections for enterprise-wide scenario analysis. In addition, BHCs should establish a strong governance structure to critically scrutinize assumptions, methods, and estimates generated in an enterprise-wide scenario analysis and offer needed adjustments. BHCs should carefully evaluate the validity and relevance of underlying assumptions across business lines, portfolios, loss, expense, and revenue estimates if an enterprise-wide scenario analysis produces post-stress results that are more favorable than the baseline conditions. The outcomes of such analyses should also be reconciled for regulatory as well as management reporting purposes.

KEY CONCEPTS

LO 51.1

The Federal Reserve's Capital Plan Rule mandates all top-tier, U.S. domiciled bank holding companies with consolidated assets equal to or greater than $50 billion to develop and maintain an effective and robust internal capital plan for evaluating and assessing their capital adequacy.

There are seven principles on which the Federal Reserve assesses the effectiveness of a BHC's internal capital planning, also known as the capital adequacy process (CAP). These seven principles are related to risk management foundation, resource and loss estimation methods, capital adequacy, capital planning and internal controls policies, and governance oversight.

LO 51.2

BHCs should develop a process to effectively identify all of their risk exposures on a firm-wide basis. BHCs should establish a mechanism for a comprehensive, independent, and regular review and validation of all the models used for capital adequacy planning purposes. BHCs should have boards actively involved in evaluating and approving their internal capital adequacy plans. BHCs should develop a capital policy that clearly defines the principles and guidelines for capital goals, issuance, usage, and distributions.

Stress testing and stress scenario design should be based on a variety of factors encompassing all the risk exposures faced by BHCs on a firm-wide basis. With the option of utilizing various quantitative and qualitative methods, BHCs should carefully identify key risk exposures on a firm-wide scenario basis. BHCs should use loss estimation methodologies, which are based on sound theoretical and empirical foundations. BHCs should use a combination of inputs in order to develop loss estimates arising from operational risk. In order to estimate the counterparty credit risk, BHCs mostly use probabilistic or deterministic approaches. BHCs using a probabilistic approach should offer evidence of generating probable scenarios stronger than past observed events. BHCs using a deterministic approach should generate a wide range of stress scenarios.

While estimating pro-provision net revenue (PPNR) projection methodologies, BHCs should pay particular attention to interrelationships among numerous relevant variables such as revenues, expenses, and on- and off-balance sheet items within a given scenario. Methodologies used for projecting net interest income should incorporate ongoing, current, and projected balance sheet positions. BHCs should project non-interest income in light of stated risk scenarios and business strategies.

BHCs should have a well-defined process in place to develop projections of revenues, expenses, losses, on- and off-balance sheet items, and risk-weighted assets in an enterprise-wide scenario analysis. Projections should be based on sound underlying assumptions, interactions, and factors (main drivers of change), and the estimates should be scrutinized, documented, and reported.

Concept Checkers

1. The seven principles of an effective capital adequacy process for bank holding companies (BHCs) subject to the Capital Plan Rule include which of the following?
   I. Oversight from peer BHCs
   II. Annual reporting to the stock exchange (where their stock is listed)
   A. I only
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

2. The Federal Reserve's Capital Plan Rule requires BHCs to maintain an effective process for assessing their capital adequacy for:
   A. BHCs, U.S. or non-U.S. domiciled.
   B. BHCs with more than five years of operational history.
   C. BHCs with a net annual income of more than $5 billion.
   D. BHCs with total consolidated assets of $50 billion or greater.

3. How many of the following statements is most likely correct? BHCs should have risk identification processes that evaluate:
   I. On- and off-balance sheet positions.
   II. Risk transfer and/or risk mitigation techniques.
   III. Changes in institutions' risk profile due to portfolio quality.
   IV. Reputational risk.
   A. One statement.
   B. Two statements.
   C. Three statements.
   D. Four statements.

4. Which of the following statements is most likely correct?
   A. The internal controls policy of BHCs requires that senior management should furnish the board of directors with sufficient information to comprehend the BHC risk exposures.
   B. A governance policy offers fundamental guidelines and principles to BHCs for the capital issuance, use, distribution, and planning purposes.
   C. Suspension or reduction in dividends or repurchase programs do not fall under the capital policy of BHCs.
   D. Designing and testing a scenario-related default of a major counterparty is an example of BHC stress testing and a stress scenario design policy.

5. Which of the following statements is most likely correct?
   I. Under the expected losses methodologies, loss estimation involves three elements: probability of default, loss given default, and exposure at default.
   II. Net interest income projections should incorporate changing conditions for balance sheet positions, including embedded options, prepayment rates, loan performance, and re-pricing rates.
   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

Concept Checker Answers

1. **D** Oversight from peer BHCs and annual reporting to the stock exchange are not included in the seven principles of an effective capital adequacy process.

2. **D** BHCs with total consolidated assets of $50 billion or greater. The other answers are not part of the requirements under the Capital Plan Rule.

3. **D** All of the statements are correct. BHCs should have risk identification processes effectively identifying all risk exposures for assessing capital needs. Reputational risk, like strategic risk and compliance risk, falls under the category of "other risks" and are more difficult to quantify. Nevertheless, there are a wide range of methods BHCs employ to evaluate other risks.

4. **D** The first statement is the requirement of the governance policy and not the internal control policy. The second statement falls under capital policy and not the governance policy. Regarding the third statement, capital contingency plans (e.g., suspension or reduction in dividends or repurchase programs) are a key part of capital policies of BHCs detailing the actions intended to be taken under deficiencies in capital position. The fourth statement is correct. Many different scenarios, including counterparty default, fall under the BHCs' stress testing and scenario design policy.

5. **C** Both statements are correct. Loss estimation involves probability of default, loss given default, and exposure at default. Net interest income projections should incorporate changing conditions for balance sheet positions, including embedded options, prepayment rates, loan performance, and re-pricing rates.

The following is a review of the Operational and Integrated Risk Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Repurchase Agreements and Financing

Topic 52

Exam Focus

Repurchase agreements, or repos, are short-term financing vehicles to borrow/lend funds on a secured basis. The most common repos are for overnight lending. This topic discusses the mechanics of repos, including settlement calculations, the motivations of market participants for entering into repos, as well as the risks (credit risk and liquidity risk) that arise from their use. It also discusses collateral types used in repos, including general collateral and special collateral. For the exam, focus on the characteristics of repo transactions and the primary motivations for using repos. Understanding these motivations should give you a good indication of how and why repos are used in the market, what risks repos hedge, what risks arise from repo trading, and how changes in the market environment affect repos.

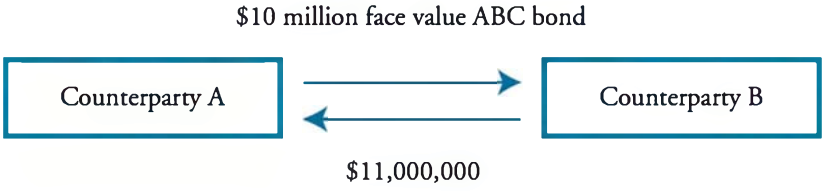
Mechanics of Repurchase Agreements

LO 52.1: Describe the mechanics of repurchase agreements (repos) and calculate the settlement for a repo transaction.

Economically, a **repurchase agreement** (i.e., **repo**) is a short-term loan secured by collateral. Mechanically, it is a contract between two parties where one party sells a security at a specified price with a commitment to buy back the security at a future date at another specified (higher) price. The difference between the sell and buy prices of the security is the implied interest (i.e., return) on the transaction. Repos are used by both borrowers needing short-term funds and by lenders needing short-term investments or access to hard-to-find collateral.

The term repo refers to the transaction from the *borrower's* side; that is, from the side that sold the security with a promise to buy it back. When we examine the same transaction from the *lender's* side, the transaction is referred to as a **reverse repurchase agreement** (i.e., **reverse repo**). Figures 1 and 2 illustrate an example of a repo trade.

Figure 1: Repo Initiation



Suppose that on May 1, counterparty A wishes to borrow $11 million for 31 days. It therefore sells ABC bonds with a face value of $10 million and a market value of $11 million to counterparty B, with a contract price of $11 million to reflect the bond's market value. Concurrently, counterparty A agrees to buy back the bond in 31 days at the contract price plus 0.3% interest (30 basis points).

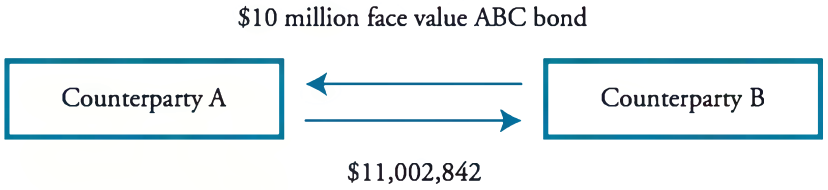
Professor's Note: Interest rates for repos are always quoted at an annualized rate, and the convention for most money market securities is to use an actual/360 day count.

The repurchase price in this example is computed as follows:

$$\$11{,}000{,}000 \times \left(1 + \frac{0.3\% \times 31}{360}\right) = \$11{,}002{,}841.67$$

As illustrated in Figure 2, on the June 1 termination of the repo trade, counterparty A will purchase back the $10 million face value ABC bond for $11,002,842.

Figure 2: Repo Termination (Settlement)



LO 52.2: Explain common motivations for entering into repos, including their use in cash management and liquidity management.

Borrowers in Repos

From the perspective of the *borrower*, repos offer relatively cheap sources of obtaining short-term funds. Relative to unsecured borrowing, repos allow the borrower to obtain funds at favorable rates because lenders are willing to accept lower returns (relative to unsecured transactions) in favor of the security of collateral.

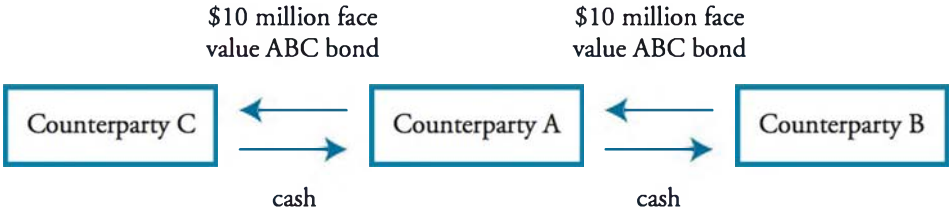
Bond Financing

Repos can also be used to obtain cash to finance a long security position. Consider a financial institution in the previous example (as counterparty A) that just purchased the same $10 million face value ABC bond from a client in hopes of selling it to another investor for a profit. Until the new buyer is found, however, the financial institution needs to finance the purchase of the bond. It can do so by borrowing cash through an overnight repo trade (from counterparty B) and pledging the ABC bond as collateral, subject to any applicable haircuts. If the financial institution cannot immediately find a buyer, it needs to roll/renew its position. If the initial repo trade and the subsequent rolls are transacted with the same counterparty, the trade flow is similar to Figure 1.

If the repo is renewed/rolled with a different counterparty, the financial institution first needs to unwind the initial trade (with counterparty B) and then enter into a new repo trade with another counterparty (counterparty C). This is illustrated in Figure 3.

Similar to financing a bond purchase, the financial institution may also use repos to finance proprietary positions or to finance its inventory in order to make markets.

Figure 3: Back-to-Back Repo Trades



Liquidity Management

Firms can borrow funds in different ways. They can issue equity capital or issue long-term or short-term debt, either on a secured or unsecured basis. Repos offer secured short-term financing; however, they are considered less stable given that repos need to be repaid within a short time period, and they are subject to swings in market conditions and sentiment. By contrast, equity financing is considered the most stable financing form given that the issuing firm has no obligation to pay dividends and equity financing does not need to be paid back. However, given its stability, equity financing is the most expensive and requires the highest expected return. By contrast, repo financing is cheaper but less stable.

Firms need to balance this tradeoff between the costs of funding among the various alternatives and potentially being left without financing. This is referred to as **liquidity management**.

Lenders in Repos

From the perspective of the *lender*, repos can be used for either investing or for financing purposes as part of an entity's cash management or financing strategies.

Cash Management (Repos as Investment Vehicles)

Lenders use repos (taking the reverse repo side) for investing when they hold cash either for liquidity or safekeeping reasons and need short-term investing opportunities to generate return on their surplus cash position. For example, money market mutual funds hold cash for safekeeping on behalf of investors and therefore need low risk, short maturity investments to generate return rather than holding idle cash. Municipalities, on the other hand, have significant surplus cash generated from tax revenues. Municipalities are prohibited from investing in high-risk investments, and repos offer a low risk, collateral-secured investment opportunity.

Investors look for liquidity and tend to favor very short-term positions in **overnight repos**, which provide significant flexibility to the investor. Following each overnight repo

transaction, the investor could re-evaluate its decision whether to continue lending cash. Investors may also transact in **open repos** by lending for a day under a contract that renews each day until it is canceled. Repos could have longer maturities out to several months, although typically the longer the maturity, the lower the overall demand.

In addition to liquidity, investors also prefer higher quality collateral. Repo collateral is generally limited to high-quality securities, including securities issued or guaranteed by governments and government-sponsored entities. Because the lender is faced with the risk of a decline in collateral value during the term of the repo transaction, repo agreements often require collateral haircuts. A **haircut** refers to discounting the value of the collateral posted in relation to its risk. In our earlier repo trade example, counterparty B may only lend $10.5 million against the $11 million market value of the ABC bond collateral received. Finally, repo transactions are also subject to margining and (daily) margin calls. A margin call requires a borrower to post additional collateral in a declining market, but it also allows the borrower to withdraw excess collateral in up markets.

Short Position Financing (Repos as Financing Vehicles)

Lenders may also use repos (as the reverse repo side) to finance short positions in bonds. Consider an investment management firm that has a view that interest rates will rise and bond prices will fall. It can take advantage of this view by obtaining the desired bond collateral through lending cash in a reverse repo trade. It would then short sell the bond received through the reverse repo and buy it back at the market price at a later date, hoping to benefit from the trade from a fall in prices. The transaction flows would be similar to what we previously illustrated in Figure 1 and Figure 2, with the investment management firm as counterparty B.

Counterparty Risk and Liquidity Risk

LO 52.3: Explain how counterparty risk and liquidity risk can arise through the use of repo transactions.

Repo transactions involve the exchange of cash as well as the exchange of collateral. As a result, both counterparty risk (credit risk) and liquidity risk are present.

Counterparty risk is the risk of borrower default or non-payment of its obligations, and it arises because the lender is exposed to the risk of a failure by the borrower to repay the repo loan and interest. Given, however, that repo loans are secured by collateral, this makes the lender much less vulnerable to a decline in the creditworthiness of the borrower. The lender can recover any amounts owed by simply selling the collateral. As a result, because repos are generally very short-term transactions secured by collateral, counterparty (credit) risk is less of a concern.

Liquidity risk is the risk of an adverse change in the value of the collateral and can be of particular concern to the lender. Even if the lender is less concerned with the credit risk of a counterparty given the security of collateral, the lender is still exposed to the risk of collateral illiquidity and to the value of the collateral declining during the repo term. Especially during times of market turbulence (as we will see in next LO), the value of

collateral can decline significantly and its liquidity can dry up. This risk can be mitigated with the use of haircuts, margin calls, reducing the term of the repo, and accepting only higher quality collateral.

Repos During the Credit Crisis

LO 52.4: Assess the role of repo transactions in the collapses of Lehman Brothers and Bear Stearns during the (2007–2009) credit crisis.

Prior to the 2007–2009 credit crisis, the repo market was considered relatively liquid with stable demand by both borrowers and lenders. Borrowers often posted weaker quality collateral, including corporate bonds or mortgage-backed securities. This benefited both borrowers, who were able to post less desirable collateral, and lenders, who were able to obtain higher repo rates in exchange for accepting lower quality collateral. However, as the crisis escalated, lenders were reluctant to continue to accept these securities, and were increasingly demanding higher quality collateral and larger haircuts. At the extreme, they simply withdrew liquidity and stopped transacting in the markets. Borrowers that were the worst hit experienced collateral liquidations, capital declines, and ultimately bankruptcies. The case studies of Lehman Brothers and Bear Stearns provide important insights into the role of repo transactions in the demise of these once important institutions.

Repos and Lehman Brothers

JPMorgan Chase & Co. (JPM) was the tri-party repo clearing agent of Lehman Brothers Holdings, Inc. (Lehman). (In a tri-party repo agency arrangement, the repo trades are still executed between two counterparties; however, the collateral selection, payment, settlement, and repo management is outsourced to a third-party agent. Agents are essentially custodians and do not take on the risks of the transactions.) These tri-party repos were traded in the overnight market, and were transacted predominantly between institutional repo lenders and financial institution borrowers (including Lehman). Given that the trades were overnight transactions, they matured each morning, leaving the borrowers without funding during the rest of the day. To bridge this funding gap, JPM, as tri-party agent, was lending directly to Lehman on a secured basis during the day, typically without requiring haircuts on intraday advances. By August 2008, however, due to the increased risk in the repo markets, JPM began to phase in haircuts on intraday loans, with the loan amounts exceeding $100 billion in the final week of Lehman's bankruptcy.

Professor's Note: Lehman was one of the largest U.S. investment banks. The failure of Lehman in September 2008 was the largest in U.S. history ($600 billion in assets).

Both Lehman and JPM provide different viewpoints of the events leading up to Lehman's bankruptcy in September 2008. Despite the differing accounts, it is clear that the liquidity and value of collateral pledged in repo transactions declined during the crisis, and additional collateral and additional haircuts were necessary to mitigate the risks in repos.

According to Lehman, JPM, despite a conflict of interest due to its agent and lender role, breached its duty to Lehman and took advantage of its insider status (being insider to Lehman's internal financial condition and proposed business plans). Lehman accused JPM of using its influence to drain close to $14 billion in collateral from Lehman during the last few days before the bankruptcy, despite already being in an overcollateralized position. Although Lehman agreed at the time to provide additional collateral, it did so unwillingly and simply because there were no viable alternatives.

According to JPM, however, JPM acted in good faith by providing continued funding to Lehman up until the last day, despite Lehman's deteriorating financial condition. When it became clear that the collateral posted to JPM by Lehman was illiquid with apparently overstated values, JPM's exposure to Lehman was growing at a time when Lehman's creditworthiness and financial condition was deteriorating. Nevertheless, JPM continued to lend money despite inadequate haircuts and collateral values. The close to $14 billion in additional collateral requested by JPM was significantly less than what was needed to cover JPM's true exposure.

Repos and Bear Stearns

Prior to 2007, Bear Stearns Companies, Inc., (Bear Stearns) relied on funding its borrowings primarily in the form of short-term unsecured commercial paper. By 2007, however, Bear Stearns switched from unsecured borrowing to a more stable form of borrowing through longer term, secured repo financing, which better positioned the firm to withstand market liquidity events. Given the high-quality collateral posted, the firm was able to obtain financing at favorable rates on a term basis.

Given the events of 2007–2009, lenders during this period became increasingly less willing to provide loans in the form of repo trades, and were especially averse to providing term (rather than overnight) repos. This led to a general shortening of repo terms, requiring larger haircuts, and requesting borrowers to post higher quality collateral. In early March 2008, Bear Stearns experienced a run on the bank that resulted from a general loss of confidence in the firm. This bank run led to a massive withdrawal of cash and unencumbered assets (i.e., assets that have not been committed or posted as collateral), and lenders refused to roll over their repo trades. The rapid decline in market confidence and withdrawal of capital ultimately led to Bear Stearns' collapse.

Professor's Note: Bear Stearns was a U.S. investment bank and brokerage firm that was bailed out by the Federal Reserve Bank of New York and subsequently sold to JPM in March 2008.

Collateral in Repo Transactions

LO 52.5: Compare the use of general and special collateral in repo transactions.

Repo trades can be secured either with general collateral or with specific (i.e., special) collateral.

General Collateral

While lenders care about the quality of collateral delivered, under **general collateral** (GC), repo lenders are not concerned with receiving a particular security or class of securities as collateral. Instead, only the broad categories of acceptable securities are specified. The logic here is that when lenders are looking to receive a specific rather than generic security as collateral, this creates a demand for that security and lenders have to accept a lower return on the repo trade. GC trades suit investors in repos because they can obtain the highest repo rate for the collateral received.

The repo rate for trades secured with general collateral is called the **GC rate**. GC rates can be used for repos with U.S. Treasury collateral, and the overnight rate for U.S. Treasury collateral is referred to as "the" GC rate. In the United States, the GC repo rate is typically slightly below the federal funds rate, although repos with U.S. Treasury collateral are considered safer and in fact can trade below the federal funds rate. The difference between the federal funds rate and the GC rate is measured through the **fed funds-GC spread**. This spread widens when Treasuries become scarcer (the GC rate falls) or during times of financial stress, as was the case during the recent financial crisis.

Professor's Note: The federal funds rate is an interest rate that depository institutions in the United States charge each other for lending funds maintained at the Federal Reserve.

Special Collateral

When lenders are concerned with receiving a particular security as collateral, the collateral is referred to as **special collateral**, and the repo trade is called a **specials trade**. If you recall our discussion on financing as a motivation for repo lending, it should be clear that specials trades are particularly important in financing transactions used to obtain specific bonds. The repo rate for trades secured with special collateral is called the **special rate**.

In specials trading, the lender of cash is concerned with receiving a particular security in order to finance the purchase of a bond (for shorting), or to finance its inventory or proprietary positions. Lenders accepting special collateral face a trade-off between receiving the desired security and lending at below GC rates to receive the desired security. Special rates differ by security because there is a rate for each security for each term. Special rates are determined by market supply and demand; however, it is important to note that the supply and demand of the underlying security is not the same as the supply and demand of the specials trade itself. In fact, a bond that is in high demand in the market may not be in great demand as collateral for a specials trade. The reverse could equally be true.

Special Spreads and the Auction Cycle

LO 52.6: Describe the characteristics of special spreads and explain the typical behavior of US Treasury special spreads over an auction cycle.

The difference between the GC rate and the special rate for a particular security and term is called a **special spread**. Special spreads are important because in the United States, they are tied closely to the U.S. government Treasury bond auctions, and the level and volatility of the spread can be an important gauge of market sentiment.

In the United States, federal government bonds are sold at auction based on a predetermined, fixed schedule. The most recent issue is called the **on-the-run** (OTR) or *current* issue, while all other issues are called **off-the-run** (OFR). Current OTR issues tend to be the most liquid, with low bid-ask spreads, that can be liquidated quickly even in large sizes. This liquidity makes them desirable for both long positions and short positions. For example, a repo lender would favor these securities for short positions because the shorts could be covered quickly and at a relatively low cost. The popularity of OTR issues as special collateral in repo trades historically resulted in lower repo rates and wider special spreads.

Several observations can be made by looking at the special spreads of OTR Treasury securities (OTR special spreads) and the auction-driven pattern of special spreads. First, OTR special spreads can be volatile each day depending on the special collateral. Second, spreads can fluctuate over time. Third, and most important, OTR special spreads are generally narrower (smaller) immediately after an auction but wider before auctions. They are narrower after auctions due to the extra supply of a new OTR security, which depresses special spreads. Spreads widen before auctions due to the substitutability of the special collateral as shorts change to the new OTR security.

The influence of auctions can also be observed from the term structure of individual OTR issues based on term special spreads (the difference between term GC rates and term special rates). Term special spreads are expected to decline immediately following the issue of the new OTR security but increase closer to the dates of the new auctions.

Special Spreads and Rate Levels

Special spreads generally move within a band that is capped at the GC rate (implying a floor of 0% for the special rate). When a trader short sells the OTR Treasury security but fails to deliver on settlement, the trader would not receive cash from the sale and would also miss out on a day's interest on the cash. To satisfy the settlement obligation to deliver the bond, the trader could borrow the bond in the overnight repo market and pay a special rate of 0% (essentially the trader provides free financing in exchange for receiving the desired bond). At any rate below 0%, no trader would borrower the bond. This puts both an effective lower bound and an effective cap of the special spread at the GC rate.

The special spread can also be tied to the penalty for failed trades. Until 2009, there was no penalty for failed trades. However, in light of the financial crisis and trillions of dollars in failed OTR deliveries, regulators adopted a penalty rate for failed trades, equal to the greater of 3% minus the federal funds rate, or zero. This means that as the federal funds rate

increases, the penalty falls, and when the federal funds rate declines to zero, the penalty rate reaches its maximum at 3%. As a result, the new upper limit for the special spread is the penalty rate.

LO 52.7: Calculate the financing advantage of a bond trading special when used in a repo transaction.

The premium trading value of OTR bonds is due both to their liquidity and financing advantage as we previously discussed. The liquidity advantage stems from the ability to sell these bonds quickly for cash. The financing value stems from the ability to lend the bonds at a cheap special rate and use the cash to lend out at higher GC rates. This financing value is dependent on the trader's expectation of how long the bond will continue trading at its special rate before the rate moves higher toward the GC rate.

Let's assume that an OTR bond is issued on January 1 and trades at a special spread of 0.18%. A trader expects the bond to trade at GC rates past March 31. The financing value of the OTR bond is therefore the value over 90 days. The value of $100 of cash at the spread of 0.18% is:

$$\$100 \times \frac{90 \times 0.18\%}{360} = \$0.045$$

Thus, the financing value is 4.5 cents per $100 market value of the bond.

Key Concepts

LO 52.1

Repurchase agreements, or repos, are 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 we refer to repos, while from the perspective of the lender we refer to reverse repos. Repos are valued based on a simple time value of money calculation.

LO 52.2

From the perspective of the borrower, repos offer relatively cheap sources of obtaining short-term funds. Balancing the cost of funding (e.g., through repos) and other sources of funds (including potentially no funding) is called liquidity management.

From the perspective of the lender, repos can be used for either investing (cash management) or for financing purposes (e.g., to finance short bond positions).

LO 52.3

Repos give rise to both counterparty risk and liquidity risk. Counterparty (credit) risk is the risk of borrower default or non-payment of its obligations. Liquidity risk is the risk of an adverse change in the value of the collateral. Counterparty risk is mitigated with collateral, while liquidity risk is mitigated with haircuts, margin calls, shorter repo terms, and higher quality collateral.

LO 52.4

During the recent financial crisis, lenders were increasingly demanding higher quality collateral and larger haircuts and even withdrew liquidity altogether. Borrowers experienced collateral liquidations and capital declines, leading to several high profile company failures and bankruptcies. The failures of Bear Stearns and Lehman Brothers illustrate these events.

LO 52.5

Repo trades can be secured either with general collateral or with specific collateral. Lenders (as investors) in general collateral (GC) repo trades are not concerned with receiving a specific security, and only the broad categories of acceptable securities are specified. GC trades suit investors in repos because they can obtain the highest repo rate for the collateral received. Lenders (as financing participants) in special collateral repo trades (specials trades) are concerned with receiving a particular security as collateral. The particular security received can then be used to finance the purchase of a bond (for shorting) or to finance its inventory or proprietary positions.

LO 52.6

The difference between the GC rate and the special rate for a particular security and term is called a special spread. Special spreads are tied closely to Treasury bond auctions, and the level and volatility of the spread can be an important gauge of market sentiment. Special spreads are generally narrower immediately after an auction, but widen before auctions. Spreads generally move within a band that is capped at the GC rate (implying a floor of 0% for the special rate).

Following the recent financial crisis, regulators adopted a penalty rate for failed trades at the greater of 3% minus the federal funds rate, or zero. As a result, the penalty rate becomes the new upper limit for the special spread.

LO 52.7

The financing value of the bond is the ability to lend the bonds at a relatively cheap special rate and use the cash to lend out at higher GC rates. This financing value is dependent on the trader's expectation of how long the bond will continue trading at its special rate.

Concept Checkers

1. Pasquini Investments (Pasquini) is a private brokerage looking for 30-day financing of $25 million of its accounts payable but is unsure whether the appropriate investment is a term repurchase agreement (repo) or a term reverse repo agreement. Pasquini is willing to post AAA-rated government bonds as collateral. The bonds have a face value of $27 million and a market value of $25 million. The firm is quoted a rate of 0.5% for the transaction. Which of the following choices most accurately reflects the contract type and the contract price needed by Pasquini?

	Contract type	Contract price
A.	Repo	$27,011,250
B.	Reverse repo	$25,010,417
C.	Repo	$25,010,417
D.	Reverse repo	$27,011,250

2. Posting collateral and requiring collateral haircuts are important risk mitigants in repo transactions with respect to which of the following risks?

	Posting collateral	Collateral haircuts
A.	Market risk	Interest rate risk
B.	Credit risk	Interest rate risk
C.	Market risk	Liquidity risk
D.	Credit risk	Liquidity risk

3. Kotra Bank Holdings, Inc., (Kotra) is currently weighing the cost of its funding against the risk of being left without financing. The term that best describes Kotra's activities is:
   A. counterparty (credit) risk.
   B. specials trading.
   C. liquidity management.
   D. overnight funding.

4. In a presentation to management, a bond trader makes the following statements about repo collateral:

   Statement 1: *"The difference between the federal funds rate and the general collateral rate is the special spread."*

   Statement 2: *"During times of financial crises, the spread between the federal funds rate and the general collateral rate widens."*

   Which of the trader's statements are accurate?
   A. Both statements are incorrect.
   B. Only Statement 1 is correct.
   C. Only Statement 2 is correct.
   D. Both statements are correct.

5. The latest on-the-run (OTR) Treasury bond issued on March 1 is trading at a special spread of 0.25%. Traders expect the bond to trade at general collateral (GC) rates past June 30. The financing value of the OTR bond is therefore the value over 122 days. Given this information, the value of lending $100 of cash is closest to:
A. $0.085.
B. $0.250.
C. $0.305.
D. $0.847.

Concept Checker Answers

1. **C** Given that Pasquini is a borrower in the repo market, the transaction is a repo from the perspective of the firm (but a reverse repo from the perspective of the lender). The contract price is calculated as follows:

$$\$25,000,000 \times \left(1 + \frac{0.5\% \times 30}{360}\right) = \$25,010,417$$

2. **D** Collateral is an important counterparty credit risk mitigant. Repo loans are secured by collateral, which makes the lender much less vulnerable to a decline in the creditworthiness of the borrower. Collateral haircuts are important in mitigating liquidity risk in repo transactions. The lender is exposed to the risk of the value of the collateral declining during the repo term, which can be mitigated by requiring (higher) haircut values, that is, discounts to the value of the posted collateral.

3. **C** The process of weighing the cost of its funding against the risk of being left without financing is called *liquidity management*. Counterparty (credit) risk is the risk of borrower default or non-payment of its obligations. In specials trading, a lender of cash initiates a repo trade in order to receive a particular security (special collateral). Overnight funding refers to borrowing and lending in the overnight market.

4. **C** The trader's first statement is incorrect. The difference between the federal funds rate and the general collateral (GC) rate is known as the *fed funds-GC spread*. The *special spread* is the difference between the GC rate and the special rate for a particular security.

   The trader's second comment is correct. During times of financial crises, the spread between the federal funds rate and the general collateral rate widens as the willingness to lend Treasury securities declines, lowering the GC rate (thereby increasing the spread).

5. **A** The financing value of $100 of cash at a spread of 0.25% is calculated as:

$$\$100 \times \frac{122 \times 0.25\%}{360} = \$0.0847 \text{ or } 8.47 \text{ cents}$$

The following is a review of the Operational and Integrated Risk Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Estimating Liquidity Risks

Topic 53

Exam Focus

This topic addresses the calculation of liquidity cost and applies this value to the value at risk measure. We will see how to compute liquidity-adjusted VaR (LVaR) when considering both a constant spread and an exogenous spread approach. Be familiar with how to make these calculations, particularly for the constant spread approach. Also, understand the concept of cash flow at risk (CFAR) and how liquidity is impacted during a crisis.

Liquidity Risk

LO 53.1: Define liquidity risk and describe factors that influence liquidity, including the bid-ask spread.

Liquidity risk is the degree to which a trader cannot trade a position without excess cost, risk, or inconvenience. When liquidity risk exists, there can be several types of price uncertainty. First, the usual market quote of the average of the bid and ask prices becomes less meaningful because the spread is wider, which means the market quote is even farther from either the buy or sell transaction price. Second, a larger bid-ask spread means a higher cost to get in and out of the position. Third, the actual price of either a buy or sell order is less certain because the assets do not trade frequently, and the quoted bid and ask prices will probably not be the prices of the respective sell and buy transactions when actually executed. There is also an increased risk in that the spread can change (i.e., it is stochastic), which will increase the risks of trading.

Liquidity is a function of the type of market and its characteristics. It depends on factors such as the number of traders in the market, the frequency and size of trades, the time it takes to carry out a trade, the cost, and the risk of the transaction not being completed. It also depends on the type of asset and the degree to which the asset is standardized. A less standardized asset will have higher liquidity risk. A forward contract has much more liquidity risk than a futures contract, for example, because the forward contract is not a standardized contract. Over-the-counter (OTC) derivatives of all types usually have relatively high liquidity risk.

Bid-Ask Spread

The bid-ask spread is a cost of liquidity. A wider (narrower) spread indicates lower (higher) liquidity. If an asset becomes less liquid, the spread increases, and the costs of trading the asset increase. The risk of liquidity changing, and changes in the spread, should be included with other measures of market risk. The spread can also change as a result of the activities of a given trader when liquidity is endogenous, which is described in the next LO.

Exogenous vs. Endogenous Liquidity

LO 53.2: Differentiate between exogenous and endogenous liquidity.

Exogenous liquidity refers to the bid-ask spread not being affected by the individual trades made by investors. This is more likely to be the case when the trades are relatively small. **Endogenous liquidity** refers to when a given trade can influence the liquidity risk of the trade (i.e., a trader submitting a buy or sell order that increases the spread). If an investor attempts to purchase a large block of an asset, for example, the buy order may have an impact on the spread and increase the cost over that indicated by the initial bid-ask prices. This can also happen when an investor tries to liquidate an asset. This type of endogeneity problem is more likely in illiquid markets and when the trade is large relative to the market.

In summary, for endogenous markets, if a trader attempts to liquidate (buy) a large position, the trader should expect the bid (ask) price to fall (increase) and the bid-ask spread to widen. The trader should include such a market reaction when estimating liquidity costs and risks. In both the endogenous and exogenous case, the bid-ask spread is still a function of the factors already mentioned (the number of traders, the standardization of the asset, low transactions costs, etc).

Liquidity-Adjusted VaR

LO 53.3: Describe the challenges of estimating liquidity-adjusted VaR (LVaR).

One of the challenges of estimating liquidity-adjusted value at risk (LVaR) is choosing the best method. As in most choices, there is a tradeoff between sophistication and ease of implementation, and it is worth noting that sophistication and usefulness are not necessarily positively correlated. It is recommended to find approaches that are transparent in their assumptions and simple to implement (e.g., implementable with just a spreadsheet). A good way to do this is to determine liquidity "add-ons" that allow a researcher to modify original VaR estimates that did not include factors for illiquidity. In addition to addressing liquidity, the approach can also assess the impact of assumptions on estimates of VaR.

Another challenge is liquidity adjustments that are compatible with the basic VaR approach and each other. This is because different methods look at different aspects of illiquidity, and it can be helpful to combine 'add-ons' that give the best overall liquidity adjustment. In other words, two less sophisticated methods may be much better than one really good sophisticated method.

Another challenge is to check how the liquidity adjustment changes other inputs, such as the confidence level, holding period, or any other parameters (i.e., the sensitivity of the other inputs to the liquidity adjustment). The researcher should be aware of some basic relationships (e.g., an increase in the holding period should lower the level of the liquidity adjustment).

The researcher should try to calibrate the model against real data (e.g., check if the bid-ask spread parameters are empirically plausible), and properly stress test the model, as well as backtest the model. The researcher should be aware that there is probably not a single, best

approach that would exclude the use of all others. Furthermore, using different approaches can help highlight different liquidity concerns.

LO 53.4: Describe and calculate LVaR using the constant spread approach and the exogenous spread approach.

The **constant spread approach**, as the name implies, calculates LVaR assuming the bid-ask spread is constant. This makes the liquidity cost equal to half the spread multiplied by the size of the position to be liquidated. The liquidity cost (LC) to add on to the initial VaR estimate is then:

$$LC = 0.5 \times V \times \text{spread}$$

where:
V = value of the position

$$\text{spread} = \frac{(\text{ask price} - \text{bid price})}{(\text{ask price} + \text{bid price})/2}$$

Recall that VaR quantifies the maximum loss for a given confidence level over a particular holding period. For example, a typical VaR calculation may indicate a 1% probability of losses exceeding $10 million over a five-day holding period. LVaR is calculated using the following formula assuming a constant spread:

$$LVaR = (V \times z_{\alpha} \times \sigma) + [0.5 \times V \times \text{spread}]$$

$$LVaR = VaR + LC$$

where:
V = asset (or portfolio) value
z_{α} = confidence parameter
σ = standard deviation of returns

Professor's Note: Notice that VaR in this example is dollar VaR as opposed to percentage VaR.

The confidence level of the estimate is $1 - \alpha$ (e.g., 5% level of significance (α) = 95% confidence level). Note that the larger the spread, the larger the calculated LVaR. Since liquidity risk incorporates selling the asset, not a full "round trip," only half of the spread is used.

Example: Computing LVaR

Suppose that ABC Company has a current stock price of $100 and a daily standard deviation of 2%. The current bid-ask spread is 1%. **Calculate** LVaR at the 95% confidence level. Assume a constant spread.

Answer:

LVaR = (100 × 1.65 × 0.02) + (0.5 × 100 × 0.01) = $3.80

The previous discussion involved the use of normal VaR (i.e., VaR assuming asset prices are normally distributed). In practice, asset prices are lognormally distributed as was illustrated in the FRM Part I curriculum when we examined the Black-Scholes-Merton option pricing model. In this assigned reading, the author uses **lognormal VaR** to calculate the liquidity-adjusted VaR. The conventional lognormal VaR, with no adjustment for liquidity risk, is calculated in the following fashion:

$$\text{Lognormal VaR} = [1 - \exp(\mu - \sigma \times z_\alpha)] \times V$$

where:
μ = mean return

The liquidity-adjusted VaR is then calculated as follows:

$$\text{LVaR} = \text{VaR} + \text{LC} = [1 - \exp(\mu - \sigma \times z_\alpha) + 0.5 \times \text{spread}] \times V$$

Using the simplifying assumption of $\mu = 0$, the ratio of LVaR to VaR becomes:

$$\frac{\text{LVaR}}{\text{VaR}} = 1 + \frac{\text{spread}}{2 \times [1 - \exp(-\sigma \times z_\alpha)]}$$

This expression indicates that the liquidity adjustment will increase (decrease) when there is an increase (decrease) in the spread, a decrease (increase) in the confidence level, and a decrease (increase) in the holding period.

Professor's Note: Notice that the calculation of lognormal VaR and normal VaR will be similar when we are dealing with short-time periods and practical return estimates.

Example: Computing LVaR to VaR ratio (constant spread)

Assume the following parameters: $\mu = 0$, $\sigma = 0.012$, spread = 0.02, and a 95% confidence level. **Compute** the LVaR to VaR ratio.

Answer:

$$\frac{\text{LVaR}}{\text{VaR}} = 1 + \frac{0.02}{2 \times [1 - \exp(-0.012 \times 1.65)]} = 1.51$$

The increase from VaR to LVaR is just over 50%, from only a 2% spread. This demonstrates that even a small spread can translate into a surprisingly large liquidity adjustment to VaR.

LVaR can also be calculated given the distribution characteristics of the spread. This is the foundation underlying the **exogenous spread approach**. If you are given the mean and standard deviation of the spread, you would apply the following formula:

$$\text{LVaR} = \text{VaR} + 0.5 \times [(\mu_S + z'_\alpha \times \sigma_S)] \times V$$

Professor's Note: We add the confidence parameter times the volatility of the spread to the mean of the spread since the liquidity adjustment increases the value at risk. Also, notice that the confidence parameter (or z-score) used for the uncertainty of the spread is labeled differently. The confidence parameter, in this case, is a value to be determined.

The exogenous spread approach assumes that the spread is stochastic and that the trades of a single trader do not affect the spread. The spread could follow one of many distributions; for example, the normal distribution or a more leptokurtic distribution (historically, the distribution of the spread has been highly non-normal with excess amounts of kurtosis). Once having assumed a distribution, the researcher can estimate the LVaR using Monte Carlo simulation by simulating values for both V and the spread, incorporating the spread into V to get liquidity-adjusted prices, and then infer the liquidity-adjusted VaR from the distribution of simulated liquidity-adjusted prices.

Example: Computing LVaR (assuming normal VaR)

Suppose that ABC Company has a current stock price of $100 and a daily standard deviation of 2%. The mean of the bid-ask spread is 2%, and the standard deviation of the bid-ask spread is 1%. **Calculate** LVaR at the 95% confidence level assuming the confidence parameter of the spread is equal to 3.

Answer:

$$\text{LVaR} = (100 \times 1.65 \times 0.02) + \frac{1}{2} 100 \times (0.02 + 3 \times 0.01) = \$5.8$$

The researcher can determine the optimal value of z'_α using some suitably calibrated Monte Carlo exercise [Bangia et al. (1999)[1] assume a value of three for z'_α]. Applying lognormal assumptions, the LVaR using the exogenous spread approach is the lognormal VaR plus the liquidity adjustment:

$$LVaR = VaR + LC = V \times \{[1 - \exp(\mu - \sigma \times z_\alpha)] + [0.5 \times (\mu_S + z'_\alpha \times \sigma_S)]\}$$

It is worth noting that if σ_S equals zero, then this expression becomes the LVaR formula for the constant spread approach where μ_S = spread. Thus, this approach is simply the constant spread approach with an added expression to allow for a stochastic spread.

We can now apply the familiar LVaR to VaR ratio:

$$\frac{LVaR}{VaR} = 1 + \frac{LC}{VaR} = 1 + \frac{(\mu_S + z'_\alpha \times \sigma_S)}{2 \times [1 - \exp(-\sigma \times z_\alpha)]}$$

Example: Computing LVaR to VaR ratio (exogenous spread)

A researcher estimates the mean and standard deviation of the spread to be 0.02 and 0.005, respectively. He also estimates that $\mu = 0$ and $\sigma = 0.012$ for the underlying returns distribution. Using a 95% confidence level, **compute** the ratio of LVaR to VaR. Assume the confidence parameter for the spread, z'_α, is equal to 3.

Answer:

$$\frac{LVaR}{VaR} = 1 + \frac{(0.02 + 3 \times 0.005)}{2 \times [1 - \exp(-0.012 \times 1.65)]} = 1.89$$

The result here, when compared to the previous answer, demonstrates how including the possibility of the spread being random (stochastic) can increase the liquidity adjustment. In this case, it almost doubles from 51% to 89%.

Endogenous Price Approaches

LO 53.5: Describe endogenous price approaches to LVaR, their motivation and limitations, and calculate the elasticity-based liquidity adjustment to VaR.

Both the constant spread approach and the exogenous spread approach assume that prices do not change in response to trading (i.e., prices are exogenous). This may not always be the case, and it may be necessary to make a liquidity adjustment for endogenous prices. In the case of selling for example, there may be downward pressure on prices, which causes a loss. VaR should include an adjustment for the possibility of this loss. The adjustment should be larger if the market prices are more responsive to trades.

1. Bangia, A.F. Diebold, T. Schuermann, and J. Stroughair. (1999). "Liquidity on the outside." *Risk* 12 (June): 68–73.

Of the various ways to include an adjustment, a relatively simple method uses the concept of **elasticity**, *E*. In this case, it is the proportional change in price divided by the proportion of the market traded:

$$E = \frac{\Delta P/P}{\Delta N/N}$$

where:
$\Delta N/N$ = size of the trade relative to the entire market

Generally, it is the case that $E < 0$ and $\Delta N/N > 0$. A researcher can estimate values for *E* and $\Delta N/N$ and input them into an expression for LVaR as follows:

$$LVaR = VaR \times \left(1 - \frac{\Delta P}{P}\right) = VaR \times \left(1 - E \times \frac{\Delta N}{N}\right)$$

$$\frac{LVaR}{VaR} = 1 - E \times \frac{\Delta N}{N}$$

The approach is very convenient because the adjustment is independent of the computation of VaR and its assumptions, and the ratio of LVaR to VaR is a function of only two inputs. The obvious limitation is its narrow focus and that it entirely ignores bid-ask spreads and transactions costs. On the other hand, a researcher can easily combine this adjustment with one of the other liquidity adjustments by simply multiplying the effects:

$$\left.\frac{LVaR}{VaR}\right|_{combined} = \left.\frac{LVaR}{VaR}\right|_{exogenous} \times \left.\frac{LVaR}{VaR}\right|_{endogenous}$$

Example: Endogenous price approach

A trader has a position worth 10% of the size of the market (i.e., $\Delta N/N = 0.1$) and estimates that $E = -0.4$ so that $\Delta P/P = E \times \Delta N/N = -0.4 \times 0.1 = -0.04$. **Compute** the ratio of LVaR to VaR based only on endogenous factors and the combined LVaR to VaR ratio assuming the ratio for the exogenous approach is 1.89.

Answer:

$$\left.\frac{LVaR}{VaR}\right|_{endogenous} = 1 - (-0.04) = 1.04$$

Thus, the adjustment for endogeneity will increase the total adjustment for liquidity by 4%. Using the liquidity adjustment for the exogenous approach yields the following combined result:

$$\left.\frac{LVaR}{VaR}\right|_{combined} = 1.89 \times 1.04 = 1.97$$

Jarrow and Subramanian (1997)[2] offer a more sophisticated method called the **liquidity discount VaR**, where the trader maximizes expected utility by liquidating the position within a certain period of time. It incorporates both exogenous and endogenous market liquidity, spread cost, spread risk, an endogenous holding period, and an optimal liquidation policy. It does so with three modifications: (1) uses an optimal holding period based on the trader's expected-utility optimization problem, (2) adds the average liquidity discount to the trader's losses, and (3) has the volatility measure include the volatility of the time to liquidation and the volatility of the liquidity discount factor, as well as the volatility of the underlying market price.

Liquidation, Transaction Costs, and Market Price Impact

As with most financial activities, there are tradeoffs to consider when executing a trade. Attempting to sell quickly will usually increase the transactions costs and may have an unfavorable impact on the selling price. Taking more time to sell can increase the exposure to exogenous and unfavorable price changes. A trader should recognize the tradeoff and identify a set of efficient trading strategies that produce the minimum remaining risk exposure at any given point in time, for any given expected cost. The trader should choose the strategy that best fits his risk aversion. A more (less) risk averse trader would choose a strategy that executes more (less) quickly. A more (less) quick execution will reduce (increase) price uncertainty with higher (lower) transactions costs.

Liquidity at Risk

LO 53.6: Describe liquidity at risk (LaR) and compare it to LVaR and VaR, describe the factors that affect future cash flows, and explain challenges in estimating and modeling LaR.

Liquidity at risk (LaR) is also known as **cash flow at risk** (CFaR) and is the maximum likely cash outflow over the horizon period at a specified confidence level. A positive (negative) value for LaR means the worst outcome will be associated with an outflow (inflow) of cash. LaR is similar in concept to VaR, but instead of a change in value, it deals with a cash flow. LaR is also distinct from liquidity-related losses, but they are related.

As an example, an investor has a large market risk position that is hedged with a futures position. If the hedge is a good one, the basis risk is small, and the VaR should be small. There is the possibility of margin calls on the futures position, however, and this means there is the possibility of a cash outflow equal to the size of that position. In summary, the hedged position has a small VaR but a large LaR. At the other extreme, European options have zero LaR until expiration, but potentially large VaR prior to maturity.

The following is a list of factors that influence cash flows and LaR:

- Borrowing or lending.
- Margin requirements on market risk positions that are subject to daily marking to market.
- Collateral obligations, such as those on swaps, which can generate inflows or outflows of cash from changes in market factors, such as interest rates.

2. Jarrow, R.A. and A. Subramanian. (1997). "Mopping up liquidity." *Risk* 10 (December): 170–173.

- Short explicit options or implicit options (e.g., convertibility and call features).
- Changes in risk management policy (e.g., a change in the type of hedge), which may change mark-to-market requirements.

Two other considerations are as follows: (1) LaR can increase when the firm is facing hard times (e.g., a credit downgrade increases the rate on bank loans); and (2) there are positions that are similar in terms of market risk (e.g., a futures versus an options hedge), but are very different in terms of LaR.

As a practical matter for the firm attempting to estimate LaR, consider using the firm's VaR procedures to estimate the VaRs of marginable securities and then combine this LaR estimate with comparable figures from other sources of liquidity risk within the organization to produce an integrated measure of firm-wide liquidity risk. The point is to use the existing and accepted VaR procedures to estimate liquidity risks. It is obviously ad hoc, however, and a firm facing complex liquidity risks should build a more appropriate model. This would involve identifying and modeling the variables indicated in the following list:

- The certain cash flows (e.g., from U.S. Treasury investments).
- The unconditional uncertain cash flows (e.g., from risky bonds).
- The conditional uncertain cash flows (e.g., those that only result if a certain decision is made, such as making an investment).
- Other conditioning variables that might trigger cash flows.

Having identified the factors, the manager can construct an appropriate engine to estimate the risks. Estimating the LaR may only require a variance-covariance approach, or it may require a more advanced simulation approach.

Role of Liquidity During Crisis

LO 53.7: Explain the role of liquidity in crisis situations and describe approaches to estimating crisis liquidity risk.

In a crisis, assumptions concerning the level of liquidity and other properties that are reasonable in a "normal" market may not hold. Such crises have occurred in 1987, 1992, 1998, and 2007–2009. Some event usually precipitates the crisis, such as a large fall in some asset prices, which leads to lower demand and wider bid-ask spreads. The time needed for selling orders to be executed increases. Market liquidity falls at the very time the market needs it.

Many things change during the course of a crisis, and a researcher needs a model that takes into account the distinctive features of a crisis (e.g., large losses, high bid-ask spreads). **CrashMetrics** may be one way to address this. As an example, the following is the profit/loss on a derivative position based on a **delta-gamma approximation**:

$$\Pi = \delta\Delta S + \frac{\gamma}{2}(\Delta S)^2$$

where:
ΔS = change in the stock price

Taking the derivative of this measure with respect to ΔS and solving for ΔS gives the change that produces the maximum loss: $\Delta S = -\delta/\gamma$, and that maximum loss in absolute value terms is:

$$\max(\text{loss}) = -\min(\Pi) = \frac{\delta^2}{2\gamma}$$

For a derivative position that requires margin and mark-to-market, letting *m* equal the margin requirement, the worst-case cash outflow is simply *m* times this amount: $m \times \delta^2/(2\gamma)$. This approximation can be more precise with the inclusion of the effects of other Greeks (e.g., thetas), counterparty risk, and other factors.

Another method for examining the liquidity consequences associated with worst-case scenarios is to apply the basic procedure above to an extreme-value method estimated with expected shortfall (ES). The cash flow would then be $m \times ES$.

These two variations of estimating the worst-case cash flow do not address many real-world complications. A researcher might also wish to address the complications with simulations designed for specific complications. Those complications include:

- The discreteness of credit events.
- The interdependency of credit events.
- The interaction of credit and market risk factors.
- Complications arising from the use of credit-enhancement methods, such as netting arrangements, periodic settlement, credit derivatives, credit guarantees, and credit triggers.

Crisis-scenario analysis is an alternative to the probabilistic approaches described previously. This would involve analyzing the potential problems of a particular event (e.g., the failure of a major institution) and working through the specific details of how this might occur. This has the advantage of working through scenarios at a chosen level of detail and accounting for complications and interactions. The problem is that there will be a lot of subjectivity, and the results will depend heavily on the assumptions used.

Key Concepts

LO 53.1

Liquidity risk is the degree to which a trader cannot trade a position without excess cost, risk, or inconvenience. Liquidity depends on factors such as the number of traders in the market, the frequency and size of trades, the time it takes to carry out a trade, the cost, and the risk of the transaction not being completed. It also depends on the type of asset and the degree to which the asset is standardized.

A wider (narrower) bid-ask spread indicates lower (higher) liquidity. If an asset becomes less liquid, the spread increases, and the costs of trading the asset increase.

LO 53.2

Exogenous liquidity refers to the bid-ask spread not being affected by the individual trades made by investors. This is more likely to be the case when the trades are relatively small.

Endogenous liquidity refers to when a given trade can influence the liquidity risk of the trade (i.e., a trader submitting a buy or sell order that increases the spread).

LO 53.3

The main challenge in estimating liquidity is finding the best method. One approach is finding adjustments to add on to the basic VaR. The researcher must understand how the inputs affect the "add-ons" and, if there are more than one, how the add-ons interact.

LO 53.4

The constant spread approach assumes the bid-ask spread is constant and the liquidity cost is simply, LC = 0.5 × spread × V, which can be added into the VaR formula.

$$\text{VaR} = [1 - \exp(\mu - \sigma \times z_\alpha)] \times V$$

$$\text{LVaR} = \text{VaR} + \text{LC} = [1 - \exp(\mu - \sigma \times z_\alpha) + 0.5 \times \text{spread}] \times V$$

LO 53.5

To account for endogeneity, a trader may estimate the elasticity of the price to the proportion of the market in a given large trade, denoted *E*, the proportion itself, denoted ΔN/N, and adjust the VaR formula.

$$\text{LVaR} = \text{VaR} \times \left(1 - \frac{\Delta P}{P}\right) = \text{VaR} \times \left(1 - E \times \frac{\Delta N}{N}\right)$$

LO 53.6

Liquidity at risk (LaR) is also known as cash flow at risk (CFaR) and is the maximum likely cash outflow over the horizon period at a specified confidence level.

LaR can be very different from the VaR of the same position. For example, a bond hedged with a futures contract has low VaR but high LaR from the possible margin call on the futures contract.

Factors that affect future cash flows are: borrowing or lending, margin requirements, collateral obligations, options positions, and changes in risk management policy.

LO 53.7

Many things change during the course of a crisis, and a researcher needs a model that takes into account the distinctive features of a crisis (e.g., large losses, high bid-ask spreads).

Concept Checkers

1. Suppose that portfolio XYZ has a $1,000,000 portfolio invested in a stock that has a daily standard deviation of 2%. The current bid-ask spread of that stock is 1%. Assuming a constant spread, what is the liquidity-adjusted VaR (normal VaR) at the 95% confidence level?
   A. $5,000.
   B. $38,000.
   C. $44,200.
   D. $43,000.

2. Which of the following actions would most likely increase liquidity risk?
   A. A rapid execution of orders.
   B. A higher level of standardization of the asset.
   C. An increase in the number of traders and a decrease in the size of those trades.
   D. A decrease in the number of traders and an increase in the size of those trades.

3. When a given trade can influence the liquidity risk of a trade, this type of liquidity is known as:
   A. exogenous liquidity.
   B. undefined liquidity.
   C. endogenous liquidity.
   D. operational liquidity.

4. Assuming the following parameters: $\mu = 0$, $\sigma = 0.006$, spread = 0.01, and a 95% confidence level, the ratio of LVaR to VaR is closest to:
   A. 1.08.
   B. 1.51.
   C. 1.66.
   D. 2.04.

5. A trader has a position worth 5% of the size of the market (i.e., $\Delta N/N = 0.05$) and estimates that the elasticity of price to size of trade is: $E = -0.2$. The ratio of LVaR to VaR based only on endogenous factors is closest to:
   A. 0.99.
   B. 1.01.
   C. 1.05.
   D. 1.40.

Concept Checker Answers

1. **B** LVaR = (1,000,000 × 1.65 × 0.02) + (0.5 × 1,000,000 × 0.01) = $38,000

2. **D** Larger and fewer traders will ultimately lower liquidity and increase liquidity risk.

3. **C** It is "endogenous" because it is determined by the trading activity itself.

4. **B** $\frac{\text{LVaR}}{\text{VaR}} = 1 + \frac{0.01}{2 \times [1 - \exp(-0.006 \times 1.65)]} = 1.508$

5. **B** $\Delta P/P = E \times \Delta N/N = -0.2 \times 0.05 = -0.01$

$$\left.\frac{\text{LVaR}}{\text{VaR}}\right|_{\text{endogenous}} = 1 - (-0.01) = 1.01$$