2017 SchweserNotes™ Part II

FRM®

Credit Risk Measurement and Management

Exam Prep

eBook 2

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Part II FRM® Exam

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FRM Part II Book 2: Credit Risk Measurement and Management

FRM 2017 PART II BOOK 2: CREDIT RISK MEASUREMENT AND MANAGEMENT

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Reading Assignments and Learning Objectives

The following material is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by the Global Association of Risk Professionals.

Reading Assignments

Jonathan Golin and Philippe Delhaise, *The Bank Credit Analysis Handbook, 2nd Edition* (Hoboken, NJ: John Wiley & Sons, 2013).

17. "The Credit Decision," Chapter 1 (page 1)
18. "The Credit Analyst," Chapter 2 (page 15)

Giacomo De Laurentis, Renato Maino, and Luca Molteni, *Developing, Validating and Using Internal Ratings* (West Sussex, United Kingdom: John Wiley & Sons, 2010).

19. "Classifications and Key Concepts of Credit Risk," Chapter 2 (page 28)
20. "Rating Assignment Methodologies," Chapter 3 (page 38)

René Stulz, *Risk Management & Derivatives* (Florence, KY: Thomson South-Western, 2002).

21. "Credit Risks and Credit Derivatives," Chapter 18 (page 63)

Allan Malz, *Financial Risk Management: Models, History, and Institutions* (Hoboken, NJ: John Wiley & Sons, 2011).

22. "Spread Risk and Default Intensity Models," Chapter 7 (page 88)
23. "Portfolio Credit Risk," Chapter 8 (page 105)
24. "Structured Credit Risk," Chapter 9 (page 120)

Jon Gregory, *Counterparty Credit Risk and Credit Value Adjustment: A Continuing Challenge for Global Financial Markets, 2nd Edition* (West Sussex, UK: John Wiley & Sons, 2012).

25. "Defining Counterparty Credit Risk," Chapter 3 (page 141)
26. "Netting, Compression, Resets, and Termination Features," Chapter 4 (page 150)
27. "Collateral," Chapter 5 (page 158)
28. "Central Counterparties," Chapter 7 (page 169)

Learning Objectives

17. The Credit Decision

After completing this reading, you should be able to:

1. Define credit risk and explain how it arises using examples. (page 1)
2. Explain the components of credit risk evaluation. (page 2)
3. Describe, compare and contrast various credit risk mitigants and their role in credit analysis. (page 2)
4. Compare and contrast quantitative and qualitative techniques of credit risk evaluation. (page 4)
5. Compare the credit analysis of consumers, corporations, financial institutions, and sovereigns. (page 5)
6. Describe quantitative measurements and factors of credit risk, including probability of default, loss given default, exposure at default, expected loss, and time horizon. (page 7)
7. Compare bank failure and bank insolvency. (page 9)

18. The Credit Analyst

After completing this reading, you should be able to:

1. Describe, compare, and contrast various credit analyst roles. (page 15)
2. Describe common tasks performed by a banking credit analyst. (page 20)
3. Describe the quantitative, qualitative, and research skills a banking credit analyst is expected to have. (page 21)
4. Assess the quality of various sources of information used by a credit analyst. (page 22)

19. Classifications and Key Concepts of Credit Risk

After completing this reading, you should be able to:

1. Describe the role of ratings in credit risk management. (page 28)
2. Describe classifications of credit risk and their correlation with other financial risks. (page 28)
3. Define default risk, recovery risk, exposure risk and calculate exposure at default. (page 29)
4. Explain expected loss, unexpected loss, VaR, and concentration risk, and describe the differences among them. (page 30)
5. Evaluate the marginal contribution to portfolio unexpected loss. (page 32)
6. Define risk-adjusted pricing and determine risk-adjusted return on risk-adjusted capital (RARORAC). (page 32)

20. Rating Assignment Methodologies

After completing this reading, you should be able to:

1. Explain the key features of a good rating system. (page 38)
2. Describe the experts-based approaches, statistical-based models, and numerical approaches to predicting default. (page 39)
3. Describe a rating migration matrix and calculate the probability of default, cumulative probability of default, marginal probability of default, and annualized default rate. (page 40)
4. Describe rating agencies' assignment methodologies for issue and issuer ratings. (page 41)

5. Describe the relationship between borrower rating and probability of default. (page 42)
6. Compare agencies' ratings to internal experts-based rating systems. (page 42)
7. Distinguish between the structural approaches and the reduced-form approaches to predicting default. (page 43)
8. Apply the Merton model to calculate default probability and the distance to default and describe the limitations of using the Merton model. (page 44)
9. Describe linear discriminant analysis (LDA), define the Z-score and its usage, and apply LDA to classify a sample of firms by credit quality. (page 45)
10. Describe the application of logistic regression model to estimate default probability. (page 48)
11. Define and interpret cluster analysis and principal component analysis. (page 49)
12. Describe the use of a cash flow simulation model in assigning rating and default probability, and explain the limitations of the model. (page 52)
13. Describe the application of heuristic approaches, numeric approaches, and artificial neural network in modeling default risk and define their strengths and weaknesses. (page 53)
14. Describe the role and management of qualitative information in assessing probability of default. (page 56)

21. Credit Risks and Credit Derivatives

After completing this reading, you should be able to:

1. Using the Merton model, calculate the value of a firm's debt and equity and the volatility of firm value. (page 63)
2. Explain the relationship between credit spreads, time to maturity, and interest rates. (page 68)
3. Explain the differences between valuing senior and subordinated debt using a contingent claim approach. (page 70)
4. Explain, from a contingent claim perspective, the impact of stochastic interest rates on the valuation of risky bonds, equity, and the risk of default. (page 70)
5. Compare and contrast different approaches to credit risk modeling, such as those related to the Merton model, CreditRisk+, CreditMetrics, and the KMV model. (page 74)
6. Assess the credit risks of derivatives. (page 79)
7. Describe a credit derivative, credit default swap, and total return swap. (page 79)
8. Explain how to account for credit risk exposure in valuing a swap. (page 82)

22. Spread Risk and Default Intensity Models

After completing this reading, you should be able to:

1. Compare the different ways of representing credit spreads. (page 88)
2. Compute one credit spread given others when possible. (page 88)
3. Define and compute the Spread '01. (page 89)
4. Explain how default risk for a single company can be modeled as a Bernoulli trial. (page 90)
5. Explain the relationship between exponential and Poisson distributions. (page 91)
6. Define the hazard rate and use it to define probability functions for default time and conditional default probabilities. (page 91)
7. Calculate the conditional default probability given the hazard rate. (page 91)
8. Calculate risk-neutral default rates from spreads. (page 93)
9. Describe advantages of using the CDS market to estimate hazard rates. (page 95)

10. Explain how a CDS spread can be used to derive a hazard rate curve. (page 95)
11. Explain how the default distribution is affected by the sloping of the spread curve. (page 97)
12. Define spread risk and its measurement using the mark-to-market and spread volatility. (page 98)

23. Portfolio Credit Risk

After completing this reading, you should be able to:

1. Define and calculate default correlation for credit portfolios. (page 105)
2. Identify drawbacks in using the correlation-based credit portfolio framework. (page 106)
3. Assess the impact of correlation on a credit portfolio and its Credit VaR. (page 107)
4. Describe the use of a single factor model to measure portfolio credit risk, including the impact of correlation. (page 109)
5. Describe how Credit VaR can be calculated using a simulation of joint defaults. (page 114)

24. Structured Credit Risk

After completing this reading, you should be able to:

1. Describe common types of structured products. (page 120)
2. Describe tranching and the distribution of credit losses in a securitization. (page 121)
3. Describe a waterfall structure in a securitization. (page 122)
4. Identify the key participants in the securitization process, and describe conflicts of interest that can arise in the process. (page 125)
5. Compute and evaluate one or two iterations of interim cashflows in a three-tiered securitization structure. (page 126)
6. Describe a simulation approach to calculating credit losses for different tranches in a securitization. (page 129)
7. Explain how the default probabilities and default correlations affect the credit risk in a securitization. (page 130)
8. Explain how default sensitivities for tranches are measured. (page 132)
9. Describe risk factors that impact structured products. (page 132)
10. Define implied correlation and describe how it can be measured. (page 133)
11. Identify the motivations for using structured credit products. (page 133)

25. Defining Counterparty Credit Risk

After completing this reading, you should be able to:

1. Describe counterparty risk and differentiate it from lending risk. (page 141)
2. Describe transactions that carry counterparty risk and explain how counterparty risk can arise in each transaction. (page 142)
3. Identify and describe institutions that take on significant counterparty risk. (page 143)
4. Describe credit exposure, credit migration, recovery, mark-to-market, replacement cost, default probability, loss given default, and the recovery rate. (page 144)
5. Identify and describe the different ways institutions can manage and mitigate counterparty risk. (page 145)

26. Netting, Compression, Resets, and Termination Features

After completing this reading, you should be able to:

1. Explain the purpose of an ISDA master agreement. (page 150)
2. Summarize netting and close-out procedures (including multilateral netting), explain their advantages and disadvantages, and describe how they fit into the framework of the ISDA master agreement. (page 150)
3. Describe the effectiveness of netting in reducing credit exposure under various scenarios. (page 153)
4. Describe the mechanics of termination provisions and trade compressions and explain their advantages and disadvantages. (page 153)

27. Collateral

After completing this reading, you should be able to:

1. Describe the rationale for collateral management. (page 158)
2. Describe features of a credit support annex (CSA) within the ISDA Master Agreement. (page 158)
3. Describe the role of a valuation agent. (page 159)
4. Describe types of collateral that are typically used. (page 159)
5. Explain the process for the reconciliation of collateral disputes. (page 160)
6. Explain the features of a collateralization agreement. (page 160)
7. Differentiate between a two-way and one-way CSA agreement and describe how collateral parameters can be linked to credit quality. (page 162)
8. Explain how market risk, operational risk, and liquidity risk (including funding liquidity risk) can arise through collateralization. (page 163)

28. Central Counterparties

After completing this reading, you should be able to:

1. Explain the objectives and functions of central counterparties (CCPs). (page 169)
2. Discuss the strengths and weaknesses of CCPs. (page 170)
3. Describe the different CCP netting schemes, the benefit of netting, and distinguish between bilateral netting and multilateral netting. (page 171)
4. Discuss the key challenges in relation to the clearing of over-the-counter (OTC) derivative products. (page 172)
5. Describe the three types of participants that channel trade through a CCP. (page 174)
6. Explain the loss waterfall in a CCP structure. (page 174)
7. Define initial margin and variation margin and describe the different approaches and factors in calculating initial margin. (page 175)
8. Discuss the impact of initial margin on prices, volume, volatility, and credit quality. (page 176)
9. Explain factors that can lead to failure of a CCP and discuss measures to protect CCPs from default. (page 177)

29. Credit Exposure

After completing this reading, you should be able to:

1. Describe and calculate the following metrics for credit exposure: expected mark-to-market, expected exposure, potential future exposure, expected positive exposure and negative exposure, effective exposure, and maximum exposure. (page 183)
2. Compare the characterization of credit exposure to VaR methods and describe additional considerations used in the determination of credit exposure. (page 186)

3. Identify factors that affect the calculation of the credit exposure profile and summarize the impact of collateral on exposure. (page 186)
4. Identify typical credit exposure profiles for various derivative contracts and combination profiles. (page 187)
5. Explain how payment frequencies and exercise dates affect the exposure profile of various securities. (page 190)
6. Explain the impact of netting on exposure, the benefit of correlation, and calculate the netting factor. (page 191)
7. Explain the impact of collateralization on exposure, and assess the risk associated with the remargining period, threshold, and minimum transfer amount. (page 188)
8. Explain the difference between risk-neutral and real-world parameters, and describe their use in assessing risk. (page 196)

30. Default Probability, Credit Spreads, and Credit Derivatives

After completing this reading, you should be able to:

1. Distinguish between cumulative and marginal default probabilities. (page 203)
2. Calculate risk-neutral default probabilities, and compare the use of risk-neutral and real-world default probabilities in pricing derivative contracts. (page 204)
3. Compare the various approaches for estimating price: historical data approach, equity based approach, and risk neutral approach. (page 205)
4. Describe how recovery rates may be estimated. (page 207)
5. Describe credit default swaps (CDS) and their general underlying mechanics. (page 208)
6. Describe the credit spread curve and explain the motivation for curve mapping. (page 209)
7. Describe types of portfolio credit derivatives. (page 209)
8. Describe index tranches, super senior risk, and collateralized debt obligations (CDOs). (page 210)

31. Credit Value Adjustment

After completing this reading, you should be able to:

1. Explain the motivation for and the challenges of pricing counterparty risk. (page 217)
2. Describe credit value adjustment (CVA). (page 217)
3. Calculate CVA and the CVA spread with no wrong-way risk, netting, or collateralization. (page 217)
4. Evaluate the impact of changes in the credit spread and recovery rate assumptions on CVA. (page 219)
5. Explain how netting can be incorporated into the CVA calculation. (page 220)
6. Define and calculate incremental CVA and marginal CVA, and explain how to convert CVA into a running spread. (page 220)
7. Explain the impact of incorporating collateralization into the CVA calculation. (page 220)

32. Wrong-Way Risk

After completing this reading, you should be able to:

1. Describe wrong-way risk and contrast it with right-way risk. (page 226)
2. Identify examples of wrong-way risk and examples of right-way risk. (page 227)

33. The Evolution of Stress Testing Counterparty Exposures

After completing this reading, you should be able to:

1. Differentiate among current exposure, peak exposure, expected exposure, and expected positive exposure. (page 236)
2. Explain the treatment of counterparty credit risk (CCR) both as a credit risk and as a market risk and describe its implications for trading activities and risk management for a financial institution. (page 237)
3. Describe a stress test that can be performed on a loan portfolio and on a derivative portfolio. (page 238)
4. Calculate the stressed expected loss, the stress loss for the loan portfolio and the stress loss on a derivative portfolio. (page 239)
5. Describe a stress test that can be performed on CVA. (page 240)
6. Calculate the stressed CVA and the stress loss on CVA. page 240)
7. Calculate the debt value adjustment (DVA) and explain how stressing DVA enters into aggregating stress tests of CCR. (page 242)
8. Describe the common pitfalls in stress testing CCR. (page 243)

34. Credit Scoring and Retail Credit Risk Management

After completing this reading, you should be able to:

1. Analyze the credit risks and other risks generated by retail banking. (page 248)
2. Explain the differences between retail credit risk and corporate credit risk. (page 249)
3. Discuss the "dark side" of retail credit risk and the measures that attempt to address the problem. (page 249)
4. Define and describe credit risk scoring model types, key variables, and applications. (page 250)
5. Discuss the key variables in a mortgage credit assessment and describe the use of cutoff scores, default rates, and loss rates in a credit scoring model. (page 251)
6. Discuss the measurement and monitoring of a scorecard performance including the use of cumulative accuracy profile (CAP) and the accuracy ratio (AR) techniques. (page 252)
7. Describe the customer relationship cycle and discuss the trade-off between creditworthiness and profitability. (page 253)
8. Discuss the benefits of risk-based pricing of financial services. (page 254)

35. The Credit Transfer Markets—and their Implications

After completing this reading, you should be able to:

1. Discuss the flaws in the securitization of subprime mortgages prior to the financial crisis of 2007. (page 259)
2. Identify and explain the different techniques used to mitigate credit risk, and describe how some of these techniques are changing the bank credit function. (page 261)
3. Describe the originate-to-distribute model of credit risk transfer and discuss the two ways of managing a bank credit portfolio. (page 262)
4. Describe the different types and structures of credit derivatives including credit default swaps (CDS), first-to-default put, total return swaps (TRS), asset-backed credit-linked note (CLN), and their applications. (page 263)
5. Explain the credit risk securitization process and describe the structure of typical collateralized loan obligations (CLOs) or collateralized debt obligations (CDOs). (page 267)

6. Describe synthetic CDOs and single-tranche CDOs. (page 269)
7. Assess the rating of CDOs by rating agencies prior to the 2007 financial crisis. (page 269)

36. An Introduction to Securitization

After completing this reading, you should be able to:

1. Define securitization, describe the securitization process and explain the role of participants in the process. (page 275)
2. Explain the terms over-collateralization, first-loss piece, equity piece, and cash waterfall within the securitization process. (page 277)
3. Analyze the differences in the mechanics of issuing securitized products using a trust versus a special purpose vehicle (SPV) and distinguish between the three main SPV structures: amortizing, revolving, and master trust. (page 278)
4. Explain the reasons for and the benefits of undertaking securitization. (page 280)
5. Describe and assess the various types of credit enhancements. (page 281)
6. Explain the various performance analysis tools for securitized structures and identify the asset classes they are most applicable to. (page 282)
7. Define and calculate the delinquency ratio, default ratio, monthly payment rate (MPR), debt service coverage ratio (DSCR), the weighted average coupon (WAC), the weighted average maturity (WAM), and the weighted average life (WAL) for relevant securitized structures. (page 284)
8. Explain the prepayment forecasting methodologies and calculate the constant prepayment rate (CPR) and the Public Securities Association (PSA) rate. (page 287)
9. Explain the decline in demand in the new-issue securitized finance products market following the 2007 financial crisis. (page 289)

37. Understanding the Securitization of Subprime Mortgage Credit

After completing this reading, you should be able to:

1. Explain the subprime mortgage credit securitization process in the United States. (page 295)
2. Identify and describe key frictions in subprime mortgage securitization, and assess the relative contribution of each factor to the subprime mortgage problems. (page 295)
3. Describe the characteristics of the subprime mortgage market, including the creditworthiness of the typical borrower and the features and performance of a subprime loan. (page 298)
4. Describe the credit ratings process with respect to subprime mortgage backed securities. (page 299)
5. Explain the implications of credit ratings on the emergence of subprime related mortgage backed securities. (page 299)
6. Describe the relationship between the credit ratings cycle and the housing cycle. (page 299)
7. Explain the implications of the subprime mortgage meltdown on portfolio management. (page 300)
8. Compare predatory lending and borrowing. (page 333)

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

The Credit Decision

Topic 17

Exam Focus

This topic provides an overview of the credit analysis process. Credit risk can arise from multiple sources, including default, an increased probability of default, failure to perform on a prepaid obligation, more severe losses than forecasted resulting from greater exposure than expected, or smaller recoveries than expected given a default. For the exam, be able to compare and contrast the credit analysis process for consumers (i.e., individuals), nonfinancial firms, financial firms, and to a lesser degree sovereigns. Also, be able to distinguish between the probability of default (PD), the loss given default (LGD), the exposure at default (EAD), and the overall expected loss (EL). Understand that it is simple to measure these factors after the fact but difficult to forecast losses in advance. Finally, understand that outside of times of stress or crisis, banks rarely fail. Credit analysts must determine where a financial institution falls on a continuum between perfectly creditworthy and bankrupt.

Credit Risk

LO 17.1: Define credit risk and explain how it arises using examples.

Credit is an agreement where one party receives something of value and agrees to pay for the good or service at a later date. The word "credit" is derived from the ancient Latin word *credere,* which means "to believe" or "to entrust." The creditor must have knowledge of the borrower's character and reputation as well as his financial condition. Generally, there is not a definitive yes or no answer to whether a borrower can and will pay back a loan. As such, the lender must address the question of likelihood. The lender must assess the likelihood that the borrower will pay back the loan in accordance with the terms of the agreement.

Professor's Note: Borrower, obligor, counterparty, and issuer are all used to signify the party receiving credit. Lender, creditor, and obligee are primarily used to signify the party granting credit.

Credit risk is the probability that a borrower will not pay back a loan in accordance with the terms of the credit agreement. The risk can result from:

- Default on a financial obligation.
- An increased probability of default on a financial obligation.
- A more severe loss than expected due to a greater than expected exposure at the time of a default.
- A more severe loss than expected due to a lower than expected recovery at the time of a default.
- Default on payment for goods or services already rendered (i.e., settlement risk).

Credit risk arises in many personal and business contexts. In fact, nearly all businesses, except small firms that confine their businesses to "cash and carry" transactions (i.e., a good or service is exchanged simultaneously for cash), incur credit risk. Specific contexts in which credit risks arise include:

- A person or company performs a service and sends a bill for payment of the rendered service. For example, a car dealership fixes a person's car and then bills the customer, giving the customer 30 days to pay the bill in full without incurring financing charges.
- A party pays in advance for goods or services and awaits receipt of the goods or services (i.e., the settlement of a transaction). For example, a university pays in advance for computer training for its staff and faculty and then receives the training over the course of the following year.
- A person or company has provided a product and is awaiting payment for the item. **Trade credit** is an example of this type of transaction. The firm selling the product offers "terms of credit," allowing the purchaser a reasonable period of time to pay the invoice. Big-ticket items are almost exclusively sold on credit. For example, a chemistry firm buys several powerful microscopes from a supplier and is allowed to pay the full balance in 30 days.

There are two types of risks associated with these transactions. There is **settlement risk**, the risk that the counterparty will never pay for the good or service, and a more fundamental **financial obligation** that arises from the loan agreement. Credit risk that arises from trade credit is nearly indistinguishable from the credit risk that banks incur. Financial analysis must be performed in both cases to increase the likelihood that the borrower will fulfill the financial obligation. Banks cannot avoid credit risk; it is central to their business. There is no "cash and carry" model in banking. Banks accept money from depositors and other sources and lend the money to individuals and firms. Because banks cannot avoid credit risk, they must manage the risk through credit analysis and the use of risk mitigants such as collateral and loan guarantees.

Credit Risk Evaluation Components

LO 17.2: Explain the components of credit risk evaluation.

LO 17.3: Describe, compare and contrast various credit risk mitigants and their role in credit analysis.

The four primary components of credit risk evaluation are as follows.

1. **The borrower's (or obligor's) capacity and willingness to repay the loan.** Questions the lender must consider include:
   - What is the financial capacity to pay?
   - Is it likely the borrower can fulfill its financial obligations through the maturity of the loan?
   - Are there outside forces that affect the borrower's capacity and/or willingness to pay? For example, does the ownership structure of the firm, relationships within and outside the firm, and other obligations of the firm affect the borrower's ability to pay?
   - How does the business itself affect the borrower's capacity to pay? Are there credit risk characteristics tied to this particular industry or sector? Does the firm have a niche within the industry or sector?

2. **The external environment and its effect on the borrower's capacity and willingness to repay the borrowed funds.** Factors such as the business climate, country risk, and operating conditions are relevant to the lender. Are there cyclical changes that will affect the level of credit risk? Will political risks affect the likelihood of repayment?

3. **The characteristics of the credit instrument.** The credit instrument might be a bond issue, a bank loan, a loan from a finance company, trade credit, or other type of debt agreement/security. Concerns include:
   - Risk characteristics that are inherent in the credit instrument, including legal risks and obligations that are specific to the instrument.
   - The maturity (also called "tenor") of the instrument.
   - Is the debt secured or unsecured? Is there collateral backing the loan? Are there loan guarantors?
   - Is the debt subordinated or senior to other obligations? What is the priority assigned to the creditor?
   - How do loan/bond covenants increase or decrease the credit risk for each party? Can the borrower repay the loan early without penalty? Can the lender call the loan? Can the security be converted to another form (e.g., a convertible bond)?
   - What is the denominated currency of the obligation?
   - Are there any contingent risks?

4. **The quality and adequacy of risk mitigants such as collateral, credit enhancements, and loan guarantees.** Secured lending (i.e., using risk mitigants in the lending process) is generally the preferred method of lending. If there is collateral, a bank or other lender may not have to force a delinquent borrower into bankruptcy but may instead sell the collateral to satisfy the financial obligation. Secured lenders are also generally in a better position than unsecured lenders in the event of bankruptcy. The use of collateral not only mitigates losses in the event of default, but also lowers the probability of default because the obligee typically does not want to lose the collateral. Historically, banks have substituted collateral for analysis of the borrower's ability to pay. In some sense, the use of collateral eliminates the need for credit analysis, or at the very least makes the credit decision simpler. A lender can normally put a market value on collateral and determine if it is sufficient to cover potential losses. Three issues regarding risk mitigants include:
   - Is the collateral pledged to, or likely to be pledged to, another loan?
   - Has there been an estimation of the value of the collateral?
   - If there is a loan guarantor, has there been sufficient credit analysis of the third party's willingness and ability to pay in the event the borrower does not pay? A guarantor accepts liability for debt if the primary borrower defaults. The bank is able to substitute analysis of the guarantor's creditworthiness for that of the primary borrower. Typically, the guarantor has a greater ability to pay than the primary borrower (e.g., a parent guaranteeing a child's car loan or a parent company guaranteeing a loan to a subsidiary).

Qualitative and Quantitative Techniques

LO 17.4: Compare and contrast quantitative and qualitative techniques of credit risk evaluation.

The willingness to repay a loan is a subjective attribute. Lenders must make unverifiable judgments about the borrower. In some cases, intuition, or "gut feelings," are necessary to conclude whether a borrower is willing to repay a loan. As such, **qualitative credit analysis techniques** are largely used to evaluate the borrower's willingness to repay. Qualitative techniques include:

- **Gather information** from a variety of sources about the character and reputation of the potential borrower. Old-fashioned lending relied on first-hand knowledge of the people and businesses in a town. In this case, lenders knew (or thought they knew) potential borrowers. It is more difficult in the modern world, where lending decisions are centralized, to know customers personally.
- **Face-to-face meetings** with the potential borrower to assess the borrower's character are routine in evaluating willingness to pay.
- "**Name lending**" involves lending to an individual based on the perceived status of the individual in the business community. Some lenders substitute name lending for financial analysis.
- **Extrapolating past performance into the future.** Lenders often assume that a pattern of borrowing and repaying in the past (e.g., a credit record compiled from past history with the borrower and data garnered from credit bureaus) will continue in the future.

Historical lending norms relied on the *moral obligation* of borrowers who could pay to repay their debts. Thus, gauging the borrower's willingness to pay was a critical component of credit analysis. However, in modern society, the moral obligation to pay if one is capable of paying has been replaced by the legal obligation to pay. In other words, in terms of credit analysis, determining the capacity to pay is more important than determining the willingness to pay because the legal system will force those who can pay to honor their commitment. Courts can seize the assets of those who will not fulfill their financial obligations. In corrupt or ineffective states, a borrower will not suffer, even if able to pay but not doing so.

The willingness to pay is more important in countries with less-developed financial markets and legal systems. Creditors must evaluate the legal system and the strength of creditors' rights in emerging markets, along with the prospective borrower's ability and willingness to repay the obligation. This is a qualitative endeavor. **Sovereign risk ratings** may be used to evaluate the quality of a country's legal system and, by extension, the legal risk associated with the country or region. The lower the score, the greater the legal risk. For example, in 2010, Finland had a Rule of Law Index of 1.97, the United States had a rating of 1.58, Brazil had a rating of 0.0, and Somalia had a rating of –2.43. However, even in countries with robust legal systems such as Finland and the United States, the creditor must also consider the costs associated with taking legal action against a delinquent borrower. If costs are high, the creditor may be unwilling to take action regardless of the strength of the enforcement of creditor rights. As such, the willingness to pay should never be completely ignored in credit analysis.

The ability of a borrower to repay a loan is an objective attribute. **Quantitative credit analysis techniques** are largely used to evaluate the borrower's ability to repay. The primary quantitative technique used in financial analysis is examining the past, current, and forecasted financial statements of the prospective borrower. This forms the core of the quantitative credit analysis used to determine a borrower's capacity to meet its financial obligations. There are limitations associated with quantitative data, which include:

- **Historical nature of the data.** Financial data is typically historical and thus may not be up-to-date or representative of the future. Also, forecasted financial data is notoriously unreliable and susceptible to miscalculations and/or misrepresentations.
- **Difficult to make accurate projections using historical data.** Financial statements attempt to represent the economic reality of a firm in a highly abbreviated report. As such, some information is lost in translation that is critical to the loan decision. The rules guiding financial reporting are created by a diverse group with varying interests and are often decided by compromise. Also, firms are given discretion regarding what and how they report financial information, subject to established accounting rules. Firms may use the latitude in financial reporting to deceive interested parties. Even if the reports are accurate, financial data is subject to interpretation. There can be a range of conclusions drawn from the same data due to the variety of needs, perspectives, and experiences of the various analysts. This means there is a subjective, qualitative component to an objective, quantitative exercise.

Given the shortcomings of financial reporting, lenders should not ignore qualitative analysis. The quality of management, the motivation of the firm's management, and the incentives of management are relevant for both nonfinancial and financial firms. Even quantitative analysis is subject to interpretation. In fact, many would argue that financial analysis is much more of an art than a science. Judgment is as important as the quantitative analysis supporting it. The most effective analysis combines quantitative assessments with qualitative judgments.

Credit Analysis Comparison

LO 17.5: Compare the credit analysis of consumers, corporations, financial institutions, and sovereigns.

Four basic types of borrowers for which credit analysis must be performed are as follows:

1. **Consumers**—the analyst evaluates the creditworthiness of individuals.

2. **Corporations**—the analyst evaluates the creditworthiness of nonfinancial firms. Businesses are typically more difficult to analyze than individuals, although the process is similar.

3. **Financial institutions**—the analyst evaluates the creditworthiness of financial institutions, including banks and nonbank firms such as insurance companies and investment companies.

4. **Government or government-related entities (i.e., sovereigns)**—the analyst evaluates the creditworthiness of nations, government bodies, and municipalities. Non-state entities in specific locations or jurisdictions are also subject to analysis in the sovereign category.

There are similarities and differences in the approaches taken to analyze the creditworthiness of the various groups. Figure 1 details some specific aspects of each type of analysis.

Figure 1: Comparison of Borrowers

	Consumers	*Corporations*	*Financial Institutions*	*Sovereigns*
Capacity	Wealth (i.e., net worth), salary, or incoming cash per period, expenses per period, assets such as houses and cars, amount of debt (e.g., credit card debt), net cash available to service debt (i.e., cash flow minus household and mortgage expenses).	Liquidity, cash flow combined with earnings capacity and profitability, capital position (solvency), state of the economy, strength of the industry.	Similar to nonfinancial firms but bank specific. Liquidity (the bank's access to cash to meet obligations), capital position, historical performance including earnings capacity over time (and ability to withstand financial stress), asset quality (affects the bank's likelihood of being paid back and by extension the bank's lender's likelihood of being paid back), state of the economy, strength of the industry.	Financial factors including the country's external debt load and debt relative to the overall economy; tax receipts are important.
Willingness	Reputation of individual, payment history.	Quality of management, historical debt service.	Quality of management; qualitative analysis is even more important for financial firms than for nonfinancial firms.	Credit analysis for sovereigns is often more subjective than for financial and nonfinancial firms because the legal system and the enforcement of creditor rights is critical to the analysis. Sovereign legal risk ratings, as discussed previously, are often considered in the analysis.

Figure 1: Comparison of Borrowers (Cont.)

	Consumers	*Corporations*	*Financial Institutions*	*Sovereigns*
Methods of evaluation	Credit scoring models that consider income, duration of employment, and amount of debt for unsecured debt like credit cards. Credit scoring and some manual input and review for large exposures such as mortgage loans or automobile loans.	Detailed manual analysis including financial statement analysis, interviews with management. More complex than consumer analysis because companies are so diverse in terms of assets, cash flow, financial structure, etc.	Similar to nonfinancial firms.	Similar to financial and nonfinancial firms but with increased subjective analysis of the political environment.
Loan size/type	Large exposures are typically secured (e.g., mortgage loans). Smaller exposures are unsecured (e.g., credit card loans).	Typically larger exposures (sometimes considerably larger) than loans to consumers. Debt may be secured or unsecured.	Similar to nonfinancial firms (i.e., large).	Similar to nonfinancial and financial firms (i.e., large).

The two primary differences between nonfinancial firm credit analysis and financial firm credit analysis are (1) the importance of the quality of assets in financial firms and (2) cash flow as an indicator of capacity to repay for nonfinancial firms but not a key indicator of creditworthiness for financial firms. It is clear from the 2007–2009 financial crisis that asset quality is a key indicator of a bank's financial health. The ability to withstand financial stress is critical for a bank. That is why earnings capacity over time is a more relevant indicator of creditworthiness than cash flow. A bank must be able to withstand periods of financial stress/crisis in order to repay debts.

Professor's Note: Sovereign credit analysis is not explicitly discussed in this topic. However, in contrast to consumers and financial and nonfinancial firms, consider the political issues/concerns that would arise when lending to a foreign government. Even a financially healthy sovereign may be a risky loan candidate due to the legal system's strength (or lack thereof); a lack of legal protections for creditors and other factors might negatively affect the lender and the lender's rights. If you have to compare credit analysis across the four groups (i.e., consumers, nonfinancial firms, financial firms, and sovereigns), think about the differences between the groups and the various factors that explain and/or increase/decrease the lender's risk in each case.

Quantitative Measures

LO 17.6: Describe quantitative measurements and factors of credit risk, including probability of default, loss given default, exposure at default, expected loss, and time horizon.

Credit risk, the likelihood that a borrower will repay a loan according to the loan agreement, and default risk, the probability that a borrower will default, are essentially the

same because a default on a financial obligation almost always results in a loss to the lender. In the last decade, there have been significant changes in the financial sector. These changes, combined with regulatory changes in the industry, have resulted in a somewhat revised view of credit and default risks. Current measures used to evaluate creditworthiness are described as follows:

Probability of default (PD): The likelihood that a borrower will default is not necessarily the creditor's greatest concern. A borrower may briefly default and then quickly correct the situation by making a payment, paying interest charges or penalties for missed payments. Creditors must rely on other measures of risk in addition to PD.

Loss given default (LGD): LGD represents the likely percentage loss if the borrower defaults. The severity of a default is equally as important to the creditor as the likelihood that the default would occur in the first place. If the default is brief and the creditor suffers no loss as a result, it is less of a concern than if the default is permanent and the creditor suffers significant losses. Both PD and LGD are expressed as percentages.

Exposure at default (EAD): The loss exposure may be stated as a dollar amount (e.g., the loan balance outstanding). EAD can also be stated as a percentage of the nominal amount of the loan or the maximum amount available on a credit line.

Expected loss (EL): Expected loss for a given time horizon is calculated as the product of the PD, LGD, and EAD (i.e., PD × LGD × EAD).

Time horizon: The longer the time horizon (i.e., the longer the tenor of the loan), the greater the risk to the lender and the higher the probability of default. Also, EAD and LGD change with time. The exposure (EAD) increases as the borrower draws on a credit line and falls as the loan is paid down. The LGD can also change as the terms of the loan or credit line change.

Expected loss generally depends on four variables: PD, LGD, EAD, and time horizon. A bank should also consider the correlations between various risk exposures when analyzing credit risk in a portfolio context.

Example: Calculating expected loss

Star City Bank and Trust has examined its loan portfolio over the past year. It has determined that the probability of default was 4%, adjusted for the size of the exposure. The loss given default over the period was 80%. Bank risk managers estimate that the exposure at default was 75% of the potential exposure. **Calculate** the expected loss given a one-year time horizon.

Answer:

expected loss = 4% × 80% × 75% = 2.4%

Professor's Note: It is straightforward to calculate PD, LGD, and EAD after the fact. As the previous example illustrates, a lender can analyze historical occurrences of default, loss given default, and loss exposure. However, it is difficult to estimate these measures in advance. A financial institution or other nonbank lender can use historical experience to help predict future losses, but the forecast will not be perfect. Using historical mortgage loss data would have been little help in forecasting actual losses that occurred during the 2007–2009 financial crisis.

Failure vs. Insolvency

LO 17.7: Compare bank failure and bank insolvency.

Bank insolvency and bank failures are not identical. Banks become insolvent and are often merged into healthier institutions. It is more convenient and less expensive for the government to simply fold a troubled bank into a stronger bank than it is to close the bank. In fact, there is an assumption that bank failures are relatively common, but in reality, it rarely happens in non-crisis periods. Weak banks are merged with healthier banks, and the system avoids outright failures. This is especially true for large, international banks (i.e., banks that are "too big to fail"). In the United States, only 50 banks failed between 2001 and 2008, half of which failed in 2008. This equates to a rate of approximately 0.1% per year during the period. Following the financial crisis, approximately 2% of banks failed in both 2009 and 2010. An additional 1.2% of banks failed in 2011. Research indicates that bank failures are considerably less likely than nonfinancial firm failures.

In the last few years, beginning with the financial crisis in late 2007, many more large banks in Europe and the United States have suffered from financial stresses. However, it was clear during the crisis that some banks were considered too big to fail. In response, the Financial Stability Board (FSB) created a list of 29 "systemically important financial institutions" that are required to hold "additional loss absorption capacity tailored to the impact of their [possible] default." The concern is systemic risk that spreads to other institutions. There was substantial evidence of this occurrence during the financial crisis.

A bank can remain insolvent (without failing), so long as it has a source of liquidity. The Federal Reserve is one such source and acts as a "lender of last resort." A bank failure that results in significant losses to depositors and other creditors is quite rare, although as noted, the incidence increases in times of crisis, such as in 2007. For a credit analyst evaluating a financial institution, the expectation of an outright failure is unlikely. However, because banks are heavily leveraged, the risks cannot be ignored. The analyst must place the bank somewhere on the continuum between "pure creditworthiness" and bankrupt. At one end of the continuum are banks with AAA-rated debt, and at the other end are banks with default ratings. Thus, thinking about bank risk on a continuum is useful in defining the bank's credit risk.

Key Concepts

LO 17.1

Credit risk is the probability that a borrower will not pay back a loan in accordance with the terms of the credit agreement. Credit risk results when an individual or firm defaults on a financial obligation. It arises short of default when there is an increased probability of default on a financial obligation. A more severe loss than expected due to a greater than expected exposure at the time of a default or a more severe loss than expected due to a lower than expected recovery at the time of a default are also components of credit risk. Finally, credit risk can arise from a default on a payment for goods or services that are already rendered (i.e., settlement risk).

LO 17.2

There are four primary components of credit risk evaluation: (1) the borrower's (obligor's) willingness and capacity to repay the loan, (2) the effect of external conditions on the borrower's ability to repay the loan, (3) the inherent characteristics of the credit instrument and the extent to which the characteristics affect the borrower's willingness and ability to perform the obligation, and (4) the quality and adequacy of risk mitigants such as collateral and loan guarantees.

LO 17.3

If collateral is used as a credit risk mitigant, a bank or other lender may not have to force a delinquent borrower into bankruptcy but may instead sell the collateral to satisfy the financial obligation. If a loan guarantor is used as a credit risk mitigant, the guarantor accepts liability for debt if the primary borrower defaults. Typically, the guarantor has a greater ability to pay than the primary borrower.

LO 17.4

Qualitative techniques are used primarily to assess the borrower's willingness to repay the loan. Quantitative techniques are used primarily to assess the borrower's ability to repay the loan. Gathering information from a variety of sources about the character and reputation of the potential borrower, face-to-face interviews with potential borrowers, and using past loan payment information to draw conclusions about a borrower's willingness to pay in the future are all qualitative techniques. Analyzing the borrower's recent and past financial statements is the primary quantitative method used in credit analysis.

LO 17.5

There are key differences between the analysis of the creditworthiness of consumers, versus that of nonfinancial and financial firms. Individual factors such as a person's net worth, salary, assets, reputation, and credit score are used to evaluate individuals. It is more complex to evaluate firms. Liquidity, cash flow combined with earnings capacity and profitability, capital position (solvency), state of the economy, and strength of the industry are used to evaluate nonfinancial firms. Similar data is used for financial firms in addition to bank-specific measures such as capital adequacy, asset quality, and the bank's ability to withstand financial stress. Detailed manual analyses, including financial statement analysis and interviews with management, are used to analyze the creditworthiness of both nonfinancial and financial firms.

LO 17.6

Current measures used to evaluate credit risk are:

- The probability of default (PD), which is the likelihood that a borrower will default.
- The loss given default (LGD), which represents the likely percentage loss if the borrower does default.
- Exposure at default (EAD), which can be stated as a dollar amount (e.g., the loan balance outstanding) or as a percentage of the nominal amount of the loan or the maximum amount available on a credit line.
- Expected loss (EL), which is, for a given time horizon, calculated as the product of the PD, LGD, and EAD (i.e., PD × LGD × EAD).
- Time horizon or tenor of the loan. The longer the time horizon, the greater the risk to the lender.

LO 17.7

Bank insolvency and bank failure are not one in the same. A bank may be insolvent but avoid failure so long as liquidity is available. Also, many insolvent banks are merged with financially sound banks, avoiding outright failure. For the credit analyst, the fact that failure of financial institutions is rare makes analysis easier. However, banks are highly leveraged, placing the bank somewhere on the continuum between fully creditworthy and insolvent.

Concept Checkers

1. Blackstone Credit, Inc., made a loan to a small start-up firm. The firm grew rapidly, and it appeared that Blackstone had made a good credit decision. However, the firm grew too fast and could not sustain the growth. It eventually failed. Blackstone had initially estimated its exposure at default to be $1,200,000. Because of the firm's rapid growth and resulting increases in the line of credit, Blackstone ultimately lost $1,550,000. In terms of credit risk, this is an example of:
   A. default on payment for goods or services already rendered.
   B. a more severe loss than expected due to a ratings downgrade by a rating agency.
   C. a more severe loss than expected due to a greater than expected exposure at the time of a default.
   D. a more severe loss than expected due to a lower than expected recovery at the time of a default.

2. Brent Gulick, a credit analyst with Home Town Bank, is considering the loan application of a small, local car dealership. The dealership has been solely owned by Bob Justice for more than 20 years and sells three brands of American automobiles. Because of the rural location, most of the cars sold in the past by the dealership have been large pick-up trucks and sports utility vehicles. However, sales have declined, and gasoline prices have continued to increase. As a result, Justice is considering selling a line of hybrid cars. Justice has borrowed from Home Town Bank before but currently does not have a balance outstanding with the bank. Which of the following statements is not one of the four components of credit analysis Gulick should be evaluating when performing the credit analysis for this potential loan?
   A. The business environment, competition, and economic climate in the region.
   B. Justice's character and past payment history with the bank.
   C. The car dealership's balance sheets and income statements for the last few years as well as Justice's personal financial situation.
   D. The financial health of Justice's friends and family who could be called upon to guarantee the loan.

3. Sarah Garrison is a newly hired loan officer at Lexington Bank and Trust. Her boss told her she needs to make five commercial loans this month to meet her sales goal. Garrison talks to friends and hears about a local businessperson with a great reputation. Everyone in town says John Johnson is someone you want to meet. Garrison sets up a meeting with Johnson and is immediately impressed with his business sense. They discuss a loan for a new venture Johnson is considering, and Garrison agrees that it is a great idea. She takes the loan application back to the bank and convinces the chair of the loan committee that Lexington Bank and Trust is lucky to be able to do business with someone with Johnson's reputation. This is an example of:
   A. historical analysis technique.
   B. qualitative analysis technique.
   C. quantitative analysis technique.
   D. extrapolation analysis technique.

4. Stacy Smith is trying to forecast the potential loss on a loan her firm made to a mid-size corporate borrower. She determines that there will be a 75% loss if the borrower does not perform the financial obligation. This is the:
   A. probability of default.
   B. loss given default.
   C. expected loss.
   D. exposure at default.

5. Bank of the Plain States has been struggling with poor asset quality for some time. The bank lends primarily to large farming operations that have struggled in recent years due to a glut of soybeans and corn on the market. Bank regulators have recently required that the bank write off some of these loans, which has entirely wiped out the capital of the bank. However, the bank still has some liquidity sources it can use, including a correspondent bank and the Federal Reserve. Bank of the Plain States is:
   A. an insolvent but not failed bank.
   B. both a failed bank and an insolvent bank.
   C. neither a failed bank nor an insolvent bank.
   D. a failed bank but not an insolvent bank.

Concept Checker Answers

1. C Blackstone lost more than expected due to greater exposure at the time of default than initially estimated. The borrowing firm was a small start-up, so it was not likely rated. There were no goods or services rendered in this case. In addition, there is no mention of recovery. This is also an example of credit risk arising from default on a financial obligation.

2. D There are four primary components of credit risk evaluation: (1) the borrower's (obligor's) willingness and capacity to repay the loan, (2) the effect of external conditions on the borrower's ability to repay the loan, (3) the inherent characteristics of the credit instrument and the extent to which the characteristics affect the borrower's willingness and ability to repay the loan, and (4) the quality and adequacy of risk mitigants such as collateral and loan guarantees. In this case, the local business environment, Justice's character, his payment history, and the business's financial positions are all relevant. While risk mitigants such as collateral and loan guarantees are part of credit analysis, it is unlikely that a local car dealer who has been in business for 20 years would be seeking a loan guarantee from a friend or family member. In addition, even if Justice were looking at a potential loan guarantor, Gulick would not simply evaluate his "friends and family" but would evaluate the specific person or business that intended to guarantee the loan.

3. B Name lending is a qualitative technique that is sometimes used to take the place of financial analysis. It is a technique used to evaluate the borrower's willingness to repay a financial obligation.

4. B Current measures used to evaluate credit risk include the firm's probability of default, which is the likelihood that a borrower will default; the loss given default, which represents the likely percentage loss if the borrower does default; the exposure at default; and the expected loss, which is, for a given time horizon, calculated as the product of the PD, LGD, and EAD. The stated 75% loss if the borrower defaults is the loss given default or LGD.

5. A Bank of the Plain States is insolvent because capital is wiped out. However, the bank has not failed because it is still operating with liquidity from the correspondent bank and the Federal Reserve. Therefore, the bank is insolvent but not failed.

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

The Credit Analyst

Topic 18

Exam Focus

This topic focuses on the role and tasks performed by a banking credit analyst. For the exam, understand the objectives of the analyst (e.g., risk management, investment selection) as well as the difference between primary and secondary research. In addition, know the quantitative and qualitative skills that an analyst must possess in order to be successful. Finally, be able to recognize and describe the key information sources used by credit analysts such as the annual report, auditor's report, and company financial statements.

Credit Analyst Roles

LO 18.1: Describe, compare, and contrast various credit analyst roles.

There are several methods to describe, compare, and contrast the various credit analyst roles, including:

- Job descriptions (e.g., consumer credit analyst, credit modeling analyst, corporate credit analyst, counterparty credit analyst, credit analysts at rating agencies, sell-side/buy-side fixed-income analysts, bank examiners and supervisors).
- Functional objective (e.g., risk management vs. investment selection, primary vs. secondary research).
- Type of entity analyzed (e.g., consumer, corporate, financial institution, sovereign/municipal).
- Classification by employer (e.g., banks and other financial institutions, institutional investors, rating agencies, government agencies).

Job Description

Brief descriptions of typical analyst roles provide a general understanding and an appreciation for the wide range of available roles.

Consumer Credit Analyst

- An administrative role with little opportunity for detailed analysis, data entry duties for loans that are then scored electronically (i.e., the relative score will determine status as approved or declined).
- Primarily works with individual consumer mortgages, with a key objective that all documentation is in place for approved loans.
- Large dollar loans referred by analyst to more senior personnel.

Credit Modeling Analyst

- A more quantitative role focused on the electronic scoring system described previously; some interaction with risk management personnel.
- Developing, testing, implementing, and updating various consumer credit scoring systems.

Corporate Credit Analyst

- Scope of analysis is limited to corporations (i.e., no financial institutions or sovereign credits).
- Some duties developing credit risk models may be required.

Counterparty Credit Analyst

- Analyzes typical counterparties (i.e., banks, nonbanks—brokers, insurance companies, hedge funds); usually employed by a financial institution to analyze other institutions with which it contemplates a two-way transaction.
- Performs credit reviews, approves limits, and develops/updates credit policies and procedures.
- Review process is often detailed requiring the following: (1) capital structure analysis (i.e., debt, equity), (2) financial statement analysis, (3) qualitative analysis of counterparty, and (4) qualitative analysis of the operating sector of counterparty.
- Finally, an internal rating is assigned and the analyst may also be required to comment on any of the following: (1) recommended limits to set on certain credit risk exposures, (2) approval or denial of a given credit application, and (3) recommended changes to the amounts, tenor, collateral, or other provisions of the transaction.

Credit Analysts at Rating Agencies

- Provide unbiased external ratings on bonds and other debt instruments issued by financial institutions, corporations, and governments.

Sell-Side and Buy-Side Fixed-Income Analysts

- Employed by financial institutions or hedge funds.
- In addition to credit risk, there is a focus on the relative value of debt instruments and their attractiveness as investments.

Bank Examiners and Supervisors

- Assessing the financial stability of financial institutions within a supervisory (risk management) role.

Functional Objective

Most credit analysts are employed to evaluate credit risk as part of an entity's overall risk management function. At the same time, others are employed for security selection and investment opportunity purposes. In terms of the amount and nature of work performed by analysts, there is a distinction between performing primary research versus secondary research.

Risk Management

Credit risk management is the most common functional objective, and it occurs in both the private and public sector. Credit risk analysts in the public sector will perform research on potential counterparties. The output of the research typically consists of internal use credit reports on the counterparties as well as recommendations as to which deals to accept and the appropriate risk limits. Bank examiners operate in the public sector in a regulatory capacity by reviewing the credit risk of certain financial institutions. Within that role, two key risk management objectives for the financial system are to ensure it is robust and to promote depth and liquidity.

Investment Selection

Investment selection is a much less common functional objective. Generally, credit analysts examine fixed-income securities with a focus on the risk of default. Specifically, an analyst must assess the likelihood of a given investment deteriorating in credit quality, thereby increasing credit risk and resulting in a decline in value. Additionally, a fixed-income analyst must also focus on the relative value of the investment. Relative value refers to the attractiveness of a given debt security compared to similar securities (e.g., other debt issues with the same asset class or same rating).

Rating Agency

The work of rating agency analysts is used for both risk management and investment selection purposes. The analysts examine issuers, counterparties, and debt in generally the same manner as credit risk analysts in the public sector.

Primary Research

Primary research refers to analyst-driven credit research or fundamental credit analysis. This is usually detailed (and often time-consuming) research with human effort that is both quantitative and qualitative in nature. The analysis looks at microeconomic factors (specific to the entity) and macroeconomic factors (e.g., political, industry). Rating agency analysts provide value by performing detailed credit analysis and arriving at independent conclusions, all of which is subsequently relied upon by other analysts. One of the disadvantages of primary research is its high cost; as a result, some financial institutions have an automated credit scoring system for simpler and less expensive transactions.

Secondary Research

It is often difficult for the credit analyst to perform detailed first-hand analysis (e.g., in-person visits), especially if the counterparty is very large or is located in a foreign country. An alternative is to perform secondary research, which involves researching the ratings provided by other rating agency analysts. Such information is combined with other relevant information sources, current information about the counterparty, and the analyst's own research, to conclude the counterparty's credit risk assessment. Given the reliance on other research, secondary research reports tend to be much shorter than primary research reports.

The goal of using secondary research is for a financial institution to perform counterparty credit analysis in a quick and efficient manner while maintaining reliability.

Type of Entity Analyzed

Corporate Credit Analyst

This role focuses on analyzing firms that are not financial institutions, notable examples being manufacturing firms or service providers. The purpose of the analysis is to assess the level of the firm's credit risk. That assessment is then used in deciding whether or not an entity would conduct business with, lend money to, or purchase securities of the other firm. In general, such analysis is very specialized based on the industry as well as focused on specific transactions.

Although the basic analytical principles are the same, there is huge diversity in the sectors, products, size, and geographic locations of the firms being analyzed. As a result, the corporate credit analyst must possess specific industry knowledge in order to be effective. An analyst will generally focus on only one or two industries, especially among fixed-income and rating agency analysts (given their need to perform detailed primary research).

Common sectors analyzed include the following: (1) real estate, (2) chemicals, (3) energy, (4) utilities, (5) telecommunications, (6) natural resources, (7) paper and forest products, and (8) automotive.

Another point of consideration is the size of the firm being analyzed. With a large public company, there may be a lot of public information available that would only necessitate secondary research, thereby reducing costs. With a smaller private company, less information is likely available, and as a result, more due diligence and primary research would be required, thereby increasing costs.

Finally, cash flow analysis is key to assessing corporate credit risk, so corporate analysts must also be equipped with strong accounting and financial statement analysis skills.

Bank and Financial Institution Credit Analyst

Counterparty credit analysts are employed by banks and other financial institutions and focus on analyzing the creditworthiness of other banks and other financial institutions. Compared to corporate credit analysis, the objective is not to make a lending decision but to determine whether the entity being analyzed is sufficiently creditworthy to function as a counterparty in future two-way transactions, with the entity requesting the analysis. Counterparty analysts could also establish exposure limits or decide whether to transact with the potential counterparty.

Both the nature of the financial instrument(s) and the length of time (tenor) of proposed contracts have a direct impact on the potential losses, and, as a result, have a direct impact on the type of analysis to be performed. Common financial instruments involved in counterparty transactions include (1) unsecured debt through the interbank market, (2) repurchase (repo) or reverse repurchase (reverse repo) transactions, (3) receivables factoring, (4) foreign exchange, and (5) derivatives.

Sovereign/Municipal Credit Analyst

Sovereign credit analysts determine the risk of default by foreign governments on borrowed funds. Primarily, sovereign credit analysts need to consider macroeconomic indicators in determining a government's ability to repay its debts. Additionally, political risk is an important consideration; the analyst attempts to gauge political stability and its impact on the ability to repay. Sovereign credit analysts examine the risks involved with specific international transactions or transactions with specific countries, provinces, states, or cities.

The stability of a given country's banking system strongly correlates with the ability of a country's government to repay foreign debt. The correlation also means that a government's financial stability impacts its banking system. Therefore, when analyzing the credit risk of foreign banks, analysts must place a lot of emphasis on sovereign risk. The obvious component of sovereign risk would include an analysis of the foreign country's debt-issuing ability in addition to the securities already issued. Another component would include an analysis of the impact of the country's general operating environment on its banking environment.

Classification by Employer

Banks, Nonbank Financial Institutions, and Institutional Investors

Credit analysts are most frequently employed by banks. Amongst all three groups, credit analysts usually function either within a risk management or an investment selection role.

Rating Agencies

Credit analysts employed by rating agencies analyze banks, corporations, and governments to determine their creditworthiness. Analysis includes the following steps:

Step 1: A general analysis of the credit risk of the entity.
Step 2: An analysis of issued securities and their impact on credit risk.
Step 3: An overall rating recommendation for the entity (communicated through rating symbols that are widely recognized and understood).

The information provided by the rating agencies is used by investors and risk personnel in making decisions regarding lending amounts, lending rates, and investment amounts.

Government Agencies

A typical role is a regulatory one, whereby the credit analyst analyzes a bank or insurance company to determine its level of risk, financial stability, and whether it meets the regulatory requirements to continue operating. A lesser-known role is when the government acts as an investor or lender, whereby the credit analyst has similar functions (i.e., investment selection or a risk management focus) to its counterparts in other organizations.

Rating Advisor

This is a unique role most frequently found in investment banks. The rating advisor has likely been a rating agency analyst and is now working to help a debt issuer obtain the highest rating possible. The rating advisor would perform an independent credit analysis of the issuer to arrive at a likely rating. The advisor would then provide advice to the issuer on how to mitigate any issues and respond to rating agency questions.

Banking Credit Analyst Tasks

LO 18.2: Describe common tasks performed by a banking credit analyst.

There are three main types of banking credit analysts: (1) counterparty credit analyst, (2) fixed-income analyst, and (3) equity analyst. Common tasks for each type of analyst are described in the following.

Counterparty credit analysts perform risk evaluations (reports) for a given entity. The triggering event to perform such evaluations may be an annual review of the entity or an intent to engage in an upcoming transaction with that entity. The tasks might be limited to simply covering certain counterparties or even only certain transactions or might be expanded to include decision making, recommendations on credit limits, and presenting to the credit committee.

Should the duties extend into the decision-making process, responsibilities would include the following: (1) authorizing the allocation of credit limits, (2) approving credit risk mitigants (i.e., guarantees, collateral), (3) approving excesses or exceptions over established credit limits, and (4) liaising with the legal department regarding transaction documentation.

Some analysts may be required to review and propose amendments to the bank's existing credit policies. With the implementation of the extensive regulatory requirements of Basel II and Basel III, credit analysts are now responsible for a wider range of regulatory compliance tasks.

Finally, counterparty credit analysts must understand the risks inherent with specific financial products and transactions. Therefore, it is necessary to obtain knowledge of the bank's products to supplement their credit decisions.

In an effort to make profits for the entity, **fixed-income analysts** provide recommendations regarding the decision to buy, sell, or hold debt securities. Therefore, they must ascertain the relative value to determine whether the security is undervalued, overvalued, or correctly valued. Both fundamental and technical analyses are generally performed in arriving at investment decisions. Fundamental analysis focuses on default risk while technical analysis focuses on market timing and pricing patterns. In making an investment decision, fixed-income analysts consider the ratings for specific debt securities issued by the rating agencies. The ratings provide reliable input in computing the relative value of securities.

Equity analysts analyze publicly traded financial institutions to help in determining whether an investor should buy, sell, or hold the shares of a given financial institution. When performing valuations, there is an emphasis on using return on equity (ROE). ROE takes into account both profitability and leverage. Other types of analysts would look at a wider range of financial ratios dealing with a bank's asset quality, capital strength, and liquidity. Equity analysts usually perform company valuations based on unaudited projections (while other analysts usually use audited historical data). Similar to fixed-income analysts, there are two general approaches to equity analysis. Analysts could choose to perform fundamental analysis, technical analysis, or a combination of the two.

Banking Credit Analyst Skills

LO 18.3: Describe the quantitative, qualitative, and research skills a banking credit analyst is expected to have.

Quantitative skills are necessary to assist in determining the ability of the entity to repay debt. A banking credit analyst must be able to read and interpret financial statements in order to perform a wide range of ratio analysis. The ratios to be analyzed depend on which measures of financial performance are relevant (i.e., liquidity, solvency, profitability). For example, return on equity (ROE) is a commonly used measure because it considers efficiency and leverage in addition to profitability. Because of the standardized nature of financial performance measures, peer analysis (i.e., comparison with similar banks and financial institutions) is possible and can be used to compare financial results.

Analysts must also understand statistical concepts (e.g., sampling, confidence intervals, correlation) in order to properly interpret data to arrive at reasonable conclusions under uncertainty. An example of a statistical analytical tool would be trend analysis (comparison of current year performance to past performance). The ability to analyze asset quality is also important. For example, a banking credit analyst could quantitatively assess a bank's loan portfolio by computing nonperforming loan ratios. Finally, analysts should have an understanding of monetary policy and an ability to compute and interpret macroeconomic data (e.g., GDP growth rates), both of which impact the general banking industry.

Qualitative skills are necessary to assist in determining the willingness of the entity to repay debt (e.g., reputation, repayment track record). It is critical for analysts to think beyond numbers and apply considerable judgment, reasoning, and experience in determining which factors are relevant for making decisions (e.g., management competence, bank's credit culture, and the robustness of credit review process).

The ability to analyze the quality, reliability, and consistency of reported earnings is also necessary. In addition, an understanding of the regulatory environment of banks and the impact(s) of any regulatory changes is important (e.g., central bank given more authority to regulate banks).

An analyst should have basic **research skills** in order to analyze an unfamiliar banking sector. Some preliminary research on overall sector structure, sector characteristics, and nature of regulation should be performed first. Then a reasonably detailed review of the largest banks followed by smaller banks may be performed. Examining larger banks first provides a basis of comparison when subsequently looking at smaller banks. After gaining a

thorough understanding of the banking sector, a bigger-picture perspective might be taken. For example, an analyst might try to research the country's entire banking sector, making note of the dominant entities and their impact on the sector.

A rating agency analyst would most frequently utilize **primary** research skills while a counterparty credit analyst would most frequently utilize **secondary** research skills.

Primary research skills include detailed analysis of (audited) financial statements for several years together with annual reports and recent interim financial statements. In addition, the rating analyst would usually need to make one or more due diligence visits to the bank to meet with senior management to discuss operational and business strategy. In addition to the visit, a questionnaire may also be provided to management to complete and return to the analyst.

Secondary research skills involve using the research published by others (e.g., rating agencies). The counterparty credit analyst would not make frequent visits to banks. Any site visits would tend to be brief and focused on very specific areas.

Information Sources

LO 18.4: Assess the quality of various sources of information used by a credit analyst.

Annual Report

Although there is likely bias on the part of management to present the entity in the most favorable way, the annual report does contain some useful information about culture, strategy, company performance, and economic outlook in the Management Discussion and Analysis (MD&A). Other information pertaining to regulation, such as changes to accounting or banking rules, may also be present in the annual report.

Auditor's Report

The auditor of a bank's financial statements is usually a major international accounting firm, and the staff on the audit engagement would possess specialized knowledge of the accounting rules pertaining to banks in order to successfully audit the bank in question.

The auditor provides an independent opinion on the bank's financial statements. If an **unqualified opinion** (or clean opinion) is provided, then it means that the auditor accepts the financial statements prepared by management as meeting the minimum standards of presentation (i.e., no material misstatements). The opinion assumes that management has provided the auditors with accurate information. Because of the cost-benefit tradeoff of analyzing every single item, auditors utilize a sampling approach and/or focus on high-risk areas during the testing phase. As a result, the financial statements may not be perfect or 100% accurate, but they present a reasonable indication of the financial performance for the stated period (income statement) and financial condition at a given point in time (balance sheet). In addition, it is not the auditor's responsibility to detect fraud committed by the

audited bank. It is up to the analyst to verify that an unqualified opinion has been issued and to watch for any exceptions from the standard wording of an unqualified opinion.

Analysts should be cautious when a qualified opinion is issued. With a qualified opinion, the auditors are saying that the financial statements might not fairly represent the company's financial performance and condition. The wording will be clear in the final paragraph of the report, with the existence of the word *except*. Common reasons for a qualified opinion include (1) substantial doubt as to the bank's ability to continue as a going concern, (2) a specific accounting treatment used by management is inconsistent with accounting rules, and (3) significant amounts of related-party transactions. It is up to the analyst to investigate and determine the exact nature of the qualification, its severity, and its impact on the analyst's overall assessment.

Rarely will the auditors issue an **adverse opinion** where they state that the financial statements do not fairly present the bank's financial performance and condition.

Sometimes there will be a change in auditors, and it is up to the analyst to inquire and determine if the change was valid. For example, sometimes management will dismiss its auditors because of a disagreement over one or more accounting treatments or the auditor's unwillingness to provide an unqualified opinion. The analyst should generally look upon those situations unfavorably. Alternatively, it is sometimes mandatory in some countries for a change in auditors every few years because they may have developed a comfortable relationship with the audited entity, preventing them from demonstrating independence and objectivity. In such a situation, the change in auditors is valid.

Financial Statements—Annual and Interim

The financial statements generally consist of the (1) balance sheet, (2) income statement, and (3) statement of cash flows. The balance sheet documents the net worth of the bank at a given point in time (e.g., year-end), and the income statement provides a quantification of performance over the period (e.g., net income for the year). The statement of cash flows is very useful for analyzing nonfinancial entities but not useful for bank credit analysis. An additional item, the statement of changes in capital funds, is useful for bank credit analysis (and regulatory purposes) because it explains changes in capital levels.

Supplementary footnotes to the financial statements may be included that provide more detail on specific items (e.g., off-balance sheet items such as leases and accounting policies).

Interim financial statements may be issued quarterly or semiannually, and they provide more timely financial information that would be useful to an analyst in making a current assessment of the bank.

Bank's Website

On the bank's website, the analyst is often able to find valuable information such as the annual report, financial statements, press releases, and background information. The quality, layout, and ease of accessibility of the website itself are often good indications of the stability of the bank.

News, the Internet, Securities Pricing Data

The analyst should check for any significant subsequent events (e.g., mergers, acquisitions, or new regulations) occurring after the corporate year-end that might not be covered in the annual report.

Proprietary electronic data services such as Bloomberg or a simple web search may provide necessary data on current bond and equity prices (especially for public listings or debt offerings).

Prospectuses and Regulatory Filings

Prospectuses and regulatory filings tend to minimize the discussion of the benefits of the investment and emphasize more of the potential risks so they could provide some useful information. Notably, prospectuses for equity and international debt issues may provide an effective resource.

Rating Agency Reports and Other Third-Party Research

As stated previously, counterparty credit analysts will find the rating agency reports most useful for their analysis. Other third party research includes investment reports from regulatory agencies and equity analysts.

Key Concepts

LO 18.1

Common credit analyst roles include consumer credit, credit modeling, corporate credit, counterparty credit, rating agency, fixed income, and bank examiner/supervisor. The roles are generally risk management in nature, although the fixed-income credit analyst focuses on investment selection. Primary and/or secondary research methods may be applied, and analysts could be analyzing nonfinancial entities, financial institutions, or sovereigns. Credit analysts are generally employed by banks, nonbank financial institutions, institutional investors, rating agencies, or government agencies.

LO 18.2

A counterparty credit analyst may perform risk evaluations of a given entity on a transaction-by-transaction basis or through an annual review. At times, the duties may extend into decision making (e.g., authorizing credit limits, suggesting guarantees and collateral, authorizing excesses). Additionally, there may be duties related to examining and amending the bank's existing credit policies and compliance tasks related to Basel II and III.

Fixed-income and equity analysts provide recommendations whether to buy, sell, or hold securities. Both types of analysts use fundamental and/or technical analysis techniques. Fixed-income analysts focus on determining relative value while equity analysts focus on determining return on equity.

LO 18.3

As a fundamental skill, banking credit analysts should be able to read and interpret financial statements in order to perform ratio analysis. They should also have a reasonable background in statistical concepts, in order to properly process and analyze data, and in macroeconomics, in order to understand the given bank's performance within the context of the overall economic environment. Additionally, significant judgment and skill in choosing relevant information to analyze is required in order to capture the important qualitative elements of any analysis.

LO 18.4

The annual report, auditor's report, financial statements (annual and interim), bank's website, internet, rating agency reports, other third-party research, prospectuses, and regulatory filings are some of the many available sources of information that may be used by a credit analyst. The annual report, together with financial statements, is the usual starting point for the analyst. For example, a counterparty credit analyst will rely heavily on rating agency reports.

Concept Checkers

1. Richard Marshall, FRM, is a rating agency analyst who is currently performing financial statement analysis on a major bank. Which of the following financial statements would be least useful for bank credit analysis?
   A. Balance sheet.
   B. Income statement.
   C. Statement of cash flows.
   D. Statement of changes in capital funds.

2. Krista Skujins, FRM, is a bank credit analyst who is examining the financial statements of a bank. She notices that there is a paragraph noted in the auditor's report that states that although the auditors agreed with virtually all of the bank's accounting treatments of the financial statement items, the auditors did not agree with the bank's decision to treat some of the leases as operating leases instead of capital leases. Based on that information, which of the following audit report opinions has the auditor most likely issued?
   A. Adverse opinion.
   B. Denial of opinion.
   C. Qualified opinion.
   D. Unqualified opinion.

3. Which of the following statements regarding a banking credit analyst's skills is most likely correct?
   A. High earnings quality suggests that the bank is profitable.
   B. Peer analysis is facilitated by the standardized nature of financial performance measures.
   C. Although qualitative analytical skills are required, quantitative analytical skills are more important.
   D. In analyzing an unfamiliar banking sector, an analyst should start by performing detailed reviews of the major banks.

4. Which of the following types of credit analysts would most likely be performing fundamental and/or technical analysis on a day-to-day basis?
   A. Equity analyst only.
   B. Fixed-income analyst only.
   C. Counterparty analyst and equity analyst.
   D. Equity analyst and fixed-income analyst.

5. Which of the following statements regarding the role of a corporate credit analyst is most likely correct?
   A. Earnings analysis is by far the most important analyst task.
   B. The larger the size of the firm, the lower the cost of analysis.
   C. Analysts are generally required to cover multiple industry areas given the huge diversity among corporations.
   D. The smaller the firm, the lower the cost of analysis.

Concept Checker Answers

1. C Although the statement of cash flows is most useful for analyzing nonfinancial entities (uses of cash and sources of cash differentiated between operating, investing, and financing), it is not useful for bank credit analysis.

2. C This situation is one where a specific accounting treatment used by the bank's management is inconsistent with the accounting rules. It is an isolated instance and so a qualified opinion would most likely be issued.

3. B Peer analysis refers to the comparison (financial and creditworthiness) of a subject bank to similar banks and financial institutions.

   High earnings quality does not necessarily mean a bank is profitable. Earnings quality refers to the reliability and consistency of the reported earnings.

   Quantitative and qualitative analytical skills are equally important and serve different (but related) purposes; qualitative skills are necessary to assist in determining the *willingness* of an entity to repay debt while quantitative skills are necessary to assist in determining the *ability* of an entity to repay debt.

   In analyzing an unfamiliar banking sector, the analyst should start with preliminary research on the overall structure, characteristics, and nature of regulation. After that, a detailed review of the largest (followed by smaller) banks could be performed.

4. D Both fixed-income analysis and equity analysis can be divided into two broad approaches: fundamental and technical analysis. Those approaches are valid because both types of analysts have the objective to earn profits for their respective employers and/or clients. In contrast, counterparty credit analysts are not likely to use either approach and are more focused on performing risk evaluations and possibly making some decisions on granting credit.

5. B With a large public company, there may be a lot of publicly available information that would only necessitate secondary research, thereby reducing costs. With a smaller private company, less information is likely available, and, as a result, more due diligence and primary research would be required, thereby increasing costs.

   Although the basic analytical principles are the same, there is huge diversity in the business sectors, products, size, and geographic locations of the firms being analyzed. As a result, the corporate credit analyst must possess specific industry knowledge in order to be effective. An analyst will most likely focus on only one or two industry areas.

   Corporate credit analysts specifically analyze firms that are NOT financial institutions.

   Cash flow analysis, not earnings analysis, is key to assessing corporate credit risk.

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

Classifications and Key Concepts of Credit Risk

Topic 19

Exam Focus

In this topic, we look at the various classifications of credit risk, how to measure individual and portfolio credit risks, and how to apply risk-adjusted pricing when making credit decisions. For the exam, be able to distinguish between default-mode valuations (default, recovery, and exposure risks) and value-based valuations (migration, spread, and liquidity risks). Also, understand the differences between expected and unexpected losses, since they have materially different implications on risk expectations and measurement. Value at risk (VaR), marginal VaR, and concentration risks are important measures of unexpected losses. Finally, understand risk-adjusted pricing, and be ready to interpret and calculate risk-adjusted return on risk-adjusted capital.

The Role of Credit Ratings

LO 19.1: Describe the role of ratings in credit risk management.

Credit ratings measure a borrower's creditworthiness. They are critical in ensuring that (1) borrowers can access capital markets, (2) the various risks of value creation are appropriately managed, and (3) the economic performance of business units can be compared.

Classifications of Credit Risk

LO 19.2: Describe classifications of credit risk and their correlation with other financial risks.

The concept of **credit risk** encompasses a range of risk measures. Those relating to *default* include default risk, recovery risk, and exposure risk. Those relating to *valuation* include migration risk, spread risk, and liquidity risk. Additional measures include concentration risk and the correlation with pure financial risks (e.g., interest rate, exchange rate, and inflation risks).

Default risk, or counterparty risk, relates to a borrower's inability to make promised payments. **Recovery risk** is the risk that the recovered amount, in the event of default, is less than the full amount that is due. **Exposure risk** measures the risk that a credit exposure at the time of default increases relative to its current exposure.

Migration risk looks at the risk that the credit quality and market value of an asset or position could deteriorate over time. To mitigate this risk, a periodic assessment of the credit quality of assets is necessary, and institutions may need to make credit provisions and record gains and losses. **Spread risk** is the risk that spreads may change during adverse market conditions as investors require different risk premiums, leading to gains and losses. **Liquidity risk** is the risk that asset liquidity and values deteriorate during adverse market conditions, lowering their market value.

LO 19.3: Define default risk, recovery risk, exposure risk and calculate exposure at default.

Default Risk

As mentioned, default risk relates to a borrower's inability to make promised payments. Determining the **probability of default** (PD) can be based on the following approaches:

- *Analyzing historical default frequencies of a borrower's homogenous asset classes.* Historically, credit analysis was based on subjective analysis, and rating agencies assigned ratings and historical default rates on past observations on an ex post basis (i.e., after an event).
- *Using mathematical and statistical tools.* Statistical models are typically used for large portfolios with hundreds or even thousands of positions, which allows for segmentation into different risk classes, measuring risk on an ex ante basis (i.e., before an event).
- *Using a hybrid approach that combines mathematical and judgmental analyses.* The mathematical results are generated automatically, which are then corrected using qualitative analysis.
- *Extracting implicit default probabilities from market prices of publicly listed counterparties.*

Default risk is typically measured over one year, although measuring cumulative probabilities of default beyond one year is also important. Shorter exposures are also exposed to default risk. For example, overnight lending will have a non-zero default probability due to unexpected shocks.

Recovery Risk

Recovery risk measures the risk that the amount recovered, in the event of a default, is less than the full amount that is due. The recovery rate is a conditional metric expressed as a percentage which assumes that default has already occurred. It is the complement to **loss given default** (LGD) such that the recovery rate equals 1 – LGD. The amount of recovery depends on the following factors:

- *The type of credit contracts used and the relevant legal system.*
- *General economic conditions.* Firms operating in more volatile sectors may see larger swings in asset values.
- *Covenants.* Negative covenants restricting the sale of assets that are important to the borrower should be considered in LGD estimations.

Estimating the recovery rate on ex ante basis is complex due to the difficulty in collecting recovery rate data (including lost data) and problems with uniformity of information. Even when sophisticated techniques allow for the collection of good information, it is challenging

to create a comprehensive model. As a result, less sophisticated models, often using a top-down approach, are commonly used in determining LGD and recovery rates.

Exposure Risk

Exposure risk measures the amount of risk a firm is exposed to in the event of a default. For term loans, exposure is easily determined. For revolving credit facilities, determining exposure is more challenging since it depends on borrower behavior and external events. In this situation, exposure risk [i.e., **exposure at default** (EAD)] can be calculated as:

$$EAD = \text{drawn amount} + (\text{limit} - \text{drawn amount}) \times LEQ$$

where:
drawn amount = amount of the credit facility currently used
limit = maximum amount granted by a bank to the borrower
LEQ = loan equivalency factor (rate of usage of available limit beyond ordinary use)

Other assets (e.g., accounts receivable) pose additional challenges, including events of noncompliance in contractually obligated terms and certain conditions which could alter the amounts due from the borrower. Determining EAD for derivatives contracts is also challenging since market conditions could alter the value of these contracts. In this case, EAD is calculated using stochastic models that forecast future events.

Credit Risk Measurement

LO 19.4: Explain expected loss, unexpected loss, VaR, and concentration risk, and describe the differences among them.

Expected loss (EL) calculates the average loss in the long run generated from credit facilities. The *EL rate* is a percentage of the EAD. EL can be determined on a financial basis, defined as a decrease in market value resulting from credit risk, or on an actuarial basis, ignoring credit risk and considering only losses from the EAD.

EL can be calculated as:

$$EL = PD \times LGD \times EAD$$

EL is determined based on expectations and is a cost that is incorporated into business and credit decisions. However, actual losses may be different from expectations, resulting in **unexpected losses** (ULs). ULs are problematic because they can jeopardize the viability of a bank as a going concern. Banks can prepare for ULs by holding sufficient equity capital to cover all risks, not just credit risks. Capital can be replenished from profits in good times, which can absorb ULs. Credit risk models and credit ratings are important in determining the overall credit contributions needed by banks.

In measuring UL, standard deviation is not an adequate measure since it assumes a symmetrical loss distribution. In practice, risks are often not symmetric, so other credit

measures, such as **value at risk** (VaR), are more useful. VaR is defined as a percentage of EAD and is calculated as the difference between the maximum loss at a certain confidence level and the EL at a given time horizon. For example, VaR at a 99% confidence level defines the capital that a bank must put aside to cover ULs in 99% of the cases. The bank's insolvency (due to catastrophic losses) is therefore confined to events whose probability does not exceed 1%.

As mentioned, credit risk probability distributions are asymmetric, where events with small probabilities (e.g., insolvency) may significantly impact a bank's profitability. **Credit risk models** can help estimate probability density functions. Loss distributions and calculating VaR measures can be done by (1) adopting a parametric closed-form distribution, (2) using numerical simulations, or (3) using discrete probability solutions.

Despite the usefulness of VaR and EL measures, these measures do not factor in portfolio concentration and typically ignore diversification between assets. Diversification reduces risk; therefore, the aggregate of individual risk measures does not equal portfolio risk. As a result, analyzing credit risk from a portfolio perspective should account for **concentration risk**. Concentration risk arises in credit portfolios where borrowers all face common risk factors, including interest rates, exchange rates, and changes in technology. Facing common risks is problematic since they simultaneously affect a borrower's willingness and ability to repay their obligations.

Banks traditionally avoided concentration risk by limiting their exposures to individual customers, and, thus, minimizing risk through higher granularity (i.e., a well-diversified portfolio). When analyzing with quantitative credit risk management, the need for granularity is already integrated into default correlations. Full portfolio credit risk models look at how much individual borrower risk factors contribute to concentration. They also enable segmentation of portfolio risk or viewing the entire portfolio risk profile as a whole. Portfolio credit risk models are critical in quantifying how much marginal risk can be attributed to various credit exposures. Without these models, it is not possible to properly quantify risks.

Default codependencies can be modeled through (1) asset value correlations and (2) default correlations. When modeling with **asset value correlations**, portfolios could be affected by external events, which influence counterparty values and could cause asset values to drop below the value of outstanding debt. Diversification is measured by considering the debt outstanding between two borrowers and by looking at the correlation among asset values.

Modeling with **default correlations** looks at historical correlations of data among homogenous borrower groups Since default correlations are generally not perfectly positively correlated, banks will have to separately address their potential losses in changing financial periods. This would allow banks to address risks in a more organized fashion, with less committed capital and smaller fluctuations in provisioning.

LO 19.5: Evaluate the marginal contribution to portfolio unexpected loss.

From a portfolio perspective, it is also important to measure how an individual exposure, or the addition of a new exposure, contributes to overall portfolio risk. One such measure is **marginal VaR**, which calculates the incremental portfolio risk from an individual exposure. The marginal contribution can be calculated as:

$$ULC_i = \frac{\partial UL_{portfolio}}{\partial w_i} w_i$$

This measure can be expressed under the Markowitz mean-variance framework as:

$$ULC_i = \rho_{i,portfolio} \times w_i \times UL_{portfolio}$$

where:
ULC_i = marginal contribution of the i^{th} loan portfolio unexpected loss
$\rho_{i,portfolio}$ = default correlation between the i^{th} loan and the overall portfolio
w_i = weight of the i^{th} loan in the overall portfolio
$UL_{portfolio}$ = portfolio unexpected loss

A practical interpretation of marginal contribution comes from calculating betas. For example, the beta of the i^{th} loan can be valued by rearranging the above formula as follows:

$$\beta_i = \frac{ULC_i / w_i}{UL_{portfolio}}$$

We can interpret this measure as the marginal risk contribution from the i^{th} loan relative to the average portfolio risk. A beta greater than one would imply that the marginal risk from the i^{th} loan is greater than the average portfolio risk and would, therefore, increase portfolio concentration risk. A beta less than one would reduce portfolio risk and increase the effect from diversification. With this measure, loans can be quickly selected based on their betas in order to identify which loans would lead to portfolio concentration or diversification.

Risk-Adjusted Pricing

LO 19.6: Define risk-adjusted pricing and determine risk-adjusted return on risk-adjusted capital (RARORAC).

As VaR increases, so does the expectation of higher returns and economic capital. The cost of capital multiplied by VaR needs to be incorporated into lending decisions as a cost for banks that are price takers, or as a lending cost (to be included in credit spreads) for banks that are price setters.

Economic capital is important from a pricing perspective and should, therefore, be incorporated into loan pricing decisions. While, in theory, price is an external factor and banks are price takers in an integrated market, in reality, markets are segmented, so pricing decisions vary. For example, in the wholesale market, banks are typically price takers,

whereas in retail markets, banks are price setters (due to information asymmetries and costs). Regardless of the market, prices are an important component of credit decisions and loan pricing. For banks, risk-based pricing policy is important for (1) active portfolio management (by using credit derivatives), (2) integrating credit, market, and operational risks into risk budgeting, and (3) setting management objectives.

The **risk-adjusted return on capital** (RAROC) has been widely used by banks in measuring risk-adjusted performance. A common variant of RAROC is the **risk-adjusted return on risk-adjusted capital** (RARORAC). Both of these measures are used by business lines to assess whether returns generated exceed the market risk premium required by capital. The market risk premium should be in proportion to the credit spread. Transactions create value if RARORAC exceeds a minimum target, for example, a target return on equity (ROE):

$$\text{RARORAC} > \text{ROE}_{\text{target}}$$

Applied in the context of **economic value added** (EVA), which is a measure of the firm's economic profit, EVA can be determined as the risk premium of economic capital, where K_e is the cost of shareholder capital:

$$\text{EVA} = (\text{RARORAC} - K_e) \times \text{economic capital}$$

The pricing of credit products should include fundamental variables, including costs and potential losses. Therefore, RARORAC should incorporate funding cost, EL (to cover loan provisions), allocated economic capital, and excess return required by shareholders (with respect to the cost of funding). In simple form, RARORAC can be calculated as:

$$\text{RARORAC} = \frac{\text{spread} + \text{fees} - \text{EL} - \text{cost of capital} - \text{cost of operations}}{\text{economic capital}}$$

Firms can make certain exceptions to override credit decisions for relationship or reputational reasons. For example, a bank may decide to maintain ties with an otherwise unprofitable customer for reputational or relationship reasons. These decisions should be made at the senior management level.

In general, credit decisions and outcomes, as well as customer profitability analysis, should be communicated to senior management. The goal of such analysis is to generate a comprehensive view of customer profitability, costs, revenues, and risks by segmenting customers, with the aim of identifying profitable and unprofitable relationships. Capital currently set aside for unprofitable or marginally profitable customers could then be freed up and allocated to more profitable opportunities. The relative risk-adjusted profitability models of customers are important in optimizing the risk-return decisions regarding bank portfolios. These models have gained more traction recently because of the growth in investor sophistication, and the growth in size and complexity of banking groups, which now have a greater need for risk-adjusted performance measures.

Key Concepts

LO 19.1

Credit ratings measure a borrower's creditworthiness. Ratings enable borrowers to access capital markets and properly manage risks.

LO 19.2

There are several classifications of credit risk. Risks relating to default include default risk, recovery risk, and exposure risk. Risks relating to valuation include migration risk, spread risk, and liquidity risk. Credit risk also encompasses concentration risk and can be correlated with pure financial risks.

LO 19.3

Determining default probability can be based on (1) analysis of historical default frequencies of a borrower's homogenous asset classes, (2) mathematical and statistical tools, (3) a hybrid approach that combines mathematical and judgmental analyses, and (4) implicit default probabilities from market prices of publicly listed counterparties.

Default risk is typically measured over one year. However, cumulative default rates extending beyond one year are important. Shorter exposures, such as overnight lending, are also exposed to default risk.

Recovery risk is a conditional metric assuming that default has already occurred. The amount of recovery depends on (1) the type of credit contracts used and the relevant legal system, (2) general economic conditions, and (3) covenants. Estimating the recovery rate on ex ante basis is challenging due to the difficulty in collecting recovery rate data, uniformity of information, and challenges in creating a comprehensive model.

Exposure risk is easily determined for term loans. For revolving credit facilities, exposure depends on borrower behavior and external events. In this case, exposure risk [i.e., exposure at default (EAD)] can be calculated as:

$$\text{EAD} = \text{drawn amount} + (\text{limit} - \text{drawn amount}) \times \text{loan equivalency factor}$$

LO 19.4

Expected loss (EL) is the average loss generated from credit facilities. EL can be calculated as:

$$\text{EL} = \text{PD} \times \text{LGD} \times \text{EAD}$$

Unexpected losses (ULs) result from actual losses that may be different from expectations. The risk of ULs can be mitigated by holding sufficient equity capital.

Value at risk (VaR) measures are more useful in measuring unexpected losses than traditional volatility measures since loss distributions are not symmetric. VaR is computed as the difference between the maximum loss at a certain confidence level and the EL at a given time horizon.

Traditional risk measures, like VaR, do not account for concentration risk, which arises when borrowers are exposed to common risk factors which could simultaneously affect their willingness and ability to repay their obligations.

Concentration was traditionally mitigated by minimizing exposure to a single borrower. Portfolio credit risk models specifically factor in a borrower's risk contribution to concentration, and allow for segmentation of portfolio risk or viewing the portfolio risk profile as a whole.

Default codependencies can be modeled with (1) asset value correlations, which look at the influence of external events on asset values, and (2) default correlations, which look at historical correlations among homogenous borrower groups.

LO 19.5

Marginal VaR calculates the incremental portfolio risk from an individual exposure. Marginal VaR is useful in calculating betas, which can be interpreted as the marginal risk contribution from a loan to average portfolio risk. A beta greater than one implies concentration risk, while a beta less than one indicates diversification.

LO 19.6

The risk-adjusted return on risk-adjusted capital (RARORAC) is an important risk-adjusted performance measure used to assess whether returns generated exceed the market risk premium required by capital. Transactions add value as long as RARORAC exceeds a minimum target (e.g., a target return on equity).

Economic value added (EVA) measures economic profit and looks at the additional return generated relative to the cost of capital:

$$EVA = (RARORAC - K_e) \times \text{economic capital}$$

Concept Checkers

1. Which of the following credit risks best reflects the risk that an entity may have to accept lower-than-expected values for credit exposures that must be sold?
   A. Recovery risk.
   B. Exposure risk.
   C. Spread risk.
   D. Liquidity risk.

2. During a conversation about credit risk, a colleague mentions that the typical measure of default risk is the probability of default (PD) over a one-year horizon, because overnight lending has a zero PD. Is your colleague correct with respect to her statements?
   A. She is correct with respect to both statements.
   B. She is correct with respect to default risk over a one-year horizon only.
   C. She is correct with respect to overnight lending only.
   D. She is not correct with respect to either statement.

3. A credit analyst notes that value at risk (VaR) is a more useful measure than volatility of losses, because loss distributions tend to be asymmetric. The analyst further notes that VaR does not account for portfolio concentration risk. Is the analyst correct with respect to his statements?
   A. The analyst is correct with respect to both statements.
   B. The analyst is correct with respect to VaR as a more useful measure only.
   C. The analyst is correct with respect to concentration risk only.
   D. The analyst is not correct with respect to either statement.

4. Which of the following risks is most likely associated with marginal value at risk (marginal VaR)?
   A. Recovery risk.
   B. Spread risk.
   C. Concentration risk.
   D. Exposure risk.

5. A bank estimated that its risk-adjusted return on risk-adjusted capital (RARORAC) is 15%. The bank's marginal cost of capital is 7%, and its economic capital is $100 million. What is the bank's economic value added (EVA)?
   A. $7 million
   B. $8 million.
   C. $15 million.
   D. $22 million.

Concept Checker Answers

1. **D** Liquidity risk measures the risk that asset liquidity and values deteriorate during adverse market conditions, resulting in lower market value.

2. **B** The colleague's statement with respect to the PD being measured over a one-year time horizon is correct. She is incorrect with respect to her statement on overnight lending, which has a non-zero PD.

3. **A** The analyst is correct with respect to both of his statements. Value at risk (VaR) is a more useful measure than the standard deviation of losses, since loss risk distributions tend to be asymmetric. VaR, however, does not account for portfolio concentration risk.

4. **C** Marginal VaR is a measure of concentration risk, which measures the probability of loss arising from a borrower's exposure to common risk factors.

5. **B** EVA measures economic profit as the additional return generated relative to the cost of capital. EVA is calculated as:

   EVA = (RARORAC – K_e) × economic capital

   EVA = (0.15 – 0.07) × $100 million = $8 million

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

Rating Assignment Methodologies

Topic 20

Exam Focus

The focus of this topic is on the assessment of default risk and assigning ratings as a means of quantifying this risk. For the exam, be comfortable with the relationship between default probability and ratings. Also, understand how ratings are derived for issues and issuers, how ratings migrate over time, how various default probabilities are calculated, and what defines a good ratings system. Default is predicted using many different approaches: experts-based (heuristic), reduced form (statistical and numerical), structural (the Merton model), linear discriminant analysis, logistic regression models, cluster analysis, principal component analysis, and cash-flow simulations. You should be familiar with the advantages and limitations of each of these approaches as well as the similarities and differences among them. These approaches are heavily quantitative, so it is critical to also factor qualitative information into any analysis of default probability.

Rating Systems

LO 20.1: Explain the key features of a good rating system.

Ratings play a critical role in supporting credit risk management. Ratings are also used to support credit pricing and capital provisions used to cover unanticipated credit losses. Given that defaults represent a significant source of losses for lenders, ratings are used to measure the probability of a default event occurring in a specific time horizon. Ratings are also used to support decisions made at various levels of an organization, as assessments are used to support a structured internal governance system. Ratings represent the most critical instrument used in modern and quantitative credit risk management. However, ratings must be as objective as possible—meaning different credit analysts using the same inputs and methodologies should reach similar ratings.

A good rating system will possess the following three features, which together will help entities measure the appropriateness of their internal rating systems:

- *Objectivity and Homogeneity*. An objective rating system will produce judgments based only on considerations tied to credit risk, while a homogeneous system implies that ratings are comparable among market segments, portfolios, and customer types.
- *Specificity*. A rating system is specific if it measures the distance from a default event while ignoring other financial elements that are not directly tied to potential default.
- *Measurability and Verifiability*. Ratings must provide correct expectations related to default probabilities which are backtested on a continuous basis.

Experts-Based, Statistical-Based, and Numerical Approaches

LO 20.2: Describe the experts-based approaches, statistical-based models, and numerical approaches to predicting default.

Although the consequences of default can be substantial, fortunately a default itself is a relatively rare occurrence (the default rate during deep recessions peaks in the range of 2% to 5%). A credit analyst whose job it is to assess the potential for default is typically an individual with a great deal of experience who can balance his knowledge with perception and intuition when evaluating default scenarios.

An early model for assessing default was created by Wilcox (1971)[1] using what was called "gambler's ruin theory." His model for predicting the probability of default was dependent on assessing the probability of gains and losses as well as the level of profits relative to a company's initial capital endowment. Another theory applied to corporate finance is the "point of no return theory," which implies that business operations must produce enough cash to cover required interest and principal payments on debt. As long as the operational flow of funds exceeds interest and principal payments needed, the company will be successful. The balance needed represents the no-return point, as a company can only be sustainable as long as it can meet its debt payments.

Credit quality analysis from an **experts-based approach** will apply frameworks such as the four Cs of credit (Character, Capital, Coverage, Collateral) proposed by Altman/NYU, LAPS (Liquidity, Activity, Profitability, Structure) from Goldman Sachs, and CAMELS (Capital Adequacy, Asset Quality, Management, Earnings, Liquidity, Sensitivity) from JP Morgan. As Porter (1980, 1985)[2,3] emphasized, qualitative features need to be factored into any analysis along with quantitative components.

A **statistical-based classification** centers on the fact that a quantitative model is essentially just a description of the real world within a controlled environment. Models are simply used to express a viewpoint of how the world will likely behave given certain criteria. A quantitative model will have a qualitative (formal) formulation that describes the basic view of the world we are trying to capture in the model; it will also have the underlying assumptions needed to build the model. The assumptions, which serve to simplify the process, should cover organizational behavior, possible economic events, and predictions on how market participants will react to these events. Statistical-based models are primarily focused on assessing the default risk associated with unlisted firms, even though they certainly can be useful in managing default risk for many other entities and organizations. Here, the model is based on quantitative and qualitative variables, as well as publicly unavailable and low-frequency data.

As will be described later in the topic, **numerical approaches** have the objective of deriving optimal solutions using "trained" algorithms and incorporating decisions based on relatively weak information in very complex environments. An example is a "neural network," which is able to continuously update itself for changes to the environment.

1. Wilcox, J. W. (1971), A Gambler's Ruin Prediction of Business Failure Using Accounting Data, *Sloan Management Review*, 12 (3).
2. Porter, M. (1980), Competitive Strategy, Free Press.
3. Porter, M. (1985), Competitive Advantage: Creating and Sustaining Superior Performance, Free Press.

Rating Migration Matrix

LO 20.3: Describe a rating migration matrix and calculate the probability of default, cumulative probability of default, marginal probability of default, and annualized default rate.

A migration frequency represents how often ratings change from one class to another. A **migration matrix** shows relative frequencies of counterparties that move from one rating class (shown in each row) to another class (shown in each column). Figure 1 shows a one-year Moody's migration matrix across a 30-year period (1970–2007), with WR representing withdrawn ratings.

Figure 1: One-Year Moody's Migration Matrix

		Final Rating Class (%)									
		Aaa	Aa	A	Baa	Ba	B	Caa	Ca-C	Default	WR
Initial Rating Class	Aaa	89.1	7.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	3.2
	Aa	1.0	87.4	6.8	0.3	0.1	0.0	0.0	0.0	0.0	4.5
	A	0.1	2.7	87.5	4.9	0.5	0.1	0.0	0.0	0.0	4.1
	Baa	0.0	0.2	4.8	84.3	4.3	0.8	0.2	0.0	0.2	5.1
	Ba	0.0	0.1	0.4	5.7	75.7	7.7	0.5	0.0	1.1	8.8
	B	0.0	0.0	0.2	0.4	5.5	73.6	4.9	0.6	4.5	10.4
	Caa	0.0	0.0	0.0	0.2	0.7	9.9	58.1	3.6	14.7	12.8
	Ca-C	0.0	0.0	0.0	0.0	0.4	2.6	8.5	38.7	30.0	19.8

It is worth noting that migrations are correlated and dependent transitions that occur over time (as opposed to being random walks). Observations over time have shown that when initial ratings are low (high), they become better (worse) than expected. However, default frequencies do have inherent limitations tied to the different applied methodologies of rating agencies. These limitations include differences in definitions, observed populations, amounts rated, and initial ratings.

Several key measures are used to assess the risk of default. The first is the **probability of default** (PD), which is shown in the following equation:

$$PD_k = \frac{defaulted_t^{t+k}}{names_t}$$

where:
PD = probability of default
defaulted = number of issuer names that have defaulted in the applicable time horizon
names = number of issuers
k = time horizon

A **cumulative probability of default**, given a sequence of default rates, can be calculated as follows:

$$PD_k^{cumulative} = \frac{\sum_{i=t}^{i=t+k} defaulted_i}{names_t}$$

Comparing the two equations above, a **marginal probability of default** can be calculated as follows:

$$PD_k^{marginal} = PD_{t+k}^{cumulative} - PD_t^{cumulative}$$

Finally, the **annualized default rate** (ADR) can be computed for both discrete and continuous time intervals as follows:

$$\text{discrete: } ADR_t = 1 - \sqrt[t]{\left(1 - PD_t^{cumulative}\right)}$$

$$\text{continuous: } ADR_t = -\frac{\ln\left(1 - PD_t^{cumulative}\right)}{t}$$

Rating Agencies' Methodologies

LO 20.4: Describe rating agencies' assignment methodologies for issue and issuer ratings.

Rating agencies have a goal of running systematic surveys on all default risk determinants. In their approach, both judgmental and model-based analyses are integrated. Whereas a small component of revenues for rating agencies comes from selling information to market participants and investors, the vast majority of their revenues comes from counterparty fees. Because rating agencies are concerned with maintaining their reputations, and because the issuers who pay the rating agencies to rate them want to demonstrate the credit quality of their issues, the investment community (investors, buyers, and traders) can rely on the work of these agencies.

An agency will have potential access to privileged information, as they have a window into management's strategies and vision. To successfully assign a rating, an agency must have access to objective, independent, and sufficient insider information. As an example of the decision-making process for assigning a rating, Standard & Poor's has an eight-step process beginning with receiving a ratings request from an issuer and followed by the initial evaluation, meeting with management, analysis, a review and vote by the rating committee, a notification to the issuer, the dissemination/publication of ratings opinions, and continued monitoring of issuers and issues.

The final rating for a corporate borrower will come from two analytical areas: financial risks (accounting, cash flow, capital structure, etc.) and business risks (industry analysis, peer comparisons, company positioning relative to peers, country risk, etc.). As an example, in

assessing financial risks, Standard & Poor's focuses on coverage ratios, liquidity ratios, and profitability ratios. Higher margins equate to a safer financial structure and a higher credit rating for the borrower. This analysis is then merged with assessments of sovereign risk, the competitive environment of the issuer, and the strength of the business sector.

Along with the factors noted above, additional analytical areas include firm strategy coherence and consistency, management's reputation and experience, profit and cash-flow diversity, the ability of an organization to address competitive needs, and the organization's resilience to business uncertainty and volatility. The quality of a firm's internal governance; exposures to legal, political, environmental, and institutional risks; technological sustainability; and potential liabilities tied to employees are all relatively new factors addressed in ratings analyses. It is worth noting that an entity can have favorable positions in some of these analytical areas and less-favorable positions in other areas without it negatively affecting ratings.

At this point, there are only three main international ratings agencies: Moody's, Standard & Poor's (S&P), and Fitch. Moody's focuses more on ratings for actual issuances themselves, as opposed to ratings for issuers. S&P focuses on ratings for issuers. Fitch provides issuer ratings based on potential defaults for publicly listed bonds (which ignore commercial and private bank borrowings). The obvious challenge is the lack of comparability among the agencies, although recent market pressures have led to agencies using more quantitative analyses that facilitate easier comparisons.

Borrower Rating and Probability of Default

LO 20.5: Describe the relationship between borrower rating and probability of default.

Based on the law of large numbers (i.e., a large number of trials will approximate the expected value) and the fact that with a homogeneous population, actual frequencies observed serve as strong predictors of central probabilities, default probabilities can be applied to estimate the future behavior of a population. Not surprisingly, what has been observed is that higher-rated issues have a lower probability of default. The highest-rated issues almost never default even over a period of 10 years, while the lowest-rated issues often default early on and are almost assured of default after a 10-year period.

Agencies' Ratings vs. Experts-Based Approaches

LO 20.6: Compare agencies' ratings to internal experts-based rating systems.

A rating agency's assignment processes will be different than the internal classification methods used by banks, even though the underlying processes are often analogous. Relative to a formal approach, such as quantitative analysis based on statistical models, experts-based approaches are neither considered to be inferior nor superior. An experts-based approach relying on judgment will require significant experience and repetitions in order for many judgments to converge. Also, the challenges of such an approach include the dynamic nature of organizational patterns; M&A activity, which blends portfolios and processes; and

changing company cultures. A predictive performance that may work in one period is not necessarily indicative of future performance. Also, internal credit rating systems are difficult and time-consuming to develop. However, having a reliable internal system represents a significant value added for an entity.

In terms of the criteria for a good rating system discussed earlier, the following comparisons can be made between agencies' ratings and internal experts-based rating systems:

- *Objectivity and Homogeneity*. Agencies' ratings are 75% compliant, while internal experts-based rating systems are 50% compliant.
- *Specificity*. Agencies' ratings are close to 100% compliant, while internal experts-based rating systems are 75% compliant.
- *Measurability and Verifiability*. Agencies' ratings are 75% compliant, while internal experts-based rating systems are 25% compliant.

Structural Approaches vs. Reduced Form Approaches

LO 20.7: Distinguish between the structural approaches and the reduced-form approaches to predicting default.

The foundation of a **structural approach** (e.g., the Merton model) is the financial and economic theoretical assumptions that describe the overall path to default. Under this approach, building a model involves estimating the formal relationships that link the relevant variables of the model. In contrast, **reduced form models** (e.g., statistical and numerical approaches) arrive at a final solution using the set of variables that is most statistically suitable without factoring in the theoretical or conceptual causal relationships among variables.

A reduced form model will not make any ex ante assumptions about causal drivers for default (unlike structural models); specific firm characteristics are linked to default, using statistics to tie them to default data. As such, the default event itself represents a real-life event. The independent variables in these models are combined based on their estimated contribution to the final result and can change in terms of relevance depending on firm size, firm sector, and economic cycle stage.

A significant model risk in reduced form approaches results from a model's dependency on the sample used to estimate it. To derive valid results, there must be a strong level of homogeneity between the sample and the population to which the model is applied.

Reduced form models used for credit risk can be classified into statistical and numerical-based categories. Statistical-based models use variables and relations that are selected and calibrated by statistical procedures. Numerical-based approaches use algorithms that connect actual defaults with observed variables. Both approaches can aggregate profiles, such as industry, sector, size, location, capitalization, and form of incorporation, into homogeneous "top-down" segment classifications. A "bottom-up" approach may also be used, which would classify variables based on case-by-case impacts. While numerical and statistical methods are primarily considered bottom-up approaches, experts-based approaches tend to be the most bottom up.

The Merton Model

LO 20.8: Apply the Merton model to calculate default probability and the distance to default and describe the limitations of using the Merton model.

The **Merton model**, which is an example of a structural approach, is based on the premise that the technical event of default occurs only when the proprietary structure of the defaulting company is no longer considered worthwhile. Assuming that a default event is dependent on financial variables, default probability can be calculated using the Black-Scholes-Merton formula. The five relevant variables include the market risk interest rate, the maturity (when the debt expires), the debt face value (similar to an option strike price), the value of the borrower's assets, and the volatility of the assets' value. The output provides the probability that the borrower will be insolvent.

In Merton's approach, the equity of a firm represents a call option on the market value of the assets. As such, the value of equity is a by-product of the market value and volatility of the assets, as well as the book value of liabilities; this implies that a firm's asset volatility serves as the link between its business and financial risk. A firm's risk structure is used to set its optimal financial structure, which in turn affects equity due to the probability of shareholders losing their investments due to default.

The default probability using the Merton approach and applying the Black-Scholes-Merton formula is as follows:

$$PD = N\left(\frac{\ln(F) - \ln(V_A) - \mu T + \frac{1}{2}\sigma_A^2 T}{\sigma_A \sqrt{T}}\right)$$

where:
ln = the natural logarithm
F = debt face value
V_A = firm asset value (market value of equity and net debt)
μ = expected return in the "risky world"
T = time to maturity remaining
σ_A = volatility (standard deviation of asset values)
N = cumulated normal distribution operator

In the preceding equation, the components that lie within the brackets are seen as a standardized measure of the "distance to the debt barrier." This distance represents a threshold beyond which a firm will enter into financial distress and subsequently default.

The **distance to default** (DtD) using the Merton approach (assuming T = 1) is as follows:

$$DtD = \frac{\ln(V_A) - \ln(F) + \left(\mu_{risky} - \frac{\sigma_A^2}{2}\right) - \text{"other payouts"}}{\sigma_A} \cong \frac{\ln V - \ln F}{\sigma_A}$$

There are many challenges associated with using the Merton model. Neither the asset value itself nor its associated volatility are observed. The structure of the underlying debt

is typically very complex, as it involves differing maturities, covenants, guarantees, and other specifications. Because variables change so frequently, the model must be recalibrated continuously. Also, its main limitation is that it only applies to liquid, publicly traded firms. Using this approach for unlisted companies can be problematic due to unobservable prices and challenges with finding comparable prices. Finally, due to high sensitivity to market movements and underlying variables, the model tends to fall short of fully reflecting the dependence of credit risk on business and credit cycles.

Professor's Note: The Merton model will be discussed in greater detail in the next topic (Topic 21).

Linear Discriminant Analysis

LO 20.9: Describe linear discriminant analysis (LDA), define the Z-score and its usage, and apply LDA to classify a sample of firms by credit quality.

A scoring model is a family of statistical tools developed from qualitative and quantitative empirical data that determines the appropriate parameters and variables for predicting default. **Linear discriminant analysis** (LDA) is one of the most popular statistical methods used for developing scoring models. An LDA-based model is a reduced form model due to its dependency on exogenous variable selection, the default composition, and the default definition. A scoring function is a linear function of variables produced by an LDA. The variables are chosen based on their estimated contribution to the likelihood of default and come from an extensive pool of qualitative features and accounting ratios. The contributions (i.e., weights) of each accounting ratio to the overall score are represented by **Altman's Z-score**. Although there are many discriminant analysis methods, the one referenced in this topic is the ordinary least squares method.

LDA categorizes firms into two groups: the first represents performing (solvent) firms and the second represents defaulting (insolvent) firms. One of the challenges of this categorization is whether or not it is possible to predict which firms will be solvent and which will be insolvent prior to default. A Z-score is assigned to each firm at some point prior to default on the basis of both financial and nonfinancial information. A Z cut-off point is used to differentiate both groups, although it is imperfect as both solvent and insolvent firms may have similar scores. This may lead to incorrect classifications.

Altman (1968)[4] proposed the following LDA model:

$$Z = 1.21x_1 + 1.40x_2 + 3.30x_3 + 0.6x_4 + 0.999x_5$$

where:
x_1 = working capital / total assets
x_2 = accrued capital reserves / total assets
x_3 = EBIT / total assets
x_4 = equity market value / face value of term debt
x_5 = sales / total assets

4. Altman, E. I. (1968), Financial Ratios, Discriminant Analysis and Prediction of Corporate Bankruptcy, *Journal of Finance*, 23 (4).

In this model, the higher the Z-score, the more likely it is that a firm will be classified in the group of solvent firms. The **Z-score cut-off** (also known as the *discriminant threshold*) was set at Z = 2.675. The model was used not only to plug in current values to determine a Z-score, but also to perform stress tests to show what would happen to each component (and its associated weighting) if a financial factor changed.

Another example of LDA is the **RiskCalc© model**, which was developed by Moody's. It incorporates variables that span several areas, such as financial leverage, growth, liquidity, debt coverage, profitability, size, and assets. The model is tailored to individual countries, with the model for a country like Italy driven by the positive impact on credit quality of factors such as higher profitability, higher liquidity, lower financial leverage, strong activity ratios, high growth, and larger company sizes.

With LDA, one of the main goals is to optimize variable coefficients such that Z-scores minimize the inevitable "overlapping zone" between solvent and insolvent firms. For two groups of borrowers with similar Z-scores, the overlapping zone is a risk area where firms may end up incorrectly classified. Historical versions of LDA would sometimes consider a gray area allowing for three Z-score range interpretations to determine who would be granted funding: very safe borrowers, very risky borrowers, and the middle ground of borrowers that merited further investigation. In the current world, LDA incorporates the two additional objectives of measuring default probability and assigning ratings.

The process of fitting empirical data into a statistical model is called **calibration**. LDA calibration involves quantifying the probability of default by using statistical-based outputs of ratings systems and accounting for differences between the default rates of samples and the overall population. This process implies that more work is still needed, even after the scoring function is estimated and Z-scores are obtained, before the model can be used. In the case of the model being used simply to accept or reject credit applications, calibration simply involves adjusting the Z-score cut-off to account for differences between sample and population default rates. In the case of the model being used to categorize borrowers into different ratings classes (thereby assigning default probabilities to borrowers), calibration will include a cut-off adjustment and a potential rescaling of Z-score default quantifications.

Because of the relative infrequency of actual defaults, a more accurate model can be derived by attempting to create more balanced samples with relatively equal (in size) groups of both performing and defaulting firms. However, the risk of equaling the sample group sizes is that the model applied to a real population will tend to overpredict defaults. To protect against this risk, the results obtained from the sample must be calibrated. If the model is only used to classify potential borrowers into performing versus defaulting firms, calibration will only involve adjusting the Z cut-off using Bayes' theorem to equate the frequency of defaulting borrowers per the model to the frequency in the actual population.

Prior probabilities represent the probability of default when there is no collected evidence on the borrower. Prior probabilities q_{insolv} and q_{solv} represent the prior probabilities of insolvency and solvency, respectively. One proposed solution is to adjust the cut-off point by the following relation:

$$\ln\left(\frac{q_{solv}}{q_{insolv}}\right)$$

If it is the case that the prior probabilities are equal (which would occur in a balanced sample), there is no adjustment needed to the cut-off point (i.e., relation is equal to 0). If the population is unbalanced, an adjustment is made by adding an amount from the relation above to the original cut-off quantity.

For example, assume a sample exists where the cut-off point is 1.00. Over the last 20 years, the average default rate is 3.75% (i.e., q_{insolv} = 3.75%). This implies that q_{solv} is equal to 96.25%, and the relation will dictate that we must add ln(96.25% / 3.75%) or 3.25 to the cut-off point (1.00 + 3.25 = 4.25).

The risk is the potential misclassification of borrowers leading to unfavorable decisions—rejecting a borrower in spite of them being solvent or accepting a borrower that ends up defaulting. In the case of the first borrower, the cost of the error is an opportunity cost ($COST_{solv/insolv}$). In the case of the second borrower, the cost is the loss given default ($COST_{insolv/solv}$). These costs are not equal, so the correct approach may be to adjust the cut-off point to account for these different costs by adjusting the relation equation as follows:

$$\ln\left(\frac{q_{solv} \times COST_{solv/insolv}}{q_{insolv} \times COST_{insolv/solv}}\right)$$

Extending the earlier example, imagine the current assessment of loss given default is 50% and the opportunity cost is 20%. The cut-off score will require an adjustment of: ln[(96.25% × 20%) / (3.75% × 50%)] = 2.33.

The cut-off point selection is very sensitive to factors such as overall credit portfolio profile, the market risk environment, market trends, funding costs, past performance/budgets, and customer segment competitive positions.

Note that LDA models typically offer only two decisions: accept or reject. Modern internal rating systems, which are based on the concept of default probability, require more options for decisions.

Logistic Regression Models

LO 20.10: Describe the application of logistic regression model to estimate default probability.

Logistic regression models (also known as **LOGIT models**), which are from the Generalized Linear Model (GLM) family, are statistical tools that are also used to predict default. These types of models are based on analyzing the dependencies of one or multiple dependent variables from one or more independent variables. GLMs typically have three common elements:

- A *systematic component*, which specifies the variables used in a linear predictor function.
- A *random component*, which identifies both the target variable and its associated probability function.
- A *link function*, which is a function of the target variable mean that the model ties to the systematic component.

Assume that π represents the probability that a default event takes place. The link function represents the logarithm of the ratio between the default probability and the probability that the firm continues to be a performing borrower (the ratio is known as *odds*). The LOGIT (i.e., logarithm of odds) equation is therefore:

$$\text{LOGIT}(\pi_i) = \log\frac{\pi_i}{1-\pi_i}$$

The LOGIT function associates the expected value for the dependent variable to the *linear* combination of independent variables, whereas the relationship between the probability of default (π) and the independent variables is *nonlinear*.

In the event that there is only one explanatory variable, the LOGIT function becomes:

$$\frac{\pi_i}{1-\pi_i} = e^{(\beta_0+\beta_1 x_{i1})}$$

In this equation, β_1 represents a growth rate such that odds are increased by a factor of e^{β} for each unit increase in *x*. Interpreted another way, the odds for x + 1 = the odds for x multiplied by e^{β}. If $\beta = 0$, $e^{\beta} = 1$ and the odds will remain the same even if *x* changes values. e^{β} can also be thought of as the odds ratio (the ratio of the odds after a unit change in the predictor to the original odds).

Whereas LDA does not yield a sample-based estimate of PD, logistic regression does; however, the probability does require rescaling to the prior probability of the population such that the rescaled default probability π_S is equal to:

$$\pi_S = \frac{\text{ScaledOdds}}{1+\text{ScaledOdds}}$$

A scaled default probability can be created for every possible value coming from a logistic regression. The calibration is complete once each of these default probabilities is assigned to grades in a rating scale.

Sources of information for the independent variables in statistical models include internal behavioral information, external behavioral information (legal disputes, credit bureau reports, dun letters, etc.), financial reports for the individual firm, behavioral data from the credit register, and assessments covering factors such as management quality, competitiveness of the firm, and supplier/customer relationships. Because these sources differ in terms of things like properties, frequency, and data type, models are often specifically built to manage these issues. These individual models (called modules) are then integrated into a final rating model. This serves as a second-level model that uses these inputs to derive a final score.

The individual modules can be connected in a parallel or sequence format. A parallel approach involves the modules' outputs serving as the input for the final second-level model. In the sequential (notching up/down) approach, financial information feeds the model while other modules serve to adjust the results from the financial model up or down.

Cluster Analysis and Principal Component Analysis

LO 20.11: Define and interpret cluster analysis and principal component analysis.

Both LDA and LOGIT methodologies are considered "supervised" due to having a defined dependent variable (the default event), while independent variables are applied to determine an ex ante prediction. When the dependent variable is not explicitly defined, the statistical technique is considered "unsupervised."

Cluster analysis looks to identify groups of similar cases in a data set. Groups represent observation subsets that exhibit homogeneity (i.e., similarities) due to variables' profiles that allow them to be distinguished from those found in other groups. In the context of a database with variables in columns and observations in rows, cluster analysis serves to aggregate borrowers based on the profile of their variables. The end result is a top-down, statistically-based segmentation of borrowers. An empirical default rate can be calculated for each segment, which serves as the default probability for the borrower at each segment. Various other analyses (factor, principal component, and canonical correlation) use columns to optimally transform the variables set into a smaller, statistically more significant set. Two approaches can be used to implement cluster analysis: (1) hierarchical/aggregative clustering and (2) divisive/partitioned clustering.

With **hierarchical clustering**, cluster hierarchies are created and aggregated on a case-by-case basis to form a tree structure with the clusters shown as leaves and the whole population shown as the roots. Clusters are merged together beginning at the leaves, and branches are followed until arriving at the roots. The end result of the analysis typically produces three forms:

- A small number of highly homogeneous, large clusters.
- Some small clusters with comprehensible and well-defined specificities.
- Single, very specific, nonaggregated units.

One of the key benefits of this method is the detection of anomalies. Many borrowers, such as merged (or demerged) companies, start-ups, and companies in liquidation, are unique. This analysis facilitates identifying these unique profiles and managing them separately from other observations.

Divisive clustering begins at the root and splits clusters based on algorithms that assign every observation to the specific cluster whose center (the average of all points in the cluster) is nearest. This approach serves to force the population into fewer cluster groups than what would be found under aggregative clustering. On the other side, high calculation power is needed as expanding the number of observations has an exponential impact.

As an example of applying cluster analysis, we can look to composite measures of profitability such as ROE and ROI. The task is to identify both specific aspects of a firm's financial profile and latent (hidden) variables underlying the ratio system, such that the basic information from a firm's financial statements can be extracted and used for modeling without redundant data and information.

Principal component analysis involves transforming an original tabular data set into a second, derived tabular data set. The performance of a given variable (equal to variance explained divided by total original variance) is referred to as communality, and the higher the communality (the more general the component is), the more relevant its ability to summarize an original set of variables into a new composed variable. The starting point is the extraction of the first component that achieves maximum communality. The second extraction will focus on the residuals not explained by the first component. This process will continue until we have a new principal components set, which will be orthogonal (statistically independent) by design and explain original variance in descending order. In terms of a stopping point, potential thresholds include reaching a minimum predefined variance level or a minimum communality that assures a reasonable level of information using the new set of components.

An *eigenvalue* is a measure of the communality associated with an extracted component. The ideal first component is one that corresponds to the first eigenvalue of the set of variables. The second component will ideally correspond to the first eigenvalue extracted on the residuals. All original variables once standardized contribute a value of one to the final variance. An eigenvalue greater (less) than one implies that this component is summarizing a component of the total variance which exceeds (is less than) the information provided by the original variable. Therefore, it is common that only principal components with eigenvalues greater than one are considered.

For example, a survey of 52 textile firms in Italy was taken in 2007. The results of the extracted principal components are shown in Figure 2.

Figure 2: Principal Components (Italy, Textile Firms in 2007)

Components	*Eigenvalues*	*Explained Variance as % of Total Variance*	*Cumulative Explained Variance*
Component 1	2.76	39.46	39.46
Component 2	1.83	26.10	65.56
Component 3	1.10	15.69	81.25
Component 4	0.83	11.92	93.17
Component 5	0.23	3.23	96.40
Component 6	0.17	2.45	98.85
Component 7	0.08	1.15	100.00
Total	7.00	100.00	

As shown in Figure 2, approximately 81% of the total original variance and associated eigenvalues explain the extent of the variance, which is accounted for in each component. Even though the first variable only accounts for 40%, adding two more gets us to over 80%. In this example, liquidity variables are the first component that does the best job characterizing the data set, as a strong liquidity structure lowers the amount of leverage needed. The second component is profitability, as reduced capital needed for production increases bottom-line profits. The third component focuses on the impacts of intangibles such as R&D investments and market share. The key takeaway from this analysis is that for the Northern Italy Textile sector, a firm's profile is primarily a by-product of these three components (liquidity, profitability, and intangibles). It is also important to take into account correlation coefficients between the original variables and the principal components.

Based on the pattern of these three components, another firm that is part of the population for the sample in Figure 2 could be profiled based on these same fundamental components. Figure 3 illustrates the linkage between the original variables and the first three components above.

Figure 3: Linking Variables to Components

Original Variables	*Component 1*	*Component 2*	*Component 3*
ROE (Net Profit / Net Shareholders Capital)	0.13	0.48	0.05
ROI (EBIT / Invested Capital)	0.18	0.44	–0.09
CR (Current Assets / Current Liabilities)	0.32	–0.22	0.05
QR (Liquidity / Current Liabilities)	0.32	–0.17	–0.04
MTCI (Current Liabilities + Permanent Liabilities) / Invested Capital	–0.32	0.08	0.18
SHARE (Market Share) in %	–0.02	0.14	–0.67
R&S (Intangible Fixed Assets / Invested Capital) in %	–0.08	–0.16	–0.65

From this table, a regression analysis equation can be developed for Component 1 as follows:

$$S_1 = ROE_i \times 0.13 + ROI_i \times 0.18 + CR_i \times 0.32 + QR_i \times 0.32 - MTCI_i \times 0.32 - SHARE_i \times 0.02 - R\&S_i \times 0.08$$

The value derived from this equation is nonstandardized and in the same scale as the original variables, which makes them comparable in terms of mean and variance. Principal component analysis can be used as a way to pre-filter original variables, thereby decreasing their number and eliminating much of the noise of idiosyncratic information.

Factor analysis is similar to principal component analysis, except that factor analysis is used to describe observed variables in terms of fewer unobserved variables called "factors" and can be seen as more efficient. Factor analysis is often used as the second stage of

principal component analysis. In terms of the process, step one is to standardize principal components. Then, the values of the new variables (factor loadings) should be standardized such that the mean equals zero and the standard deviation is equal to one. Even though factor loadings are not comparable (from a size and range perspective) to original variables, they are comparable to each other. Factors will be contingent on the criteria used to conduct what is called the "rotation." The *varimax method* is a rotation method used to target either small or large loadings of a particular variable associated with each factor. As a result of iteratively rotating factor pairs, the resulting solution yields results that make it feasible to identify each variable tied to a single factor. A final solution is reached once the last round provides no added benefit.

The **canonical correlation method** is a technique used to address the correspondence between a set of independent variables and a set of dependent variables. As an example, if an analyst wanted to understand what is explaining the default rate and any changes in default rates over various time horizons, he can look at the relationship between default rate factors and financial ratio factors and understand what common dimensions existed between the tests and the degree of shared variance.

This analysis, which is a type of factor analysis, helps us find linear combinations of the two sets that have a maximum correlation with each other. From this analysis, we can determine how many factors are embedded in the set of dependent variables and what the corresponding factors are out of the independent variables that have maximum correlations with the factors from the dependent variable set. The factors from both sets are independent of one another. Although this method is very powerful, the disadvantages are that it is difficult to rigorously calculate scores for factors, and measuring the borrower profiles can only be done by proxy as opposed to measuring them in new independent and dependent factors.

Cash Flow Simulation Model

LO 20.12: Describe the use of a cash flow simulation model in assigning rating and default probability, and explain the limitations of the model.

A **cash flow simulation model** is most often used to assign ratings to companies that have non-existent or relatively meaningless track records. In an ideal situation, a given firm's future cash flow simulation will stay in the middle between structural and reduced form models. The simulation will be based on forecasting a firm's pro forma financial reports and studying the volatility of future performances. The assumed measure of default probability can be based on the number of future scenarios where a default event occurs versus the total number of simulated scenarios. Structural approaches and reduced form approaches are brought together in different models and solutions.

One of the biggest risks of cash flow simulation models is *model risk*, which stems from the fact that any model serves as a simplified version of reality. Defining default for the purposes of the model is also challenging, as it cannot always be known if and when a default will actually be filed in real-life circumstances. Therefore, the default threshold needs to be set such that it is not too early (the risk of having too many defaults, resulting in transactions that are deemed risky when they are not truly risky) and not too late (the risk of having

not enough defaults, thereby understating the potential risk). Costs must also be taken into account, as models can cost a lot of money to build, maintain, and calibrate.

Even given these issues, there are not many feasible alternatives to using the simulation model for a firm in certain conditions when historical data cannot be observed. For firms such as project companies, special-purpose entities, leveraged buyouts, or recently merged companies, any existing covenants and negative pledges are specifically signed for the purpose of mitigating risky events. These clauses must be incorporated and assessed to understand when they will be triggered and the extent of their effectiveness.

Ratings (and associated default probabilities) are assigned using cash flow simulation models. The models will take into account the amount of cash flows generated by operations, the amount that will be used for any financial obligations and other investments, and related determinants such as technology, demand, and costs. The models will also take into account future pro forma specifications. Either a numerical simulation model or a scenario approach can be used to determine the probability of default. For a numerical simulation, a large number of model iterations can be used which would describe different scenarios; stages such as default, no-default, near-to-default, or stressed can then be determined, and then the frequency of different stages can be computed. For a scenario approach, probabilities can be applied to discrete predefined scenarios. Ratings can be determined using weighted averages of future outcomes.

Heuristic Approaches vs. Numerical Approaches

LO 20.13: Describe the application of heuristic approaches, numeric approaches, and artificial neural network in modeling default risk and define their strengths and weaknesses.

Through the application of artificial intelligence methods, other techniques have been applied to predicting default in recent years. These two primary approaches include:

- **Heuristic methods**. These methods are designed to mirror human decision-making processes and procedures. Trial by error is used to generate new knowledge rather than using statistical modeling. These methods are also known as "expert systems," with a goal of reproducing high frequency standardized decisions at the highest level of quality at a low cost. The fundamental idea is to learn from both successes and errors.
- **Numerical methods**. The objective of these methods is to derive optimal solutions using "trained" algorithms and incorporate decisions based on relatively weak information in very complex environments. An example of this is a "neural network," which is able to continuously update itself in order to incorporate modifications to the environment.

An **expert system**, which is a traditional application of artificial intelligence, is a set of software solutions designed to produce answers to problems where human experts would otherwise be needed. Expert systems will typically involve the creation of a knowledge base and will use knowledge engineering to gather and codify knowledge into a framework. The typical components of an expert system include the working memory (short-term memory), the user interface/communication, the knowledge base (long-term memory), and the inferential engine (the heart/nervous network). Production rules are developed by knowledge engineers and are then used to create an environment that mirrors approaches for human problem solving.

The rule base of an expert system consists of many inference rules (which are designed to resemble human behavior); these go into the knowledge base as separate rules, and the inference engine serves to bring them together to draw conclusions. The inference engine can use either backward chaining or forward chaining. With *backward chaining* (goal driven), the starting point is a list of goals. Working backward, the expert system will look to find paths that will allow it to achieve these goals. Rules are searched until one is found which best aligns to the desired goal. With *forward chaining* (data driven), the starting point is available data. Inference rules are applied until a desired goal is achieved. Once the path is recognized as successful, it is applied to the data.

An expert system may also incorporate "fuzzy logic" applications. This logic applies "rules of thumb" based on feelings and uses approximate as opposed to precise reasoning. A fuzzy logic variable will not be confined to the extremes of zero and one; rather, they can assume any value that exists between the two extreme values. Fuzzy logic will ultimately widen the rules spectrum that can be used by expert systems, which allows them to better approximate human decision processes. On occasion, an expert system may also be used when there are new conditions that haven't been experienced previously (such as new procedures, new markets, etc.). A subset of expert systems is *decision support systems* (DSSs), which are applied to certain phases of the human decision-making process and involve very complex and cumbersome calculations.

Neural networks come from biological studies and serve to simulate human brain behavior. These networks involve the interconnection of artificial neurons (software programs designed to mirror the properties of biological neurons) and have the ability to continuously learn by experience. They are used primarily when data is rough, unreliable, mistaken, or even partially missed. They are also useful when decisions come from fuzzy environments and from environments where negotiations are needed or when market conditions change rapidly.

In a neural network, weights (defined as "potential" or "intensity" of a specific neuron) are multiplied by the input data, with the sum of the products influenced by a flexible mathematical function and the specific calculation path involving some but not all nodes. The network derives the signals gathered and applies a weighting to the inputs at every node. A neuron is considered active if it generates an input to other nodes, and it is ignored if it does not. Interactions between neurons can be considered strong or weak connections, with the connections based on weights and paths that inputs travel through before getting to the specific neuron.

One of the key benefits of the neural network method is its ability to capture nonlinear relationships. Because a network may have thousands of nodes and even more potential connections, the flexibility exists to handle highly complex, nonlinear, recursive, and independent problems. The most common structure is the "hierarchically dependent neural network."

In the specific area of credit risk, "supervised learning" is the most applied method. In this method, a training set is given and the network learns how to obtain a successful result by finding the structure of the nodes and determining the optimal path to achieve the best final result. A cost function is also set to define outcome utility. So to model default risk, borrower characteristics are used to form the training set while misclassification costs are set using the cost function.

In terms of limitations, there is no way to look step-by-step at neural networks to determine how results are obtained; we have to accept that the results will come from what appears like a "black box," which makes it impossible to explain how and why we arrived at a specific result. A way around this issue is to prepare multiple data sets characterized by distinguishing profiles and then put them in the neural network to obtain results. With outputs coming from homogeneous inputs, it is possible to then deduce the critical variables and their associated weights. Also, these networks are highly sensitive to the quality of the inputs; as such, data sets must be carefully chosen to not have the model learn from outliers. In addition, continuous quantitative variables are more appropriate for neural networks than qualitative variables.

Over-fitting is a major risk for estimating neural networks, as a network that over-fits a sample of data will not be able to produce quality results when applied to other samples, such as sectors, borrowers, economic cycle stages, and geographic areas.

An expert system is advantageous when human experts have known, clear, and well-dominated experience; this experience allows for the formalization of rules and building of effective systems. Expert systems provide structure and order to real-life procedures, which facilitate the replication of decision-making processes with robust quality and high frequency. Expert systems are also useful in connecting different stages of a decision-making process to one another. For the purposes of rating assignments, expert systems provide objectivity, order, and discipline to the ratings process; however, they do not provide new knowledge because they are not inferential methods or models.

Numerical approaches, like neural networks, provide classifications, often with low granularity (like very good, pass, reject, etc.). These models are not statistical models and, therefore, do not produce outputs like probabilities of default. This limitation, along with the "black box" limitation described earlier, limits the usefulness of neural networks outside of segments such as personal loans or consumer credit. However, they can be used for potential early warnings and credit quality monitoring. Also, a neural network is very useful for processing extremely large quantities of data, adjusting quickly when a discontinuity occurs, and creating new rules when a change in the pattern of success/failure is uncovered.

Comparing heuristic approaches (i.e., expert systems and decision support systems) to numerical approaches (i.e., neural networks) across the three key features of a good ratings system discussed earlier shows the following results:

- *Objectivity and Homogeneity*. Both are almost entirely compliant.
- *Specificity*. The numerical approach is 75% compliant, while the heuristic approach is 50% compliant.
- *Measurability and Verifiability*. The numerical approach is 75% compliant, while the heuristic approach is 50% compliant.

Applying Qualitative Information

LO 20.14: Describe the role and management of qualitative information in assessing probability of default.

Although statistical methods are ideal for managing quantitative data, qualitative type information is extremely relevant to modeling default risk and must be captured. From the perspective of using judgment to ultimately determine credit approval, three categories are used to encapsulate qualitative information:

- Investment, innovation, and technology.
- Human resource management, motivation, retention of key resources, and maximizing talent.
- Effective and efficient internal processes.

The following list represents examples of qualitative type information that must be accounted for in some capacity in default analysis:

- Primary customers and suppliers (concentration and quality).
- Range of products and services, both domestic and abroad.
- Commercial network, global presence, and diversification.
- Quality, competence, and experience of management.
- In-progress investments.
- Prior experiences with nonrecurring events such as foreclosures, credit losses, payment delays, and government support.
- Usage of new and innovative technologies in payment systems, as well as integrations with accounting, managerial information, and administration systems.
- Financial reporting quality, systems, internal controls, internal reporting, audit functions, and overall transparency.
- Financial relationships.
- Resource allocations, internal organization, and management among multiple branches.
- Group structure and organization.
- Compliance and conformity with environmental concerns and social responsibilities.
- Corporate governance and checks and balances.

The types of qualitative items that may be found in a credit analysis questionnaire include things like corporate structure (incorporation date, group members), business information (competitive forces within the industry, growth forecasts), management quality (degree of involvement, experience), strategy (business plans, nonrecurring transactions such as mergers and transfers), financial position sustainability (liquidity risk, debt maturity concentration), quality of information given to the bank by the company (availability of financial projections, relationship history), and other risks (geographic focus, client base quality). Due to the enormous breadth of qualitative factors, a best practice would be to only collect qualitative information that cannot be quantified.

Categorical types of information include binary information (such as yes/no), nominal information (like locations of incorporation), and ordinal classifications with graduating levels (such as low, medium, and high). Binary information can be represented as dummy variables (i.e., 0 or 1). Ordinal information can be assigned numbers and weights differing at each level. Even with these options for quantification, the lack of historical data is a major problem with using qualitative information.

A potential mechanism for overcoming these issues is to invoke a two-stage process:

- *Stage 1*: Build a quantitative model along with launching a systematic qualitative data collection on new reports.
- *Stage 2*: Once Stage 1 has produced enough information, build a new model which includes the new qualitative information.

In spite of the challenges of incorporating qualitative data, this data set is a critical element to building powerful credit models and driving long-term value creation for banks.

Key Concepts

LO 20.1

Ratings are used as a means for banks and other lenders to manage credit risk. To be effective, a good rating system will have three key features:

1. Objectivity and homogeneity, meaning it will produce judgments tied solely to credit risk and ratings that are comparable across market segments, portfolios, and customer types.

2. Specificity, meaning it accurately captures the distance to default while ignoring other non-default-related financial elements.

3. Measurability and verifiability, meaning it will provide accurate expectations tied to default probabilities backtested on a continuous basis.

LO 20.2

Experts-based approaches (such as those that incorporate the four Cs of credit) rely on experienced individuals who can provide valuable inputs into the models. Statistical-based models use both quantitative and qualitative data to describe the real world in a controlled environment. Numerical-based models are designed to derive optimal solutions using trained algorithms.

LO 20.3

A rating migration matrix is used to show the relative frequencies with which counterparties move from one rating class to another. Migrations tend to be correlated and dependent, such that when initial ratings are high (low), they become worse (better) than expected. Key measures to assess default risk include the probability of default, the cumulative probability of default, the marginal probability of default, and the annualized default rate.

LO 20.4

The three main international ratings agencies are Moody's (provides ratings for issuances), Fitch (provides issuer ratings for public bonds), and Standard & Poor's (provides ratings for issuers).

Standard & Poor's process for assigning a rating includes the following chronological steps: (1) receiving an issuer request, (2) following up with an initial evaluation, (3) meeting with management, (4) analysis, (5) a review and vote by the rating committee, (6) a notification to the issuer, (7) the dissemination of ratings opinions, and (8) continued monitoring. Final ratings come from the primary areas of financial risk and business risk, along with factoring in sovereign risk, the competitive environment for the issuer, and business sector strength.

LO 20.5

Given the law of large numbers and homogeneous populations, default probabilities can be used to estimate future population behavior. The higher (lower) the rating is for the issuer, the lower (higher) the probability of default. Over a period of time, such as 10 years, the highest-rated issuers will practically never default, while the lowest-rated issuers often default early and are almost assured of default over that same time frame.

LO 20.6

The processes used by a rating agency to assign ratings will differ from the internal methods used by banks, even with similar underlying processes. In terms of the three features of a good ratings system, agencies' ratings are considered more compliant than internal experts-based ratings for objectivity and homogeneity (75% versus 50%), specificity (100% versus 75%), and measurability and verifiability (75% versus 25%).

LO 20.7

The structural approach to predicting default involves building a model that estimates the formal relationships linking relevant model variables. The reduced form approach (which is heavily dependent on the samples chosen) achieves a final solution using the most statistically suitable variables without accounting for their relationships. Within the category of reduced form approaches, there are statistical-based models and numerical-based models.

LO 20.8

The Merton model is a structural approach based on the premise that default occurs when a company's proprietary structure is no longer deemed worthwhile. The default probability and the distance to default can be calculated using relevant financial variables, such as interest rates, maturity, debt face value, the underlying value of the asset, and the asset's volatility. The model is highly sensitive to market movements and variables, such as asset value, volatility, and the underlying debt itself, which are difficult and complicated to value.

LO 20.9

Linear discriminant analysis (LDA) is a reduced form method used to develop scoring models and to provide accept/reject decisions. An LDA produces a scoring function, which is a linear function of variables, such as accounting ratios whose contributions to the overall score are represented by a Z-score. A Z cut-off is used to differentiate firms that are solvent from those that are insolvent, although there is an "overlapping zone" that can lead to misclassifications. Adjustments can be made to the cut-off score for unbalanced populations and the costs of misclassifications.

LO 20.10

Logistic regression (LOGIT) models are tools used to predict default based on understanding the relationships between dependent and independent variables. The output of these models is a sample-based estimate of the probability of default. The probability output must be scaled, and the model must be calibrated. The individual models developed (i.e., modules) are integrated using either a parallel or sequence approach into a final rating model.

LO 20.11

Cluster analysis serves to identify groups of similar cases into unique data sets, effectively aggregating and segmenting borrowers based on the profiles of their variables. From here, a default rate can be calculated for each segment as a proxy for their default probability. Principal component analysis takes original tabular data and transforms it into a new derived data set which is used to determine the primary drivers of a firm's profile and potential default. Factor analysis is often used as the second stage of principal component analysis.

LO 20.12

Cash flow analysis is useful for assigning ratings to companies that don't have meaningful historical data for predicting potential default. Ratings and default probabilities are assigned using these models, which account for operational cash flows, cash used for investments and obligations, and other cash-related determinants. Challenges to the model include model risk (oversimplifying reality), costs for building and maintaining the model, and accurately defining default.

LO 20.13

Heuristic methods (known as expert systems) are designed to predict default by mirroring human decision-making processes and procedures. Numerical methods predict default using trained algorithms and apply decisions based on weak information in complex environments. Artificial neural networks are examples of numerical methods that are able to continuously learn by experience.

LO 20.14

Qualitative information is very relevant for modeling default risk. This type of information centers on areas such as corporate structure, business information, management quality, strategy, financial position sustainability, communication of information, and risks. Capturing historical data for qualitative information is particularly challenging, as is placing a reasonable scope around the breadth and quantity of factors that must be analyzed.

Concept Checkers

1. Which of the following statements is most accurate in regard to describing a good rating system?
   A. A specific rating system accurately measures the distance from a default event.
   B. A verifiable rating system requires backtesting default probabilities on at least a monthly basis.
   C. A homogeneous rating system provides judgments based solely on credit risk considerations.
   D. An objective rating system results in ratings that can be compared across customer types and market segments.

2. As shown in the Moody's migration matrix (Figure 1 on page 40), the only rating class where an issuance has a greater than 50% chance of changing from its initial to final rating class is:
   A. Aaa.
   B. Baa.
   C. Caa.
   D. Ca-C.

3. In comparing agency rating systems to internal (experts-based) rating systems, evidence has shown that:
   A. internal systems and agency systems are equally compliant in regard to specificity.
   B. agency systems are more compliant in regard to verifiability than internal systems.
   C. agency systems are less compliant in regard to measurability than internal systems.
   D. internal systems are more compliant in regard to objectivity and homogeneity than agency systems.

4. A credit analyst is using linear discriminant analysis (LDA) to determine a Z-score cut-off for differentiating default from solvency. Assume that the current cut-off point is 1.00, the average default rate is 2.75%, the current assessment of loss given default is 45%, and the opportunity cost is 15%. What is the new cut-off score after the Z-score cut-off adjustment?
   A. 2.47.
   B. 3.47.
   C. 4.66.
   D. 5.66.

5. Each of the following items represents an example of qualitative information that would ideally be captured in assessing default probability except:
   A. management's education and experience.
   B. internal controls associated with financial reporting.
   C. diversification of products and customers locally and globally.
   D. trends in throughput and other operational efficiency metrics.

Concept Checker Answers

1. **A** In order for a rating system to meet the specificity requirement, it must measure the distance to a default event. A verifiable rating system requires backtesting on a continuous basis. A homogeneous rating system implies that ratings are comparable among customer types, market segments, and portfolios. An objective rating system produces judgments based on considerations tied to credit risk.

2. **D** For issuances with initial ratings of Ca-C, there is only a 38.7% chance that their final ratings will remain Ca-C. For all other ratings classes, there is a greater than 50% chance that their initial ratings will equal their final ratings.

3. **B** Across all features of a good rating system (objectivity and homogeneity, specificity, and measurability and verifiability), agency ratings are deemed more compliant than internal, experts-based rating systems.

4. **B** The cut-off score will require an adjustment of: $\ln[(97.25\% \times 15\%) / (2.75\% \times 45\%)] = 2.47$. By adding this adjustment to the original cut-off point of 1.00, the new cut-off score will be equal to 3.47.

5. **D** Trends and other efficiency measures that can be captured with metrics are considered quantifiable, which means they are not considered qualitative measures. The other three items are considered qualitative in that they are not easily and consistently quantified.