CHAPTER 1

Introduction

The goal of this book is to describe how to measure and control the interest rate and credit risk of a bond portfolio or trading position. In this chapter we provide an overview of measurement and control for these two types of risk. This overview will provide a roadmap for the chapters to follow.

The objectives of this chapter are to:
1. Explain two approaches to measuring interest rate risk—the full valuation approach and the duration approach.
2. Explain what is meant by the duration of a bond or bond portfolio.
3. Explain why the measurement of yield volatility is important in measuring interest rate risk.
4. Briefly describe what the value at risk approach is.
5. Describe what is involved in controlling interest rate risk.
6. Explain the different forms of credit risk: credit default risk and credit spread risk.
7. Briefly describe how credit ratings measure credit default risk and what downgrade risk is.
8. Identify what credit derivatives can be used to control credit risk.

INTEREST RATE RISK

The value of a bond changes in the opposite direction to the change in interest rates.[1] For a long bond position, the position's value will decline

[1] There are some products in the mortgage-backed and asset-backed securities market where the price change is in the same direction as the change in interest rates. An example is an interest-only security.

if interest rates rise, resulting in a loss. For a short bond position, a loss will be realized if interest rates fall.

Measuring Interest Rate Risk

A manager wants to know more than simply when a position will realize a loss. To control interest rate risk, a manager must be able to quantify what will result. The fundamental relationship is that the potential dollar loss of a position resulting from an adverse interest rate change is:

Potential dollar loss of a position
= Value of position after adverse rate change
– Current market value of position

Full Valuation Approach to Risk Measurement

The key to measuring the potential dollar loss of a position is how good the estimate is of the value of the position after an adverse rate change. A *valuation model* is used to determine the value of a position after an adverse rate move. Consequently, if a reliable valuation model is not used, there is no way to measure the potential dollar loss. Because valuation models are essential in the measurement of risk, we describe the principles of valuation and two commonly used valuation models in Chapter 2.

The approach to measuring the potential dollar loss whereby the value of the position after the adverse rate change is estimated from a valuation model is referred to as the *full valuation model*.[2] Given a valuation model, the dollar loss for specific scenarios can be determined. Analyzing interest rate risk in this manner is referred to as *scenario analysis*. The manager can then assess the likelihood or probability of each scenario occurring and any unacceptable outcomes can be modified by using the tools described in this book.

Duration Approach to Risk Measurement

An alternate approach is to estimate the potential dollar loss for any rate change by approximating the sensitivity of a position to a rate change. For example, suppose that a trader has a $20 million long position in a bond whose value changes by approximately 4% for a 100-basis-point change in rates. Then the manager knows that for a 100-basis-point increase in rates, the value of the position will decline by approximately $800,000 ($20 million × 0.04). For a 25-basis-point rise in rates, the position will change in value by approximately 1% or $200,000.

[2] *RiskMetrics™ —Technical Document*, JP Morgan, Third Edition, 1995, p. 14.

Duration is a measure of the approximate sensitivity of a bond's value to rate changes. More specifically, it is the approximate percentage change in value for a 100-basis-point change in rates.[3] Consequently, duration can be used to approximate the potential dollar loss. For example, if the market value of a bond held is $20 million and if its duration is 4, then the potential dollar loss for a 25-basis-point (0.0025) change in rates is:

$$\$20{,}000{,}000 \times 4 \times 0.0025 = \$200{,}000$$

For a 5-basis-point (0.0005) change in rates, the potential dollar loss is:

$$\$20{,}000{,}000 \times 4 \times 0.0005 = \$40{,}000$$

Using duration to approximate the potential dollar loss is referred to as the *duration approach to risk management*. The advantage of the duration approach over the full valuation approach is that the latter requires more computational time to obtain the new value under each scenario analyzed. The duration approach allows the manager to quickly estimate the effect of an adverse rate change on the potential dollar loss.

A drawback of the duration approach is that duration is only a first approximation as to how sensitive the value of a bond or bond portfolio is to rate changes. Thus, the potential dollar loss of a position is only an approximation, whereas the full valuation approach provides the precise amount of the loss. However, for both approaches, it is essential to have a good valuation model. The duration measure is obtained from a valuation model, so if the valuation model does not do a good job of valuing a security, the duration measure will not be useful. Consequently, when we say that the full valuation approach gives a precise amount of the potential dollar loss, we mean precise given the valuation model used.

In Chapter 3, we take a close look at duration. We will examine how it is measured and its limitations. We will see that the approximation provided by duration can be improved by introducing another parameter called convexity. Together, duration and convexity do a more effective job of estimating the sensitivity of a position to adverse rate changes. Both duration and convexity are referred to as parameters of a valuation model. Consequently, estimating the sensitivity of the value of a portfolio or position to adverse rate changes is referred to as the *parametric*

[3] Similarly, the duration of a liability is the approximate percentage change in the value of the liability for a 100-basis-point change in rates.

approach. Since the full valuation approach does not use parameters, it is also sometimes called the *nonparametric approach*.

Our discussion of the limitations of duration and convexity in Chapter 3 will lead us to the conclusion that the duration and convexity of a portfolio of bonds with different maturities does not tell the whole story about interest rate risk. Another important source of interest rate risk for a portfolio of bonds is how the yield curve changes. In Chapter 2 we describe the yield curve and its role in valuation. In Chapter 4, we discuss several measures of yield curve risk.

Yield Volatility

When measuring interest rate risk, another dimension to consider is how volatile interest rates are. For example, as we will explain in Chapter 3, all other factors equal, the higher the coupon rate, the lower the duration. Thus a 10-year high-yield corporate bond has a lower duration than a current coupon 10-year Treasury note since the former has a higher coupon rate. Does this mean that a 10-year high-yield corporate bond has less interest rate risk than a current coupon 10-year Treasury note? Consider also that a 10-year Swiss government bond has a lower coupon rate than a current coupon 10-year U.S. Treasury note and therefore a higher duration. Does this mean that a 10-year Swiss government bond has greater interest rate risk than a current coupon 10-year U.S. Treasury note? The missing link is the relative volatility of rates which we shall refer to as *yield volatility.*

The greater the expected yield volatility, the greater the interest rate risk for a given duration and current value of a position. In the case of high-yield corporate bonds, while their durations are less than current coupon Treasuries of the same maturity, the yield volatility on junk bonds is greater than that of current coupon Treasuries. For the 10-year Swiss government bond, while the duration is greater than for a current coupon 10-year U.S. Treasury, the yield volatility of 10-year Swiss bonds is considerably less than that of 10-year Treasury U.S. bonds.

Consequently, to measure the exposure of a portfolio or position to rate changes it is necessary to measure yield volatility. This requires an understanding of the fundamental principles of probability distributions. This topic is covered in Chapter 5. The measure of yield volatility is the standard deviation of yield changes. In Chapter 6, we show how to estimate yield volatility. As we will see, depending on the underlying assumptions, there could be a wide range for the yield volatility estimate.

Value at Risk

A framework that ties together the price sensitivity of a bond position to rate changes and yield volatility is the *value-at-risk* (VaR) framework.

Risk in this framework is defined as the maximum estimated loss in market value of a given position that is expected to happen a certain percentage of times. JP Morgan has been the major force in promoting VaR. Its VaR system is *RiskMetrics*™.

We will discuss the interest rate VaR framework in Chapter 5 after we have discussed duration, yield volatility, and probability distributions. What is critical to understand is that measures of duration and yield volatility are not precise, therefore, there could be considerable variation in the VaR of a position.

A VaR measure can be computed for a single bond position or a bond portfolio. Measurement of the risk of a portfolio of bonds or the risk of several trading positions in different assets is more complicated. This measurement involves the correlation between the yields or prices of these assets. For this reason, we describe correlation analysis in Chapter 7 and explain how correlation affects the risk of a portfolio.

Tracking Error

For a bond portfolio manager whose benchmark is a bond market index such as the Lehman Brothers Aggregate Bond Index or the Salomon Smith Barney Broad-Investment Grade Index, risk can be measured in terms of tracking error—the standard deviation of the difference in the return on a portfolio and the return on the benchmark. A forward-looking tracking error allows a manager to determine the future exposure of a bond portfolio relative to a benchmark. Moreover, the reasons for the tracking error can be explained in terms of risk factors—systematic and nonsystematic risk factors.

One of the major risk systematic risk factors is the term structure risk factor. Tracking error due to the term structure risk factor indicates how the duration and yield curve exposure mismatch relative to a benchmark affect will affect tracking error. Tracking error and tracking error due to the term structure risk factor are discussed in Chapter 4.

Controlling Interest Rate Risk

Once the interest rate risk of a bond portfolio or position is measured, the next step in risk management is to alter the risk exposure to an acceptable level. This is the control phase of risk management.

To control the interest rate risk of a position or portfolio, a position must be taken in another instrument or instruments. We shall refer to an instrument that is used to control the risk of a position as a *risk control instrument*. These instruments include derivative instruments and cash market instruments. The former includes futures, forwards, options, swaps,

caps, and floors. They are referred to as derivative instruments because their value is derived from some underlying price, index, or interest rate.

Typically, when cash market instruments are used the instruments of choice are Treasury securities or stripped Treasuries (i.e., zero-coupon Treasuries). In the case of positions in mortgage-backed securities, certain types of mortgage strips (i.e., interest-only and principal-only securities) and certain collateralized mortgage obligation (CMO) products are used. Typically, these products are created from mortgage passthrough securities. These mortgage products are referred to as *mortgage derivative products* because they derive their value from mortgage passthrough securities.

With the advent of derivative instruments, risk management, in its broadest sense, assumes a new dimension. Risk managers can achieve new degrees of freedom. It is now possible to alter the interest rate sensitivity of a bond portfolio, bond position, or asset/liability position economically and quickly. Derivative instruments offer risk and return patterns that previously were either unavailable or too costly to achieve.

In Chapters 9, 10, 11, and 12 we describe these derivative instruments for controlling interest rate risk. Chapter 9 describes futures, forward contracts, and forward rate agreements. Chapter 10 describes interest rate swaps and swaptions. Chapters 11 and 12 cover interest rate options and related products. Chapter 11 focuses on exchange-traded options. Chapter 12 looks at over-the-counter options, interest caps, and interest rate floors.

The selection of the specific instrument or instruments to use involves determining which risk control instruments are the most appropriate to employ given the investment objectives. A key factor in this decision is the correlation between the yield movement of a potential risk control instrument and the yield movement of the bonds whose interest rate risk the manager seeks to control. In addition, it may be necessary to estimate the relationship between yield movements using regression analysis. Correlation and regression analyses are covered in Chapter 8.

Once the appropriate risk control instrument or instruments are selected, the appropriate position (i.e., long or short) and the amount of the position must be determined. The potential outcome of the risk control strategy can then be assessed prior to its implementation. We will explain how this is done in Chapters 13 and 14 using derivative instruments.

CREDIT RISK

Credit risk includes credit default risk and credit spread risk. The former form of credit risk is the risk that an issuer of debt (obligor) is unable to

meet its financial obligations resulting in an investor incurring a loss equal to the amount owed by the obligor less any recovery amount. *Credit spread risk* is the risk of financial loss or the underperformance of a portfolio resulting from changes in the level of credit spreads used in the marking-to-market of a product. *Downgrade risk* is a form of credit spread risk because the anticipating or actual downgrading of an issue or issuer will result in an increase in the credit spread.

Measuring Credit Risk

There are various ways that the two forms of credit risk can be measured. They include the use of credit ratings, rating transition tables, credit VaR, and tracking error due to credit risk.

Rating agencies in the United States—Fitch Ratings, Moody's, and Standard & Poor's—assess the credit default risk of an issuer or issue and express their view in the form of a rating. A *rating transition table*, also called a *rating migration table*, is a table that shows how ratings at the beginning of some time period change at the end of a time period. Rating migration tables, produced periodically by the three rating agencies, can be used to gauge downgrade risk.

Credit VaR performs the same function as interest rate VaR. There are various vendors of credit VaR. Similarly, tracking error can be used to measure exposure to credit risk. Tracking error due to quality risk (one type of systematic risk) and due to nonsystematic risk (specifically, issuer-specific and issue-specific risk) can be used to assess the potential risk exposure of a portfolio due to credit risk.

The approaches to measuring credit risk are covered in Chapter 15. Also discussed in that chapter are default rates and default loss rates and recent empirical evidence regarding their historical values.

Controlling Credit Risk

Credit derivatives can be used to control the two forms of credit risk. Credit derivatives include credit default swaps, total return swaps, credit options, and credit forwards. The most popular type of credit derivative is the credit default swap. Each of these instruments is explained in Chapter 16, along with an explanation of how they can be used to control credit risk. The basics of valuing credit derivatives is the subject of Chapter 17.

In Chapter 18 we show how credit derivatives can be combined with securitization techniques to create structured products, used by banks to manage credit risk and regulatory capital. These structures include synthetic collateralized debt obligations and credit-linked notes.

KEY POINTS

1. To control interest rate risk, a manager must be able to quantify the potential dollar loss of a position resulting from an adverse interest rate change.

2. The key to measuring the potential dollar loss of a position is having a good valuation model that can be used to determine what the value of a position is after an adverse rate change.

3. The full valuation approach to measuring the potential dollar loss of a position after the adverse rate change uses a valuation model.

4. Scenario analysis is used to estimate the dollar loss for various interest rate scenarios.

5. The duration approach is an alternative approach for estimating the potential dollar loss for any adverse rate change.

6. The duration of a position is the approximate percentage change in the position's value for a 100-basis-point change in rates.

7. A good valuation model is needed to obtain the duration estimate.

8. The advantage of the duration approach over the full valuation approach is that it allows the manager to quickly estimate the effect of an adverse rate change on the potential dollar loss.

9. A drawback of the duration approach is that duration is only a first approximation of how sensitive the value of a bond or bond portfolio is to rate changes.

10. The duration approach to risk management is referred to as the parametric approach, while the full valuation approach is called the nonparametric approach.

11. Measurement of the interest rate risk of a position must take into account expected yield volatility.

12. The greater the expected yield volatility, the greater the interest rate risk of a position for a given duration and current value of a position.

13. Yield volatility is measured by the standard deviation of yield changes.

14. The value-at-risk framework ties together the price sensitivity of a bond position to rate changes and yield volatility.

15. In the value-at-risk framework, *risk* is defined as the maximum estimated loss in market value of a given position that is expected to happen a certain percentage of times.

16. Tracking error is the standard deviation of the difference between the return on a portfolio and return on a benchmark.

17. Tracking error is the most common measure used by bond portfolio managers in assessing performance versus a bond market index.

18. Yield curve risk of a bond portfolio can be assessed by computing the tracking error due to the term structure risk factor.

19. The control phase of risk management involves altering the risk exposure to an acceptable level.

20. To control the interest rate risk of a position or portfolio, a position must be taken in one or more risk control instruments.

21. Risk control instruments include derivative instruments (futures, forwards, options, swaps, caps, and floors) and cash market instruments.

22. Derivative instruments allow a risk manager to alter the interest rate sensitivity of a bond portfolio or position or an asset/liability position economically and quickly.

23. A key factor in selecting the risk control instrument to employ is the correlation between the yield movements of the bond, whose risk is sought to be controlled, and the candidate risk control instrument.

24. Once the appropriate risk control instrument (or instruments) is selected, the appropriate position (i.e., long or short) and the amount of the position must be determined.

25. Credit default risk and credit spread risk are forms of credit risk.

26. Downgrade risk is related to credit spread risk.

27. Credit rating can be used to gauge credit default risk.

28. Rating transition tables produced by rating agencies can be used to gauge downgrade risk.

29. Value-at-risk can be computed for credit risk and there are several vendors that provide credit VaR systems.

30. Tracking error due to credit risk can be computed to measure the credit risk exposure of a bond portfolio relative to a benchmark.

31. Credit derivatives can be used to control credit risk, the most popular credit derivative being credit default swaps.

32. Synthetic collateralized debt obligations and credit-linked notes can be used to manage a bank's exposure to credit risk.