CHAPTER 1
Relative Value

THE CONCEPT OF RELATIVE VALUE

Relative value is a quantitative analytical approach toward financial markets based on two fundamental notions of modern financial economics.

Proposition 1: If two securities have identical payoffs in every future state of the world, then they should have identical prices today.

Violation of this principle would result in the existence of an arbitrage opportunity, which is inconsistent with equilibrium in financial markets.

This proposition seems relatively straightforward now, but this wasn't always the case. In fact, Kenneth Arrow and Gérard Debreu won Nobel prizes in economics in 1972 and 1983 in part for their work establishing this result. And Myron Scholes and Robert Merton later won Nobel prizes in economics in 1997 for applying this proposition to the valuation of options. In particular, along with Fischer Black, they identified a self-financing portfolio that could dynamically replicate the payoff of an option, and they were able to determine the value of this underlying option by valuing this replicating portfolio.

Most of the financial models discussed in this book are based on the application of this proposition in various contexts.

Proposition 2: If two securities present investors with identical risks, they should offer identical expected returns.

This result may appear intuitive, but it's somewhat more difficult to establish than the first result. Of particular interest for our purposes is that the result can be established via the *Arbitrage Pricing Theory*, which assumes the existence of unobservable, linear factors that drive returns.

In this case, it's possible to combine securities into portfolios that expose investors to any one of the risk factors without involving exposure to any of the other risk factors. In the limit, as the number of securities in the portfolio increases, the security-specific risks can be diversified away. And in this case, any security-specific risk that offered a non-zero expected return would present investors with an arbitrage opportunity, at least in the limit, as the remaining risk factors could be immunized by creating an appropriate portfolio of tradable securities.

For our purposes, this is a powerful result, as it allows us to analyze historical data for the existence of linear factors and to construct portfolios that expose us either to these specific factors or to security-specific risks, at our discretion. In fact, *principal component analysis* (PCA) can be applied directly in this framework, and we'll rely heavily on PCA as one of the two main statistical models we discuss in this book.

THE SOURCES OF RELATIVE VALUE OPPORTUNITIES

From these two propositions, it's clear that the absence of arbitrage is the assumption that drives many of the models we use as relative value analysts. This should come as no surprise, since one of the main roles of a relative value analyst is to search for arbitrage opportunities.

But for some people, this state of affairs presents a bit of a paradox. *If our modeling assumptions are correct about the absence of free lunches, why do analysts and traders search so hard for them?*

This apparent paradox can be resolved with two observations. The first is the recognition that arbitrage opportunities are rare precisely because hardworking analysts invest considerable effort trying to find them. If these opportunities could never be found, or if they never generated any profits for those who found them, analysts would stop searching for them. But in this case, opportunities would reappear, and analysts would renew their search for them as reports of their existence circulated.

The second observation that helps resolve this paradox is that even seemingly riskless arbitrage opportunities carry some risk when pursued in practice. For example, one of the simpler arbitrages in fixed income markets is the relation between bond prices, repo rates, and bond futures prices. If a bond futures contract is too rich, a trader can sell the futures contract, buy the bond, and borrow the purchase price of the bond in the repo market, with the bond being used as collateral for the loan. At the expiration of the contract, the bond will be returned to the trader by his repo counterparty, and the trader can deliver the bond into the futures contract. In theory, this would allow the trader to make a riskless arbitrage profit. But, in practice, there are risks to this strategy.

For example, the repo counterparty may fail to deliver the bonds to the trader promptly at the end of the repo transaction, in which case the trader may have difficulty delivering the bonds into the futures contract. Failure to deliver carries significant penalties in some cases, and the risk of incurring these penalties needs to be incorporated into the evaluation of this seemingly riskless arbitrage opportunity.

These perspectives help us reconcile the existence of arbitrage opportunities in practice with the theoretical assumptions behind the valuation models we use. But they don't explain the sources of these arbitrage or relative value opportunities, and we'll discuss a few of the more important sources here.

Demand for Immediacy

In many cases, relative value opportunities will appear when some trader experiences an unusually urgent need to transact, particularly in large size. Such a trader will transact his initial business at a price that reflects typical liquidity in the market. But if the trader then needs to transact additional trades in the same security, he may have to entice other market participants to provide the necessary liquidity by agreeing to transact at a more attractive price. For example, he may have to agree to sell at a lower price or to buy at a higher price than would be typical for that security. In so doing, this trader is signaling a demand for immediacy in trading, and he's offering a premium to other traders who can satisfy this demand.

The relative value trader searches for opportunities in which he can be paid attractive premiums for satisfying these demands for immediacy. He uses his capital to satisfy these demands, warehousing the securities until he can liquidate them at more typical prices, being careful to hedge the risks of the transactions in a cost-effective and prudent manner.

Because these markets are so competitive, the premiums paid for immediacy are often small relative to the sizes of the positions. As a result, the typical relative value fund will be run with leverage that is higher than the leverage of, say, a global macro fund. Consequently, it's important to pay attention to small details and to hedge risks carefully.

Misspecified Models

It sometimes happens that market participants overlook relevant issues when modeling security prices, and the use of misspecified models can result in attractive relative value opportunities for those who spot these errors early.

For example, until the mid-1990s, most analysts failed to incorporate the convexity bias when assessing the relative valuations of Eurodollar futures contracts and forward rate agreements. As market participants came to realize the importance of this adjustment, the relative valuations of these two instruments changed over time, resulting in attractive profits for those who had identified this issue relatively early.

In recent years, as credit concerns have increased for many governments, it has become increasingly important to reflect sovereign credit risk as an explicit factor in swap spread valuation models, and we discuss this issue in considerable detail in this book.

Regulatory Arbitrage

The fixed income markets are populated by market participants of many types across many different regulatory jurisdictions, and the regulatory differences between them can produce relative value opportunities for some.

For example, when thinking about the relative valuations of unsecured short-term loans and loans secured by government bonds in the repo market, traders at European banks will consider the fact that the unsecured loan will attract a greater regulatory charge under the Basel accords. On the other hand, traders working for money market funds in the US won't be subject to the Basel accords and are likely to focus instead on the relative credit risks of the two short-term deposits. The difference in regulatory treatment may result in relative valuations that leave the European bank indifferent between the two alternatives but that present a relative value opportunity for the US money market fund.

THE INSIGHTS FROM RELATIVE VALUE ANALYSIS

In some sense, relative value analysis can be defined as the process of gaining insights into the relationships between different market instruments and the external forces driving their pricing. These insights facilitate arbitrage trading, but they also allow us more generally to develop an understanding of the market mechanisms that drive valuations and of the ways seemingly different markets are interconnected.

As a consequence, relative value analysis, which originated in arbitrage trading, has a much broader scope of applications. It can reveal the origins of certain market relations, the reasons a security is priced a certain way, and the relative value of this pricing in relation to the prices of other securities. And in the event that a security is found to be misvalued, relative value analysis suggests ways in which the mispricing can be exploited through specific trading positions. In brief, relative value analysis is a prism through which we view the machinery driving market pricing amidst a multitude of changing market prices.

As an example, consider the divergence of swap spreads for German Bunds and US Treasuries during the financial crisis, which might appear inextricable without considering the effects of cross-currency basis swaps (CCBS), intra-currency basis swaps (ICBS), and credit default swaps (CDS).

In this case, CCBS spreads widened as a result of the difficulties that European banks experienced in raising USD liabilities against their USD assets. On the other hand, arbitrage between Bunds, swapped into USD, and Treasuries prevented an excessive cheapening of Bunds versus USD LIBOR. As a consequence, Bunds richened significantly against EURIBOR (see Chapter 16 for more details).

However, given the relationship between European banks and sovereigns, the difficulties of European banks were also reflected in a widening of European sovereign CDS levels. Hence, Bunds richened versus EURIBOR at the same time as German CDS levels increased.

An analyst who fails to consider these interconnected valuation relations may find the combination of richening Bunds and increasing German CDS opaque and puzzling. But a well-equipped relative value analyst can disentangle these valuation relations explicitly to identify the factors that are driving valuations in these markets. And armed with this knowledge, the analyst can apply these insights to other instruments, potentially uncovering additional relative value opportunities.

THE APPLICATIONS OF RELATIVE VALUE ANALYSIS

Relative value analysis has a number of applications.

Trading

One of the most important applications of relative value analysis is relative value trading, in which various securities are bought and others sold with the goal of enhancing the risk-adjusted expected return of a trading book.

Identifying relatively rich and relatively cheap securities is an important skill for a relative value trader, but additional skills are required to be successful as a relative value trader. For example, rich securities can and often do become richer, while cheap securities can and often do become cheaper. A successful relative value trader needs to be able to identify some of the reasons that securities are rich or cheap in order to form realistic expectations about the likelihood of future richening or cheapening. We discuss this and other important skills throughout this book.

Hedging and Immunization

Relative value analysis is also an important consideration when hedging or otherwise immunizing positions against various risks. For example, consider a flow trader who is sold a position in ten-year (10Y) French government bonds by a customer. This trader faces a number of alternatives for hedging this risk.

He could try to sell the French bond to another client or to an interdealer broker. He could sell another French bond with a similar maturity. He could sell Bund futures contracts or German Bunds with similar maturities. He could pay fixed in an interest rate swap. He could buy payer swaptions or sell receiver swaptions with various strikes. He could sell liquid supranational or agency bonds issued by entities such as the European Investment Bank. Depending on his expectations, he might even sell bonds denominated in other currencies, such as US Treasuries or UK Gilts. Or he might choose to implement a combination of these hedging strategies.

In devising a hedging strategy, a skilled trader will consider the relative valuations of the various securities that can be used as hedging instruments. If he expects Bunds to cheapen relative to the alternatives, he may choose to sell German Bunds as a hedge. And if he believes Bund futures are likely to cheapen relative to cash Bunds, he may choose to implement this hedge via futures contracts rather than in the cash market.

By considering the relative value implications of these hedging alternatives, a skilled flow trader can enhance the risk-adjusted expected return of his book. In this way, the value of the book reflects not only the franchise value of the customer flow but also the relative value opportunities in the market and the analytical skills of the trader managing the book.

Given the increasing competitiveness of running a fixed income flow business, firms that incorporate relative value analysis as part of their business can expect to increase their marginal revenues, allowing them to generate higher profits and/or to offer liquidity to customers at more competitive rates.

Security Selection

In many respects, a long-only investment manager faces many of the same issues as the flow trader in the previous example. Just as a flow trader can expect to enhance the risk-adjusted performance of his book by incorporating relative value analysis into his hedging choices, a long-only investment manager can expect to enhance the risk-adjusted performance of his portfolio by incorporating relative value analysis into his security selection process.

For example, an investment manager who wants to increase his exposure to the 10Y sector of the EUR debt market could buy government bonds issued by France, Germany, Italy, Spain, the Netherlands, or any of the other EMU member states. Or he could buy Bund futures or receive fixed in a EURIBOR or ESTR interest rate swap. Or he might buy a US Treasury in conjunction with a cross-currency basis swap, thereby synthetically creating a US government bond denominated in euros.

An investment manager who incorporates relative value analysis as part of his investment process is likely to increase his alpha and therefore over time to outperform an otherwise similar manager with the same beta who doesn't incorporate relative value analysis.

THE CRAFT OF RELATIVE VALUE ANALYSIS

Relative value analysis is neither a science nor an art. Rather, it's a craft, with elements of both science and art. For a practitioner to complete the journey from apprentice to master craftsman, he needs to learn to use the tools of the trade, and in this book we introduce these tools along with their foundations in the mathematical science of statistics and in the social science of financial economics.

We also do our best to explain the practical benefits and potential pitfalls of applying these tools in practice. In the development of an apprentice, there is no substitute for repeated use of the tools of the trade in the presence of a master craftsman. So we make every effort in this book to convey the benefit of our experience over many years of applying these tools.

Since financial and statistical models are the tools of the trade for a relative value analyst, it's important that the analyst chooses these tools carefully, with an eye toward usefulness, analytical scope, and parsimony.

Usefulness

In our view, models are neither right nor wrong. Pure mathematicians may be impressed by truth and beauty, but the craftsman is concerned with usefulness. To us, various models have varying degrees of usefulness, depending on the context in which they're applied.

As Milton Friedman reminds us in his 1966 essay “The Methodology of Positive Economics,” models are appropriately judged by their implications. The usefulness of a particular model is not a function of the realism of its assumptions but rather of the quality of its predictions.

For relative value analysts, models are useful if they allow us to identify relative misvaluations between and among securities, and if they improve the quality of the predictions we make about the future richening and cheapening of these securities.

For example, we agree with critics who note that the Black–Scholes model is *wrong*, in the sense that it makes predictions about option prices that are in some ways systematically inconsistent with the prices of options as repeatedly observed in various markets. However, we've found the Black–Scholes model to be useful in many contexts, as have a large number of analysts and traders. It's important to be familiar with its problems and pitfalls, and like most tools it can do damage if used improperly. But we recommend it as a tool of the trade that is quite useful in a number of contexts.

Analytical Scope (Applicability)

For our purposes, it's also useful for a model to have a broad scope, with applicability to a wide range of situations. For example, principal component analysis (PCA) has proven to be useful in a large number of applications, including interest rates, swap spreads, implied volatilities, and the prices of equities, grains, metals, energy, and other commodities. As with any powerful model, there is a cost to implementing PCA, but the applicability of the model once it has been built means that the benefits of the implementation tend to be well worth the costs.

Other statistical models with broad applicability are those that characterize the mean-reverting properties of various financial variables. Over considerable periods of time, persistent mean reversion has been observed in quite a large number of financial variables, including interest rates, curve slopes, butterfly spreads, term premiums, and implied volatilities. And in the commodity markets, mean reversion has been found in quite a number of spreads, such as those between gold and silver, corn and wheat, crack spreads in the energy complexes, and crush spreads in the soybean complex.

The ubiquity of mean-reverting behavior in financial markets implies that mean reversion models have a tremendous applicability. As a result, we consider them some of the more useful tools of a well-equipped relative value analyst, and we discuss them in some detail in this book.

Parsimony

From our perspective, it's also useful for a model to be parsimonious. As Einstein articulated in his 1933 lecture “On the Method of Theoretical Physics,” “It can scarcely be denied that the supreme goal of all theory is to make irreducible basic elements as simple and as few as possible without having to surrender the adequate representation of a single datum of experience.”

In our context, it's important to note the relative nature of the word “adequate.” In most circumstances, there is an inevitable tradeoff between the parsimony of a model and its ability to represent experience. The goal of people developing models is to improve this tradeoff in various contexts. The goal of people using models is to select those models that offer the best tradeoff between costs and benefits in specific applications. And it's in that sense that we characterize the models in this book as being useful in the context of relative value analysis.

SUMMARY OF CONTENTS

Relative value analysis models can be divided into two categories: statistical and financial. Statistical models require no specific knowledge about the instrument that is being modeled and are hence universally applicable. For example, a mean reversion model only needs to know the time series, not whether the time series represents yields, swap spreads, or volatilities, nor what drives that time series.

Financial models, on the other hand, give insight into the specific driving forces and relationships of a particular instrument (and are therefore different for each instrument). For example, the specific knowledge that swap spreads versus LIBOR include the unsecured–secured basis can explain its statistical behavior.

While we present the models in two separate categories, comprehensive relative value analysis combines both. The successful relative value trader described above might first use statistical models to identify which instruments are rich and cheap relative to each other, and then apply financial models in order to gain insights into the reasons for that richness and cheapness, on which basis he can assess the likelihood for the richness and cheapness to correct. If he sees a sufficient probability for the spread position to be an attractive trade, he can then use statistical models again to calculate, among others, the appropriate hedge ratios and the expected holding horizon.

Statistical Models

The two types of statistical models presented here are designed to capture two of the most useful statistical properties frequently observed in the fixed income markets: the tendency for many spreads to revert toward their longer-run means over time and the tendency for many variables to increase and decrease together. The first chapters model these properties separately, while the last chapter models the two properties simultaneously.

Mean Reversion

Many financial spreads exhibit a persistent tendency to revert toward their means, providing a potential source of return predictability. In this chapter, we discuss stochastic processes that are useful in modeling this mean reversion, and we present ways in which data can be used to estimate the parameters of these processes. Once the parameters have been estimated, we can calculate the half-life of a process and make probabilistic statements about the value of the spread at various points in the future.

We also present the concept of a first passage time and show ways to calculate probabilities for first passage times. Once we have these first passage time densities, we can provide probabilistic answers to some of the more perplexing questions that are typical on a trading desk.

Over what time period should I expect this trade to perform? What sort of return target is reasonable over the next month? How likely am I to hit a stop-loss if placed at this level? First passage time densities can provide probabilistic answers to these questions, and we discuss practical ways in which they can be implemented in a trading environment.

Principal Component Analysis

Many large data sets in finance appear to be driven by a smaller number of factors, and the ability to reduce the dimensionality of these data sets by projecting them onto these factors is a very useful method for analyzing and identifying relative value opportunities. In this chapter we discuss PCA in some detail. We address not only the mathematics of the approach but also the practicalities involved in applying PCA in real-world applications, including trading the underlying factors and hedging the factor risk when trading specific securities.

Multivariate Mean Reversion

Chapter 2 discusses ways to model univariate series that exhibit mean reversion and Chapter 3 ways to model multivariate series that exhibit correlation. In this chapter, we discuss the multivariate Ornstein–Uhlenbeck process as a way to model multivariate series that exhibit both mean reversion and correlation. This combined perspective is capable of capturing a richer set of behaviors than even the combination of the two separate approaches, such as the nonmonotonic behavior in the path of expected values over time.

Financial Models

The financial models in this section are relative value models in that they value one security in relation to one or more other securities. To some extent, the chapters build on one another, with the material for one chapter serving as a starting point for the material in another chapter. And the links between asset, basis, and credit default swaps result in strong interdependencies between the chapters treating them, which therefore together form a “swap block” of chapters.

Some Comments on Yield, Duration, and Convexity

A working knowledge of bond and interest rate mathematics is a prerequisite for this book. But we believe some of the basic bond math taught to practitioners is simply wrong, or at the very least misleading. For example, the *basis point value* of a bond is fundamentally a different concept from the *value of a basis point* for a swap, yet many practitioners are unclear about this difference. As another example, the Macaulay duration of a bond is often referred to as the weighted average time to maturity of a bond, but this is only true when all the zero-coupon bonds that constitute the coupon-paying bond have the same yield, a condition that is almost never observed in practice. We also discuss the frequent misuse of bond convexity and suggest a more practical interpretation of the concept.

Some Comments on Yield Curve Modeling

While yield curve models take center stage in many academic papers, the practical focus of this book downgrades their role to supporting concrete analytic tasks. But even here, they are ubiquitous. This chapter therefore reflects on the implicit model assumptions. It also offers some thoughts about mixed jump-diffusion processes and shadow rate models.

Bond Futures Contracts

A simple no-arbitrage relation applies to the relative values of a cash bond, the repo rate for the bond, and the forward price of the bond. But government bond futures contracts typically contain embedded delivery options, which complicate the analysis. We present a multi-factor model for valuing the embedded delivery option, which can be implemented in a spreadsheet using basic stochastic simulation.

Fitted Bond Curves

Fitting curves to the prices of government bonds observed in the market provides two main results: (1) times series of constant maturity par (or zero) bond yields as input variables for a PCA, for example; and (2) a fair value for every individual bond, i.e. a common yardstick to measure its richness or cheapness relative to other bonds. We discuss different functional forms and add external explanatory variables to the curve fitting process, allowing adjustment for impacts from benchmark status or repo specialness on bond prices.

An Analytic Process for Government Bond Markets

Before starting the “swap block” of chapters, we take stock of the statistical and financial models presented so far and illustrate how they could be combined into a comprehensive analytical process for government bond markets.

Overview of the Following Chapters: Asset Swaps, Basis Swaps, Credit Default Swaps, and Their Mutual Influences

All global asset swaps, basis swaps, and credit default swaps are linked, resulting in interesting and complex relationships. A consequence for the presentation in this book is, therefore, that the individual pricing of the different types of swaps takes place in the framework of mutual dependencies. This framework is sketched at the beginning of the swap block of chapters in order to equip the reader with a map through the multitude of relationships between the instruments described in following chapters. Once the journey through the swap block of chapters is completed, these mutual influences can be analyzed quantitatively to a certain extent.

Reference Rates

The key conceptual approach to price swap spreads is to consider them as a basis swap between the repo rate of the bond and the reference rate of the swap, the types of which have increased following the (partial) transition away from LIBOR. This chapter classifies the different reference rates, provides a model for the spreads between them and for their spread to the repo rate. The basis between unsecured and secured reference rates is identified as a major driving force of these spreads.

Asset Swaps

With this foundation it is straightforward to calculate the impact of different funding rates (repo for the bond, LIBOR, OIS or SOFR for the swap) on asset swap spreads. Since an asset swap not only exchanges funding rates but also credit exposure, the impact of different credit risk needs to be added to the swap spread model. The CDS provides a market price for the credit risk of bonds and thus is an obvious candidate to be included among the input variables for the swap spread model.

Credit Default Swaps

However, the price of sovereign CDS usually expresses the credit risk together with the value of the delivery option and of the fact that in case of default the compensation is paid in USD. The foremost task of this chapter is therefore to extract the pure credit information from the CDS market in order to be able to use it as input in the swap spread formula. Unfortunately, the scarcity of observations of previous relevant government defaults results in a significant estimation error. We then discuss also other applications of CDS in RV analysis and trading.

Intra-Currency Basis Swaps

ICBS exchange two different reference rates in the same currency. Hence, they can be valued by applying the model for spreads between reference rates.

Cross-Currency Basis Swaps

CCBS exchange reference rates in different currencies. Since by convention one leg is always USD SOFR and there is no secured reference rate in other currencies, they also involve an exchange between different types of reference rates. By combining ICBS and CCBS, any reference rate in any currency can be swapped into any other. These basis swaps therefore fulfill the function of building blocks and of linking all global swap markets.

Combinations and Mutual Influences of Asset, Basis, and Credit Default Swaps

By combining asset and basis swaps, every bond can be expressed as a spread versus USD SOFR, which is therefore a universal yardstick for comparing all global bonds and the basis for asset allocation and funding decisions. Likewise, the CDS also measures every bond as a spread versus USD SOFR. Using the insights into the delivery option and USD-redemption from the CDS chapter, we present arbitrage relationships between both.

The existence of a universal yardstick and of arbitrage relationships results in strong interdependencies between all asset, basis, and credit default swap markets worldwide. Their analysis is therefore a complex task which should take all these mutual influences into account. We present case studies to illustrate how the links work in practice.

Global Bond RV Via Fitted Curves and Via SOFR Asset Swap Spreads

We show that the deficiencies of swap spreads as rich/cheap indicator for bonds are a consequence of the difference between the swap and bond yield curves, which are manageable in case of SOFR swap spreads only. Hence, to compare bonds in USD, the universal yardstick "SOFR swap spreads" provides a suitable alternative to fitted curves. When comparing bonds in another currency, however, fitting a curve through the basis swapped bonds remains the only reasonable option.

Other Factors Affecting Swap Spreads

At the end of the swap block of chapters we consider those driving factors not captured in its conceptual foundation, such as the impact of increasing leverage constraints and shadow costs. Since some of these variables are unobservable, the goal of modeling and predicting the relationships between bonds and swaps allows only partial and approximative solutions.

Options

We address the analysis and trading of options in a relative value context by discussing three broad categories of option trades. In the first, the trader simply buys or sells an option with a view that the underlying will finish in-the-money or out-of-the-money, with no dynamic trading. In the second, the trader attempts to capitalize on the difference between the implied volatility of the option and the actual volatility that the trader anticipates for the underlying instrument, by trading the option against a dynamic position in the underlying. In the third, the trader positions for a change in the implied volatility of the option, irrespective of the actual volatility of the underlying instrument.

Relative Value in a Broader Perspective

We conclude our sometimes rather technical description of relative value analysis by taking a broader perspective on its macroeconomic functions. At a time when professionals in the financial services industry increasingly need to justify their role in society, we present a few thoughts about the benefits of arbitrage for society.

Throughout the book, we offer pieces of general advice – words of wisdom that we've gleaned over time. We've been mentored by some of the best in the business over the years, with particular thanks to our managers and colleagues in Anshu Jain's Global Relative Value Group at Deutsche Morgan Grenfell, and especially to David Knott, Pam Moulton, and Henry Ritchotte. They were good enough to impart their wisdom to us, and we're happy to pass along this treasure trove of useful advice, hopefully with a few additional pearls of insight and experience that we've been able to add over the years.[1]

Please visit the website accompanying this book to gain access to additional material, www.wiley.com/go/fixedincome

NOTE

[1] When reviewing the first edition of this book, Christian Carrillo, Martin Hohensee, Antti Ilmanen, and Kaare Simonsen provided valuable feedback, enhancing our product. Many participants of our training courses have contributed to the improvements of the second edition.