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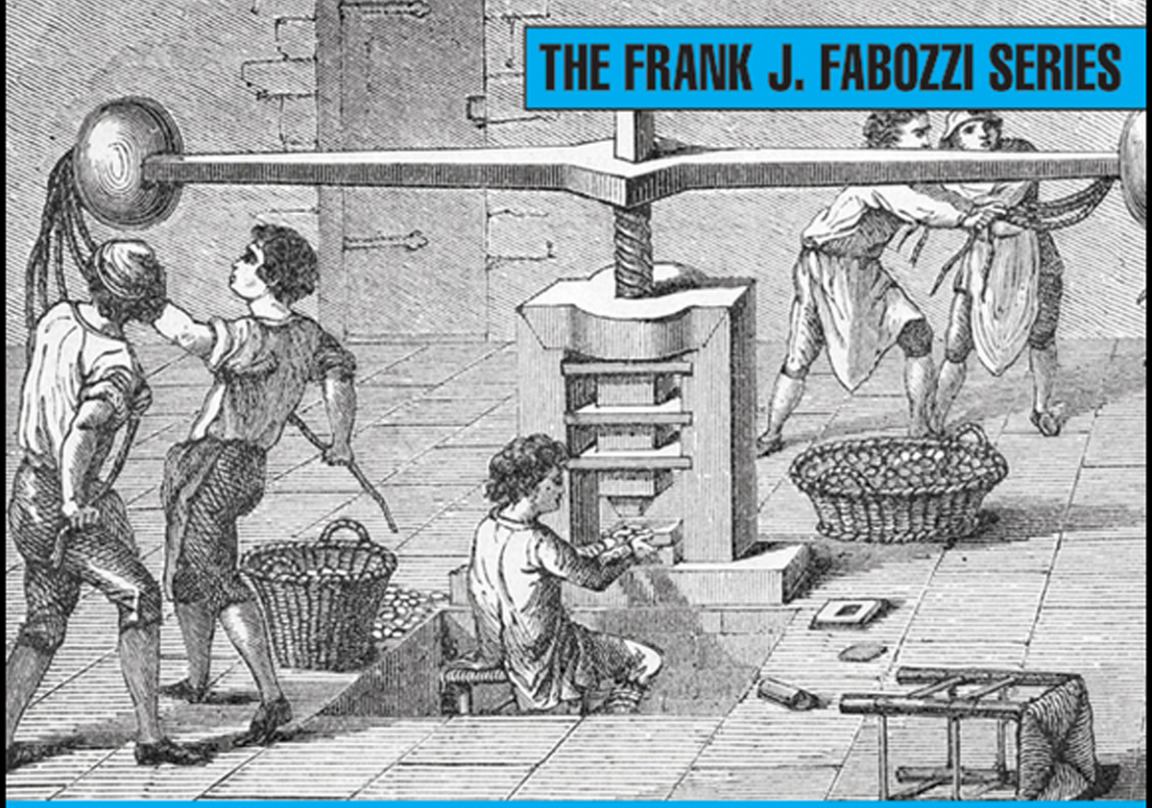

QUANTITATIVE CREDIT PORTFOLIO MANAGEMENT

Practical Innovations for Measuring and Controlling Liquidity, Spread, and Issuer Concentration Risk

ARIK BEN-DOR • LEV DYNKIN • JAY HYMAN • BRUCE D. PHELPS

Additional Praise for
Quantitative Credit Portfolio Management

"A first-class work on credit risk modeling and credit portfolio management. This book addresses real-world challenges that we face every day using extensive theoretical and empirical analysis. I strongly recommend the book to anyone who wants to understand how credit markets work and how to work in credit markets."

—Benjamin Deng, Group Head of Investment Analytics,
AIA Group, Hong Kong

"For many years this quantitative research team has offered new insights and helpful support to many institutional investors such as APG. Based on the extensive data base available to them and the truly two-way dialogue they have with end-investors like us, many empirical questions and dilemmas have been tackled. By introducing concepts such as Duration Times Spread and liquidity scores, the authors have improved our understanding of risk. Moreover, by applying these concepts to the portfolio construction process, we have gained more confidence in the robustness of our portfolios."

—Eduard van Gelderen, CIO Capital Markets,
APG Asset Management, Netherlands

"A must-read for all future and current credit portfolio managers. The book is a comprehensive review of the quantitative tools available to better manage the risks within a credit portfolio and combines the right amount of statistical work with practical answers to questions confronting credit managers."

—Curtis Ishii, Head of Global Fixed Income,
California Public Employees' Retirement System, USA

"For investors who struggled with managing credit risk through the 2007–2009 crisis, *Quantitative Credit Portfolio Management* offers practical answers to vexing questions. Duration Times Spread as a risk measure is one of those elegant innovations in finance that seem obvious in retrospect but have eluded the grasp of previous analysts. The liquidity analysis is the first robust attempt I have seen at quantifying this important factor in the OTC market of corporate bonds. All in all, a strong effort by what is arguably the best team of fixed income research analysts on the Street."

—Randolph E. Wedding, Senior Managing Director, Fixed Income,
Office of the Treasurer of the Regents, University of California, USA

"Lev Dynkin and his coauthors offer insights and practical solutions to critical issues in corporate bond risk analysis. In particular, the measurement of credit spread risk using Duration Times Spread is a powerful tool and a significant improvement over prior market practice. This book reflects top caliber analysis and has many useful applications."

—John Brennan, Portfolio Manager, DB Advisors, USA

"The practical orientation of this book on institutional credit portfolio management makes it particularly useful for practitioners. All key areas of interest are well covered. An excellent effort by a team with extensive industry experience."

—Lim Chow Kiat, President, GIC Asset Management, Singapore

"As an investor coming out of the financial crisis of 2007–2009, I began to wonder if our traditional risk models and fixed income assumptions about portfolio construction and diversification were obsolete. Was this crisis the financial market's equivalent of discovering that the earth is round, or that the earth is not really the center of the universe? As practitioners rethink traditional credit views, it's a perfect time for a fresh approach and some new concepts backed fully by empirical evidence and, most importantly, common sense. It's no longer enough to demonstrate that a risk management framework is empirically sound based on historical data from more 'normal' times. In *Quantitative Credit and Portfolio Management*, the authors apply techniques developed prior to the crisis and pose the question: Would those measures provide insight to events that happened during the crisis itself?

"In short, the ideas presented here simply make sense. Risk managers, portfolio managers and credit specialists can benefit from this book, not to mention inquisitive CIOs. I found the recommendations to be theoretically sound and fundamentally practical to implement."

—Ron Joelson, CIO, Genworth Financial, USA

"This book provides enormous insights for beginning practitioners looking to learn the most advanced credit management techniques. For experienced professionals, it provides a great update and advancement. The empirical evidence and discussion of metrics, such as DTS and Liquidity Cost Scores (LCS), illustrate how these should be used to better manage credit risk as well as liquidity risk in portfolios. The global financial crisis of 2007–2009 and the ongoing sovereign crisis have taught us that the world has changed and more focus should be put on liquidity. Applying and testing their findings in the recent market turmoil strengthens the authors' conclusions and offers many critical tips for managers. The book is a must read for all active players in credit markets given the changes after the recent crisis."

—Jan Straatman, Global CIO,
ING Investment Management, Netherlands

"Lev Dynkin and his team are of the highest authority on fixed income portfolio analytics. Their thoughtful and rigorous quantitative research, unparalleled access to high-quality data, and cooperative approach with leading fixed income managers sets them apart. This book provides the reader with new ideas to improve both risk management and alpha capture in credit portfolios."

—Carolyn Gibbs and Rich King, Co-heads of U.S. Taxable Fixed Income and Global High Income, Invesco, USA

"Quickly and accurately identifying and measuring the risk exposures of credit portfolios has become even more critical in the post-crisis era of low government bond yields. As clients increasingly want pure credit exposure, divorced from the interest rate environment, the techniques described in this book are an important advance in successfully managing fixed income credit portfolios. I recommend this book for managers looking to outperform credit fixed income benchmarks."

—Lisa Coleman, Head of Global Investment-Grade Credit, J.P. Morgan Asset Management, USA

"*Quantitative Credit Portfolio Management* is a one of a kind book addressing everyday issues and topics submitted by investors and practitioners to the QPS team. It presents a decade of research in a single volume. It is a must for portfolio managers willing to understand the nature of corporate bond spread risk (systematic, issuer specific, and liquidity). It introduces the concept of DTS, a superior measure of bond spread risk, and tests its validity across a wide spectrum of asset classes and time periods, including the recent crisis. The practical instructions advocated in this book are best practices that we already rely on in our credit investment process for superior active management."

—Ibrahima Kobar, CIO Fixed Income, Natixis Asset Management, France

"This is a convergence of in-depth analytical research and practical applications to comprehensively understand and quantify systematic and nonsystematic risks in credit and sovereign portfolios and benchmarks. This book is essential reading for investment professionals, portfolio managers, hedge fund managers, pension fund managers, and students of the industry in the post–global financial crisis environment. It shows the way to more effectively manage liquidity, downgrade, default, and derivative risks."

—Susan Buckley, Managing Director, Global Fixed Interest, Queensland Investment Corporation, Australia

"The Quantitative Portfolio Strategy Group led by Lev Dynkin is considered by the fixed income industry to be the leader in the field of quantitative bond investing research. The strength of this book is that all the concepts described are not just theoretical but are used in practice. In addition, many of them, such as liquidity scores, empirical duration, issuer diversification, and fallen angels as an asset class are very topical in today's management of credit portfolios. We consider the joint effort that led to the development of the DTS concept as a breakthrough in the field of credit risk management. The DTS concept has improved our understanding of credit risk and led to better assessment of value in credit markets by our portfolio managers."

—Edith Siermann, CIO Fixed Income, Robeco, Netherlands

"The authors' team has been a solid lighthouse for portfolio managers amid the rough seas of fixed income markets. Its gleam has never died, even in the recent credit turmoil, and guided us to a safe harbor. This book covers their new findings and developments on managing credit portfolios tested in practice during the 2007–2009 crisis, which all practitioners must read regardless of whether they are involved in corporate credit or sovereign markets."

—Seiichiro Nemoto, Head of Pension Research Center,
Sumitomo Trust & Banking Company, Japan

"This book addresses many of the questions every fixed income professional is faced with today, which includes optimal diversification, price behavior during rating changes, and measures of liquidity. The authors are especially well known for introducing the concept of Duration Times Spread for managing credit spread risk. This newest book shows a wide range of potential uses of DTS in constructing and managing a credit portfolio by looking at the results achieved with DTS in the recent crisis. I strongly recommend this book to every bond portfolio manager in the current environment of heightened credit risk even in the sovereign space."

—Sandro Streit, Head of Asset Management,
Swiss National Bank, Switzerland

"The authors . . . industry leaders from Barclays Capital . . . have done it again! Following up on their excellent book, *Quantitative Management of Bond Portfolios* (2006), which brought tremendous insight in the management of multisector bond funds, they have now done an even deeper dive into managing credit portfolios, which is not an easy task to be sure! They not only delve into improved risk management metrics, but also reveal helpful strategies to improve both passive and active fund management. Once again, this team is taking our business to new levels of excellence."

—Ken Volpert, CFA, Head of Taxable Bond Group, Vanguard, USA

"This book tackles the Big C—CREDIT. Market relationships and yield spreads of corporate, sovereign and emerging market debt have morphed nearly beyond recognition over the last 15 years, culminating with the enormous devastation of the global financial crisis. Institutional bond investors have long known to go to Lev and his team with their thorniest and most complex portfolio problems. Here they lay out a very straightforward exposition of best practices in credit portfolio management. This is a must read for those charged with navigating today's global capital markets."

—Ken Leech, former CIO, Western Asset Management Company, USA

"This is another terrific contribution by an established team of Wall Street researchers. In their characteristic style, they masterfully combine rigorous empirical work with practical wisdom and clear intuition. This book should be of great value to both practitioners and academics interested in the cutting edge of thinking in the area of credit risk and portfolio management."

—Leonid Kogan, Nippon Telegraph and Telephone Professor of Management, Sloan School of Management, MIT, USA

"Clients of credit portfolio managers typically ask: What caused the performance and unexpected high volatility during the financial crisis? What have you learned? What changes have you made to your investment process so it doesn't happen again? The right answers lie in this comprehensive book of applied research. It will be required reading for credit portfolio managers interested in risk management, superior performance, and high information ratios."

—Stanley J. Kon, Editor, *Journal of Fixed Income*, USA

"This volume will quickly become an indispensable reference for any fixed income investor. The authors are seasoned practitioners with many years of experience in helping clients manage risk, optimize expected returns, and solve real-world problems using the most sophisticated tools of financial engineering. The profession should be grateful that they're willing to share their insights with the rest of us."

—Andrew W. Lo, Harris & Harris Group Professor, Sloan School of Management, MIT, USA

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To my parents Lya and Ron, and my brother Oren, for their unconditional love, support, and encouragement, and to Shiraz and Shelly, my beloved daughters.
—ABD

To the blessed memory of my father David to whom I owe all my achievements and my motivation to reach them.
—LD

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—JMH

For my teachers
—BDP

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Contents

Foreword

The financial market crisis that began in 2007 delivered a rude shock to corporate bond investors, a constituency whose numbers had been swelled by an extended period of low interest rates and plentiful liquidity. The corporate bond asset class had offered coupon levels seemingly well in excess of any likely defaults, as well as a price volatility relative to government bonds, that was naturally dampened by the cyclical nature of credit quality. Enhanced by structural rigidities that offered well-known opportunities for active managers, these characteristics warranted a nearly permanent overweighting of corporate bonds. This worked until the credit crisis. Ever since, the corporate bond markets have misbehaved dramatically when viewed through traditional lenses, and the havoc wrought to investment portfolios is obvious given the strikingly poor performance delivered by active managers in 2007–2008.

So, is this asset class irreparably damaged? Or do we simply need to address it differently?

In this book, the authors demonstrate convincingly that the deployment of new tools enables investors to continue to harvest the benefits of corporate bond investing whose origins go back as far as the nineteenth century. Indeed, many of these tools were already available and others have been developed in response to investor experience in more recent times. While the approach here is strongly grounded in investment theory, it is also tethered to real-world experiences and does not stray into a merely academic consideration. The authors make extensive use of the rich databases available now to both develop and test the tools they recommend. These applications are eminently capable of practical deployment in day-to-day portfolio management—and I have first-hand experience in their successful utilization.

The symptoms of investor distress provided a natural "to do" list, for which the authors have supplied the remedies. The volatility of individual corporate bonds bore little relation to that suggested by traditional risk measures. The impact of interest rate duration was often surprising. The relationship between the cash markets and derivatives was bent out of shape to the degree that risk-free arbitrage was seemingly on offer. Finally, market liquidity varied widely but uniformly deteriorated. An inability to

quantitatively measure trading liquidity had led the industry to ignore this risk dimension with the result that investors were ill-prepared to manage their way through the market volatility. These symptoms were not limited to active portfolio managers. Investors who simply wished to build representative exposure to the asset class were equally challenged.

This book provides practical tools to address these issues and demonstrates new ways to manage well-established strategies in corporate bond markets. Of course, in this era of impaired national balance sheets, credit worthiness is no longer the exclusive preserve of the corporate bond investor. For this reason, the authors explore how sovereign credit risk can be better approached. With the concept of risk-free investing under threat, providing smarter tools for the management of credit risk could not be timelier.

Paul Abberley
Chief Executive
Aviva Investors
London, U.K.

Introduction

For more than 20 years, the Quantitative Portfolio Strategy Group (QPS) has been a part of Fixed Income Research at Barclays Capital and Lehman Brothers, two dominant providers of bond market indexes and fixed income analytics for institutional investors. Throughout this time, we have been actively involved in all aspects of index design and analytics, and engaged in a frequent dialog with investors benchmarked to both standard and customized indexes as well as managers with pure total return mandates. The benefit of ready access to detailed security-level historical data for index constituent securities has allowed us to address our clients' needs for sensible and implementable solutions to problems arising in managing their portfolios.

Our group's goal since its inception has been to offer objective solutions based on innovative modeling and empirical data analysis. Constant dialog with practitioners from around the globe has kept our research topics firmly grounded in the realities of asset management. In 2007, we published *Quantitative Management of Bond Portfolios* (Princeton University Press) in which we presented some of our most relevant methodologies and findings across a broad spectrum of issues covering portfolio construction, risk management, performance evaluation, and benchmark customization. Since then, the capital markets have suffered the worst calamity since the Great Depression. The tumultuous period of 2007–2009 not only raised many new questions for portfolio managers but also starkly revealed previously overlooked sources of risk and performance. Perhaps most importantly, this period provided quantitative analysts with valuable observations of extreme behavior of fixed income securities. Analysts can now base their studies on a rich historical fixed income data set that includes several "crisis" and "normal" market periods.

In this book, we focus exclusively on management of credit portfolios. Credit portfolio managers traditionally rely on fundamental research for decisions on issuer selection and sector rotation. Quantitative researchers tend to use mathematical techniques for the purpose of pricing and quantifying credit risk. Our research bridges the two approaches. Each chapter in this book is based on questions brought to our attention by credit portfolio

managers and reflects our original research aimed at answering them in an objective, quantitative way. Despite our quantitative orientation, we present all our conclusions and recommendations in an intuitive way that is implementable by all credit managers.

The book is structured in two parts. In the first part, we focus on new measures of spread risk, liquidity risk, and Treasury curve risk. We present empirical and theoretical evidence of the benefits these measures offer to portfolio managers compared to established approaches. In the second part, we turn our attention to portfolio management applications of these new risk measures as well as some new ideas for capturing more of the spread premium in credit portfolios. Throughout the book, we maintain a sharp focus on new research results and their practical implications, especially during the 2007–2009 credit crisis, and do not present a complete overview of existing approaches to each topic. Individual chapters, while often cross referenced, were written such that they can be read independently even if this meant some repetition of earlier material.

PART ONE: MEASURING THE MARKET RISKS OF CORPORATE BONDS

Yields offered to investors holding credit securities compensate them for assuming a variety of different risks together with the complexities of their interdependence. Changes in prices of corporate bonds reflect the impact of the Treasury yield curve movement on the present value of their future cash flows. They also reflect mark-to-market risk resulting from fluctuations in credit spreads to the yield curve (be it Treasury or LIBOR curve) as well as market expectations for "jumps to default" without the interim spread widening. Credit spread fluctuations, in turn, reflect changes in market expectations of future default probabilities and the compensation demanded by credit investors for giving up a certain degree of liquidity. Prices of bonds with embedded options based on call, put, or optional sink provisions are also sensitive to additional factors, such as changes in interest rate volatility.

Established market conventions exist for measuring the sensitivity of corporate bonds to most of these risk factors such as changes in yield curve, spread level, and interest rate volatility. The material in the first part of this book is by no means an overview of these conventions and cannot serve as an introduction to the topic. The issue of interdependence of the risk factors, for example, was addressed in our previous book in the context of the multifactor risk model and is not covered here. Rather, we present some new results and risk measures that we developed to overcome shortcomings of the existing methodologies.

We start by focusing on the behavior of credit spreads and the best approach to capturing a portfolio's exposure to spread changes. Since 2005, we have studied the dynamics of spread change across a broad spectrum of credit asset classes. We found strong empirical evidence that credit spreads do not move in parallel, but rather change in linear proportion to spread levels. In simple terms, when bad news hits a sector, the weakest credits in that sector widen the most. We have shown that while the volatility of absolute spread changes through time is very high, relative spread changes are much more stable, and the difference is at times striking. For instance, while the absolute volatility of the sovereign spread of Greek bonds increased tenfold as a result of the sovereign crisis that started in 2009, the relative spread volatility remained nearly unchanged. Given this evidence, we advocated that a portfolio's sensitivity to spread change should not be expressed simply as contributions to spread duration—a measure of price sensitivity to a parallel shift in spreads—but rather by Duration Times Spread (DTS), representing price sensitivity to a percentage change in spread (Chapters 1 to 4). To demonstrate the out-of-sample predictive power of the DTS approach to forecasting spread changes and managing risk in credit portfolios, we present our empirical findings in each chapter over the time period covered by the original study, rather than update all of the analysis to the present. For instance, we use the spread volatility relationship to spread calibrated to data prior to 2005 from our first DTS study and examine how well it predicted the spread volatility during the 2007–2009 crisis.

The empirical and theoretical support for the DTS approach to credit risk management and its relevance to many portfolio applications (discussed in Part Two) are very compelling. Most of our institutional clients adopted it, benefiting from it greatly, especially during the 2007–2009 crisis. In the DTS framework, a wider spread points to an instantly and proportionally higher spread volatility without the built-in delays of conventional volatility measures based on historical spread variability. As spreads widened rapidly at the start of the 2007–2009 crisis and tightened at its tail end, this instant risk adjustment served investors well in structuring credit portfolios. Practitioners always realized that the spread durations of two portfolios representing the same sector and credit quality cannot be compared if the spreads of their constituent securities are very different. Many investors resorted to empirical beta-adjusted durations obtained by regressing excess returns of a security on the excess return of its peer group—the market. Like any historically based risk measure, these betas are sensitive to the calibration period and adapt slowly to changing markets. We advocate the use of DTS in place of the beta-adjusted spread duration, as we argue that the spread itself is the best beta measure. (This comparison is addressed specifically in Chapter 8.)

We continue by examining a critical source of risk that was often overlooked prior to 2007 but was put front and center in the minds of credit investors by this crisis—liquidity risk. As the crisis unfolded, asset managers approached us with a request to quantify the cost of portfolio liquidation, especially in credit, so their investors could be given advance quantitative guidance as to the liquidity implications of their investment choices. In Chapter 5, we introduce Liquidity Cost Scores (LCS), a security-level numeric measure which represents the cost of a roundtrip transaction in a normal institutional size. LCS is based on bid-offer indications from traders, which have been captured historically as part of the pricing process of Barclays Capital bond market indexes. These quotes cover a significant percentage of securities in the Credit Index. We then calibrate a model to all available quotes and use it to estimate LCS for all non-quoted bonds based on attributes relevant to liquidity. The behavior of LCS through time, cross-sectionally and out-of-sample, strongly suggests that these scores capture market realities. In Chapter 6, we apply this new measure to the task of decomposing credit spreads into liquidity and default components and show the results to be intuitive and informative. We also employ the LCS measure in a variety of portfolio applications discussed in Part Two.

In 2003, we began to investigate the relationship between analytical durations based on theory and empirical durations based on practically observed sensitivities of corporate bonds to Treasury yield curve movement. We have examined this relationship across the spectrum of credit qualities, and through time. Our work focused initially on high-yield bonds. Investors drew our attention to the fact that with high-yield spreads at that time (2002) being historically tight, portfolio managers shouldn't ignore the Treasury durations of this asset class. To understand under what conditions empirical and analytical durations may differ, we first derive in Chapter 7 an explicit theoretical linkage between the two. This linkage suggests that empirical durations depend on the spread level and that they should decline as spreads widen. Indeed, we found that empirical durations of high-yield securities exhibit considerable variation, reaching numbers as high as 40% of the theoretical durations when spreads were at their lows and zero or even negative when high-yield spreads were wide.

We further show that an empirical duration of 25% of the theoretical duration often used by practitioners is, indeed, a good long-term estimate. During the 2007–2009 credit crisis, investment-grade spreads widened beyond levels of high-yield spreads in prior years. Naturally, the question we received from investors was whether at such levels of spread investment grade securities will exhibit the yield curve sensitivity commonly seen for high-yield bonds. Our analysis shows that this was not at all the case. It appeared that investment grade bonds remain highly

sensitive to the yield curve movement even at very wide spreads, while high-yield bonds are much less sensitive even at very tight spreads. The second part of Chapter 7 examines several possible explanations for the segmentation and shows that it is not driven by the differences in pricing conventions, liquidity, or bond characteristics of the two markets. Rather, it represents the market reality and an opportunity for investors to exploit it.

PART TWO: MANAGING CORPORATE BOND PORTFOLIOS

In the second half of the book, we turn our focus to portfolio management issues. We demonstrate how the new risk measures and sensitivities introduced in the first half of the book can be used for constructing, managing, and hedging credit portfolios. This part is structured in three segments, pertaining to the management of spread risk, issuer-specific risk, and liquidity risk.

In the first segment, we apply the concept of DTS introduced in Part One to focus on market risk in a number of portfolio applications. The paradigm shift resulting from the DTS concept has an impact on many decisions for portfolio managers, both in terms of how they manage exposures to systematic risk (industry and quality factors) and their approach to issuer exposures (non-systematic or idiosyncratic risk).

In Chapter 8, we explore the use of DTS in hedging issuer-specific trades. Within the context of long–short pairs trading in the credit default swap (CDS) market, we compare DTS-based hedging with both pure spread duration hedging and with an approach based on empirical betas. We find that the DTS approach is superior at reflecting and neutralizing the systematic spread risk exposures in these trades.

Chapter 9 addresses the use of DTS in risk-neutral positioning of a credit portfolio along the credit curve to maximize carry. For a given DTS, and, consequently, a given level of expected risk (volatility of excess return over duration-matched treasuries), short-dated portfolios offer higher excess returns than long-dated portfolios. Practitioners have long been aware of the superior Sharpe ratios of short-dated corporate bonds. As is often the case with carry trades, the combination of a long position in short-dated corporates and a short position in long-dated corporates generates high information ratios much of the time, but suffers during "tail" events when default expectations rise and the overweight to the short end leads to underperformance.

In Chapter 10, we view the credit crisis of 2007–2009 as a severe out-of-sample test of the DTS model. We revisit the empirical results from Chapter 1 and test how they held up under the extreme stresses of the crisis. We find that the relationship between spread and spread volatility remains strongly linear, albeit with a steeper slope. We show that forward-looking estimates of relative excess return volatility based on DTS (even without updating the spread volatility versus spread slope) were more accurate than those based on absolute spread volatility. In an index replication exercise, we find that matching sector-quality allocations of a credit index in terms of contributions to DTS leads to improved tracking compared with matching the contributions to spread duration. The DTS-based approach to portfolio construction can help to not only replicate an index but also more accurately express active portfolio views. Using DTS to measure spread risk can enhance portfolio risk models in several ways, as discussed at the end of this chapter.

In the second segment of Part Two, we focus on several aspects of optimizing issuer-specific risk in credit portfolios. In Chapter 11, we compare and contrast two different approaches to setting issuer limits. The first is based on an event study of the return implications of an issuer downgrade in the months leading up to it. Observing the severity of the underperformance of a downgraded issuer versus its peers prior to the downgrade helps us derive an optimal position diversification ratio needed to minimize this underperformance. Over the last 20 years, this optimal diversification ratio by the original credit rating changed significantly. In the early 2000s, the return implications of a downgrade were much more severe for issuers initially rated Baa than for those with higher initial ratings. Our study then argued for disproportional diversification of Baa positions and relatively concentrated holdings in issuers rated Aa or A. However, the market experience during the 2007–2009 crisis argues for stricter limits on higher-rated issuers, as a number of financial institutions experienced distress or even default directly from an A rating or better. Instead of relying on historical return data, a second approach to issuer diversification would be to use DTS as the basis for setting position limits. To test this, we use the average DTS of each credit quality bucket to determine its position limit. The diversification ratios by credit quality obtained by this method change over time in a way that is consistent with the results of the first model. We review the relative strengths of the history-based and DTS-based approaches to optimal diversification of issuer-specific risk and recommend using a blend of the two.

Constraints can have a strong influence on the issuer composition of a portfolio. In Chapter 12, we examine the performance implications of certain constraints, often overlooked by investors, embodied in the definition of investment-grade credit benchmarks. Over the past two decades, the excess

returns of investment-grade corporate bonds over duration-matched treasuries have been substantially lower than those implied by their spreads at the beginning of the period, adjusted for realized defaults. We find strong empirical evidence that much of the observed underperformance of investment-grade corporate bonds can be traced to the constraints implicit in the index definition. Index rules, like many investment mandates, require the sale of any securities downgraded to high yield. This rule causes the investment-grade index to lock in the loss of value in the downgraded security at the time it experiences strong, transient selling pressure. Many of these securities eventually proceed to recover, but only after they have been sold out of the index. While this effect benefits the high-yield index, especially its Ba segment, the investment-grade index loses as much as half of its excess return due to this forced selling. We show that adopting a "downgrade-tolerant" investment-grade index can nearly double the reported excess return without any observed increase in risk.

In Chapter 13, we focus on the performance of the "fallen angels" and show that they represent an attractive asset class in its own right. We present strong empirical evidence of the transient price pressure experienced by these securities due to forced selling driven by investment constraints. A study of the time course of this effect shows that this price pressure tends to peak about three months after the downgrade. Over a period of one to two years following the downgrade, most securities recover. A simple rules-based strategy of buying fallen angels immediately after the downgrade and holding them long enough to benefit from this recovery generates high risk-adjusted performance, even after transaction costs.

Finally, in the third segment of Part Two, we explore the issue of replicating the credit index with a liquid portfolio of synthetic or cash securities. Synthetic instruments (CDS baskets and interest rate swaps) remained highly liquid through the 2007–2009 crisis, in stark contrast to cash corporates. This created a high and volatile basis risk between the two as the arbitrage relationship broke down due to a lack of financing on the cash side. As a result, synthetic replicating portfolios tracked cash credit indexes very poorly on a monthly basis as the spread of illiquid cash corporate bonds widened to new highs and then tightened when liquidity returned to the market. Synthetic replication remains a viable liquid alternative for long-horizon replication of credit index returns, as the basis between cash and synthetic corporate securities tends to gradually revert to its mean. For investors who need to replicate the index over short horizons, we discuss the very attractive alternative of creating a fully rules-based basket of a small number of corporate bonds. First, we select a universe of very liquid bonds using our LCS measure; weights are then set according to a transparent and replicable stratified sampling scheme that matches the DTS contribution of the

index to broad sector-duration cells. We create a family of portfolios—TCX (tradable credit index)—and show that they tracked the index very closely on a monthly basis (even during the 2007–2009 crisis), incurred modest turnover, and kept the credit allocation much more liquid than the index itself without a significant deviation in cumulative performance. With the LCS measure built into the portfolio construction process, credit investing need not automatically mean giving up liquidity.

In conclusion, we would like to stress again that all the new ideas and methodologies discussed in this book were developed as a result of inquiries we received from portfolio managers. We consider it a privilege our team enjoyed for decades to be in constant contact with practitioners and be able to stay abreast of their current issues. We are constantly working on developing further and refining all of the risk measures and frameworks discussed here. Topics we have targeted for further research include the applicability of the DTS framework to additional asset classes, term structure effects in relative spread volatility, and finding the best ways to balance market-driven DTS-based portfolio management with minimizing portfolio turnover. We produce monthly LCS reports to give investors a sense of changes in the liquidity profile of various segments of the global bond market. We are looking for ways to quantify the market impact of trades in addition to quantifying the cost of a "normal" size transaction. We hope that credit market practitioners—portfolio managers and research analysts alike—will find the methodologies outlined in this book useful and relevant to their portfolio management needs. As always, we welcome inquiries and challenges to our work as these discussions help us advance the applicability and rigor of our future research.

Notes on Terminology

This book is based in large part on empirical studies of global credit markets, and makes extensive use of bond index data from Barclays Capital. To avoid undue repetition in the text and keep the writing simple, the following conventions are followed throughout the book.

INDEX, PRICING, AND ANALYTICS

All indexes mentioned (e.g., U.S. Corporate Index, Aggregate Index, etc.) are published by Barclays Capital unless otherwise specified. Similarly, all pricing data and the various analytics are based on Barclays Capital index data.

CREDIT RATINGS

Credit ratings reflect the index methodology for determining a bond's credit rating, which may vary from one market to another and change over time. For U.S. investment-grade credits, in particular, the rules have evolved as follows. Prior to October 2003, the index rating was set equal to Moody's, or the equivalent S&P ranking if Moody's was unavailable. From October 2003 to July 2005, it was the lower of Moody's and S&P. The rule in place since July 2005 uses the middle rating of Moody's, S&P, and Fitch. The index convention, adopted in this book as well, is to use the Moody's nomenclature regardless of the source of the rating. Thus, for example, an index rating of Baa can refer to a Moody's rating of Baa or an S&P rating of BBB.

EXCESS RETURN

The *excess return* of a bond is defined relative to a hypothetical portfolio of treasury bonds with the same duration exposures along the curve. The

precise computational methodology follows index rules, which may vary by currency.

SPREAD

Unless otherwise indicated, the term *spread* refers to option adjusted spread (OAS) relative to the treasury curve.