Comptroller of the Currency
Administrator of National Banks

Credit Rating and Scoring Models

Advances in Theory and Application

May 17-19, 2004
Hilton Mark Center Hotel
Alexandria, Virginia

Table of Contents

Welcome

Welcome to *Credit Rating and Scoring Models: Advances in Theory and Application*, a conference sponsored by The Office of the Comptroller of the Currency (OCC). Thank you for attending, we hope you find the conference useful and informative.

The use by banks of credit risk rating models has grown tremendously in the last several years. Under the proposed Basel II capital reforms, these models will only grow in importance, as they lie at the core of the advanced internal ratings-based (AIRB) approach to regulatory capital. The primary purpose of this conference will be to advance the theory and application of credit rating models, by allowing researchers and practitioners to discuss recent innovations in the design, implementation and validation of both retail and commercial models. It is hoped that the meeting will foster the building of ties between technical ratings experts in banks, the vendor industry, academia, and the supervisory community.

The Office of The Comptroller of the Currency

The OCC was established in 1863 as a bureau of the U.S. Department of the Treasury to charter, regulate, and supervise all national banks. It also supervises the federal branches and agencies of foreign banks. Headquartered in Washington, D.C., the OCC has six district offices plus an office in London to supervise the international activities of national banks.

The OCC is headed by the Comptroller, who is appointed by the President, with the advice and consent of the Senate, for a five-year term. The Comptroller also serves as a director of the Federal Deposit Insurance Corporation (FDIC) and a director of the Neighborhood Reinvestment Corporation.

The OCC's nationwide staff of examiners conducts on-site reviews of national banks and provides sustained supervision of bank operations. OCC staff and economists supervise domestic and international activities of national banks and perform corporate analyses. Examiners analyze a bank's loan and investment portfolios, funds management, capital, earnings, liquidity, sensitivity to market risk, and compliance with consumer banking laws, including the Community Reinvestment Act. They review the bank's internal controls, internal and external audit, and compliance with law. They also evaluate bank management's ability to identify and control risk.

The agency issues rules, legal interpretations, and corporate decisions concerning banking, bank investments, bank community development activities, and other aspects of bank operations. In regulating national banks, the OCC has the power to:

- Examine the banks.
- Approve or deny applications for new charters, branches, capital, or other changes in corporate or banking structure.
- Take supervisory actions against banks that do not comply with laws and regulations or that otherwise engage in unsound banking practices. The agency can remove officers and directors, negotiate agreements to change banking practices, and issue cease and desist orders as well as civil money penalties.
- Issue rules and regulations governing bank investments, lending, and other activities.

The OCC does not receive any appropriations from Congress. Instead, its operations are funded primarily by assessments on national banks. National banks pay for their examinations, and they pay for the OCC's processing of their corporate applications. The OCC also receives revenue from its investment income, primarily from U.S. Treasury securities.

An Important Note

The conference program organizers have worked hard to put together a set of presentations that illustrate the diversity of quantitative techniques that are being used to analyze and model retail and corporate credit risk. Nevertheless, the fact that a particular presentation appears on the program in no way implies that the OCC endorses or approves of the techniques and methods described therein. Statements made by presenters are their own, and in no way should be taken to represent official views of the Office of the Comptroller of the Currency, The US Department of the Treasury, or their staffs.

Program Overview

Monday, 17 May

11:00am - 1:00pm
On-Site Registration

1:30pm
CONFERENCE OPENING

2:00pm - 4:30pm
SESSION I:
Perspectives on the State
of Credit Modeling
(A brief break will be held)

5:30pm - 7:30pm
Reception

Tuesday, 18 May

7:15am
Continental Breakfast

8:00am - 9:45am
SESSION II:
Methodological Innovations in
Rating and Scoring

9:45am - 10:00
Break and Refreshments

10:00am - 11:45am
SESSION III:
Frontiers of Applied Corporate
Credit Modeling

12:00pm - 1:20pm
Luncheon

1:30pm - 3:15pm
SESSION IV:
Understanding Reject Inference

3:15pm - 3:30pm
Break and Refreshments

3:30pm - 5:15pm
SESSION V:
Key Issues in Severity Modeling

6:15pm - 6:45pm
Social

6:45pm - 9:00pm
Banquet and
KEYNOTE ADDRESS

Wednesday, 19 May

7:15am
Continental Breakfast

8:00am - 9:45am
SESSION VI:
Using Scoring Tools to
Enhance Profitability

9:45am - 10:00am
Break and Refreshments

10:00am - 11:45am
SESSION VII:
Understanding the Dynamics
of Ratings

12:00pm - 1:20pm
Luncheon

1:30pm - 3:15pm
SESSION VIII:
Model Validation Methodologies

3:15pm - 3:30pm
Break and Refreshments

3:30pm - 4:30pm
SESSION IX:
What Have We Learned?
A Panel Discussion

4:30pm
CONFERENCE CLOSING

CRSM Conference Rooms

All Sessions: Plaza Ballroom B&C, Lower Level
Lunches, Social and Banquet: The Magnolia Room, Upper Level
Registration, Reception, and Breakfasts: Plaza Ballroom Foyer, Lower Level

Session Detail

Monday, 17 May

CONFERENCE OPENING

C. Erik Larson Office of the Comptroller of the Currency, and
Nicholas Kiefer Cornell University and Office of the Comptroller of the Currency

Welcoming Remarks

John D. Hawke, JR. Comptroller of the Currency

John D. Hawke, Jr., was appointed the 28th Comptroller of the Currency in December 1998. Previously, Hawke served as Under Secretary of The Treasury for Domestic Finance, where he oversaw development of policy and legislation on financial institutions, debt management, and capital markets. Prior to joining Treasury, Hawke was a senior partner and chairman at the law firm of Arnold & Porter. He also has served as general counsel to the Board of Governors of the Federal Reserve System and as counsel to the Select Subcommittee on Education in the U.S. House of Representatives. Hawke has written extensively on the regulation of financial institutions, and taught courses on banking law at Georgetown and Boston Universities. He served on a committee of inquiry appointed by the Chicago Mercantile Exchange to study the role of futures markets in the October 1987 stock market crash, and was a founding member of the Shadow Financial Regulatory Committee. Hawke holds a B.A. in English from Yale University and a law degree from the Columbia University School of Law.

SESSION I: Perspectives on the State of Credit Modeling

Chair: **C. Erik Larson** Office of the Comptroller of the Currency

"The Interest of Bank Supervisors in Credit Rating"

Jeffrey Brown Office of the Comptroller of the Currency

The formerly obscure topic of bank internal credit rating has garnered an increasing amount of attention, especially from bank supervisors, because of the current movement to change international bank regulatory capital standards. The primary objective of the proposed capital reform is to make commercial bank capital standards more sensitive to differences in risk -- particularly credit risk. The proposed approach is appealing because the capital requirement will reflect and be consistent with a bank's internal assessments of the credit risk of individual obligors and facilities.

Credit ratings and scores, however, are not objective facts, readily determinable by all interested parties. Commercial ratings and retail scores each are outputs of a process. Whether the process is implemented though an empirically derived model, the application of a set of decision rules, or the exercise of expert judgment, it is subject to error or even manipulation. Given possibility of error, or model risk, we recognize the need to verify that the rating and scoring process is sound and well deployed.

While banks have long used ratings, and other similar devices, in internal risk management and decision making, the stakes are now higher. Many stakeholders now have a greater interest, not merely in the reliability of ratings as rank ordering devices, but also in the consistency, accuracy, and verifiability of those ratings. Thus, banks will be expected to implement systems designed to validate ratings. And banks supervisors will check the efficacy of those validation systems.

"Frontiers of Credit Scoring"

Jonathan Crook University of Edinburgh

This talk will give an overview of recent research in selected aspects of credit scoring. The talk will review studies that have investigated the relative predictive performance and interpretation of different algorithms designed to separate populations. Recent approaches to the possible reject inference problem will be discussed including, for example, the use of bureau data, mixture distributions, and multiple imputations. Markov chain models will be reviewed and in particular the stationarity and first order property of default probability transition matrices. We will consider the performance of survival models for predicting hazard rates. Graphical models and the current view that relatively few variables are deleted when the networks are used will be explained. The talk will consider the scope for international scorecards and allude to some very recent results for some European countries. We will then explain the development of the strategy curve and the model of profit maximization under specified acceptance rule constraints. We will discuss the policy implications of the curve. This will lead to the holistic profit measure of the performance of a scorecard, which is independent of the relative costs of misclassifications. Recent developments in risk-based pricing will be briefly mentioned as will recent work on portfolio analysis.

"Creating Standards for Risk Assessment: Lessons from the FICO® Score"

Hollis Fishelson-Holstine Fair Isaac Corporation

The upcoming implementation of the Basel II accord has increased focus on the assessment of risk in financial service institutions (FSIs). Traditionally, the approaches for risk assessment on the corporate and retail side of FSIs have been substantially different. Arguably, the most far-reaching single measure of risk assessment used in retail decisions has been the FICO® score. Introduced in 1989, today the FICO score is used in billions of decisions each year in North America. This talk will discuss reasons for the wide-ranging use of the FICO score and suggest lessons that might be applied to developing robust, consistent measures of risk on the corporate side. These will include issues such as the importance of sufficient sample size, models that rank order compared to those that predict absolute risk and the impact of external conditions on the risk measure.

"Credit Models in Banking: Past Present and Future"

Kyle Lundstedt VaRisk

Credit modeling is a very broad term when applied in the context of financial intermediaries such as banks and thrifts. At first glance, the tremendous variety of modeling paradigms might cause an outside observer to wonder if there was any underlying rhyme or reason to the current state of credit modeling within banks. Upon greater inspection, it becomes more apparent that the wide variety of approaches to measuring credit risk has an almost irresistible logic in their evolution. Finally, delving even deeper into different approaches reveals the underlying commonalities.

The objective of this talk is to provide a credit modeling taxonomy for the banking industry. We attempt to provide historical context to the modeling choices adopted in different parts of the bank over the last thirty years, and to show these choices evolved quite naturally given the economic, organizational, and functional context. We also show that rigorous theory-based approaches such as the Merton default model for corporate loans have a great deal in common with data-driven empirical approaches to retail loan default modeling. Finally, we advocate strongly for using as much information as practically possible, and provide examples where blending theoretical and empirical approaches is an absolute necessity.

"Similarities and Differences in Approaches to Modeling Retail and Corporate Credit Risk"

Balvinder Sangha Ernst & Young LLC

While corporate (i.e., commercial) and retail (individual) loans are in some regards similar, there are some key differences in the credit risk modeling treatment of these two different channels. This paper examines the similarities and differences in the U.S. corporate and retail lending modeling and its usage. Models of credit risk for the two sectors vary in one important way: commercial credit risk is modeled using either a through-the-cycle model (a long time horizon) or point-of-time model (a short time horizon), while retail credit risk is generally a short-run model. Correspondingly, there are well-defined theoretical models of credit risk for the corporate side, while there does not

exist a widely-accepted theoretical model for risk in retail lending, especially for unsecured retail credit (e.g., credit cards). Although all modeling methods predict outcomes detrimental to the bank, the theory differs with regards to what the model is predicting: default or days past due. The data available for modeling these two different types of portfolio risks also differs, which in part drives the choice of the model and time frame. In addition, there exist many differences in how model output is used for underwriting, establishing loan loss reserves and economic capital, and managing the portfolio. Finally, there are some key differences in the validation of the models.

Tuesday, 18 May

SESSION II: Methodological Innovations in Rating and Scoring

Chair: **Nicholas Kiefer** Cornell University and Office of the Comptroller of the Currency
Discussant: **Gary Wilhite** Wachovia Corporation

"Estimating Conditional Transition Matrices for Rated Syndicated Loans Using An Information-Theoretic Approach"

Dennis Glennon Office of the Comptroller of the Currency

In this presentation, we outline an alternative method of estimating the transition probabilities conditional on both borrower-specific and macroeconomic conditions—an approach that is in contrast with the unconditional historical frequencies (i.e., maximum likelihood estimates) approach commonly used by the rating agencies and some of the larger banks). We use a pool of Standard & Poor's-rated syndicated loans tracked over a relatively short time horizon (three years) to mimic the relatively small size (roughly 1000 loans) and short duration of loan portfolios often faced by commercial banks when developing internal risk models. The relatively small size and short duration limit the appli-

cation of conventional methods that rely on large samples tracked over relatively long time horizons. We estimate the transition matrix using a generalized maximum entropy (GME) approach in which we capture the effects of changing economic conditions that are generally assumed to be averaged out when using a "through-the-cycle" approach or effectively ignored under a point-in-time design. Our objective is to outline an estimation procedure that could be used by a larger number of banks (primarily mid- to large-size banks) to customize their estimates of the transition probabilities to the specific characteristics of their portfolio and the conditions of the regional/local markets they target.

"Auctioning Experts in Credit Modeling"

Robert Stine The Wharton School, University of Pennsylvania

The investment of effort in manually building and maintaining scorecards produces experts, that is, analysts who possess substantive familiarity and insight. Computer-intensive model building generates accurate predictions from large databases quickly, but the exotic form of the resulting models can defy explanation. The combination of manual and automatic modeling offers the advantages of both. If the automated search for predictive patterns can exploit the insight of experts then it will produce more accurate, more interpretable models adapted to the substantive domain. This presentation introduces and illustrates a method that binds automatic modeling to the recommendations of multiple experts. A type of auction allows an automatic process to formally incorporate experts when building predictive models or scoring systems. Each expert offers advice in the form of a sequence of candidate predictive features. For example, an expert might recommend features that have demonstrated value in other models or that have clear substantive interpretation. An automatic process combines the best features from the offered sequences while avoiding the danger of over-fitting. The auction guarantees that all but a small fraction of the utilized features improve predictions. Several examples from credit modeling motivate components of the methodology. These illustrations include comparisons with purely automatic modeling strategies.

"Quantile-Based Methods for Credit Scoring"

Halbert White University of California, San Diego and Bates-White LLC

We discuss a new approach to credit scoring based on recent results of Lieli (2004) for predicting binary variables. In this framework, the user's utility function, which may depend on the characteristics of the case for which prediction is desired, determines the optimal prediction of a binary outcome, such as good risk/bad risk. The result is an optimal decision rule that is not simply a constant threshold but is instead defined by a decision region that involves the quantiles of the conditional distribution of the binary outcome variable and the characteristics of the case at hand. We illustrate with an empirical credit-scoring example.

SESSION III: Frontiers of Applied Corporate Credit Modeling

Chair: **Mark Levonian** Office of the Comptroller of the Currency
Discussant: **Peter Abken** Bank of America Corporation

"Forecasting Default with the KMV-Merton Model,"

Tyler Shumway University of Michigan

We examine the accuracy and contribution of the default forecasting model based on Merton's (1974) bond pricing model and developed by the KMV Corporation. Comparing the KMV-Merton model to a similar but much simpler alternative, we find that it performs slightly better as a predictor in hazard models and in out-of-sample forecasts. However, several other forecasting variables are also important predictors, and fitted hazard model values outperform KMV-Merton default probabilities out of sample. Bond yield spreads are only weakly correlated with KMV-Merton default probabilities after adjusting for agency ratings and bond characteristics. We conclude that while the KMV-Merton model does not produce a sufficient statistic for the probability of default, it is difficult to construct such a sufficient statistic without considering the KMV-Merton model.

"Credit Risk and Risk-Neutral Default Probabilities"

Robert Geske University of California, Los Angeles

We present a study of the properties and uses of option-based estimates of risk-neutral default probabilities (RNDPs). This study is the first to show the significance of the information contained in RNDPs. Because RNDPs are the pricing probabilities, their changes should possess the information embedded in price changes. We provide the first evidence on the distribution of these important pricing probabilities. We compute RNDPs using the diffusion models of Merton (1974) and Geske (1977). The refinancing condition in the Geske model is shown to directly imply a term structure of default probabilities. We demonstrate that the RNDPs estimated from both Merton and Geske models successfully categorize firms by actual credit rating, that the RNDPs will generally serve as upper bounds to risk-adjusted default probabilities (RADPs), and that RNDPs are easier to estimate than risk-adjusted default probabilities. We argue that the time series of RNDPs allows easy estimation of default probability correlations, while actual rare event default correlations are much more difficult to estimate. We show the RNDPs estimated from both the Merton and Geske models possess significant early information about credit rating migrations. The slope of the term structure of RNDPs from the Geske model contains information about impending migrations to actual default. Finally, Geske's term structure of RNDPs should track the forward default swap curve and thus be useful for pricing forward debt securities of different maturities such as credit default swaps.

"Valuing Callable Corporate Bonds in a Reduced Form Model Using a Call Intensity Process"

Chunchi Wu Syracuse University

We present a new approach for valuing callable corporate bonds by characterizing the call probability using an intensity process. The existence of a call-arrival intensity justifies the pricing of callable bonds using a reduced-form model. As such, the callable bond model is shown to be a straightforward extension of the reduced-form model of Duffie and Singleton (1999) for risky debt. The model avoids the difficulties of identifying the firm's optimal call policy, stochastic process of assets, and dynamic liability structure encountered by the structural approach. Because of its simple structure, the model provides a convenient framework for estimating the call premium for risky bonds. A four-factor affine model is employed for empirical estimation. Empirical results show that the model fits callable bond price data well.

SESSION IV: Understanding Reject Inference

Chair: **Jeffrey Brown** Office of the Comptroller of the Currency
Discussant: **Dennis Ash** Federal Reserve Bank of Philadelphia

"Statistical and Conceptual Issues in Credit Scoring"

Nicholas Kiefer Cornell University and Office of the Comptroller of the Currency

Credit scoring models are used by lending institutions to rank applicants according to their expected performance. There are many different models and approaches. Issues to consider in the development, implementation, and evaluation of these models include the possibility of selectivity bias since the model must be estimated on extended loans; reject inference, in which an attempt is made to use applicant characteristics but not loan performance data from declined loans; parametric vs. nonparametric modeling; and experimental design. These issues are discussed and illustrated in the context of a simple stylized model.

"Reject Inference for Credit Scoring with Ignorable and Non-Ignorable Selection"

Ad Feelders University of Utrecht

Reject inference is the process of estimating the risk of defaulting for loan applicants that are rejected under the current acceptance policy. We show how the problem of reject inference can be viewed as one of statistical inference with incomplete data. We use a well known classification of missing data mechanisms into "ignorable" and "non-ignorable" to organize the discussion and comparison of different approaches to reject inference that have been proposed in the literature.

"Reject Inference in Small Business Lending Underwriting Models"

Elbert Chen Wells Fargo

Wells Fargo has been one of the leading banks in the small business lending arena, and the Business Direct Division has been developing custom scorecards for underwriting small business lines and cards. While the bank has accumulated a substantial number of accounts and performance data, we are faced with a common problem of "reject inference" in our model development. Specifically, when we develop models for predicting the probability of default, we generally only have the actual outcome for applications that passed our pre-existing underwriting filter and score cut-off. In our presentation we will discuss some of the industry practices for addressing this problem as well as review much of Wells Fargo's methodology for specific examples of small business lending. These practices mitigate the risk associated with reject inference, but they also raise theoretical problems that need further research.

SESSION V: Key Issues in Severity Modeling

Chair: **Michael Carhill** Office of the Comptroller of the Currency
Discussant: **Rosalind Bennett** Federal Deposit Insurance Corporation

"Modeling Loss Given Default – A Practitioner's Perspective"

Michel Araten JPMorgan Chase

This presentation presents findings of, and highlights issues associated with, an extensive loss severity study for the JPMorgan Chase wholesale bank. The recently completed loss given default (LGD) study draws upon 18 years of loan loss history for 3,761 defaulted borrowers at the bank's several heritage organizations. Emphasis is placed on data quality, detailed results, and analysis of relationships between LGDs and systemic default rates, with implications for Basel II implementation.

"Advancing Loss Given Default Prediction Models"

Greg Gupton Moody's KMV

Moody's (and now Moody's KMV) has published research on LGD since 1996 based on data sets extending back to 1981. In February 2002, the first security-level forecasting model was published, LossCalc. Since that time, research has accelerated with much additional data and improved techniques. Moody's KMV has found that LGD can be better predicted with information at five levels: (1) collateral, (2) instrument/structure-specific, (3) firm-specific, (4) industry-specific, and (5) macroeconomic. This presentation focuses on advances made in improved LGD modeling and forecasting. We also compare and contrast the different meanings and uses of LGD within a financial institution and seek to reconcile these.

"Defaulted Debt Prices versus Ultimate Recoveries: What can we learn about the systematic risk of defaulted debt and LGD measurement?"

Mark Carey Federal Reserve Board of Governors

This paper examines the relationship between post-default market prices and ultimate recoveries on defaulted debt. Prices are very noisy predictors of recoveries, so much so that extraction of robust estimates of risk premiums is difficult, and simple trading strategies yield material excess returns. We examine various hypotheses about sources of the noise.

KEYNOTE ADDRESS

"Rating, Scoring and the Industrial Organization of Banking"

Bruce Lehmann University of California, San Diego

Bruce N. Lehmann is professor in the Graduate School of International Relations and Pacific Studies at the University of California, San Diego. His main expertise is in the pricing of capital assets, their volatility, and the markets in which they trade. Lehmann's research interests include empirical tests of asset pricing models, the analysis of short-run stock price fluctuations, and the microstructure of securities markets. He is the founding co-editor of the *Journal of Financial Markets*, and has served as a director of the Western Finance Association. He is a member of the scientific advisory board of ITG, Inc., and a member of the board of directors at First Boston Investment Funds and BEA Associates. Lehmann has been a Batterymarch Fellow; an Olin Fellow at the National Bureau of Economic Research; and a National Fellow at the Hoover Institution. Prior to joining UCSD, Lehmann taught at Columbia University. He holds a doctorate from the University of Chicago.

Wednesday, 19 May

SESSION VI: Using Scoring Tools to Enhance Profitability

Chair: **M. Nazmul Hasan** Office of the Comptroller of the Currency
Discussant: **Robert Avery** Federal Reserve Board of Governors

"Optimization of Early Stage Collections"

Adam Lin Bank One Corporation

The presentation discusses early stage collections optimization for credit card portfolio through the building of a predictive model and test/control experiments. The new strategy targets the right accounts for early collection actions, while leaving the majority of accounts for self-cure. As a result, operation expenses are significantly reduced while unwanted customer contacts are minimized.

"Credit Line Assignment Optimization"

Frank Zhao JPMorgan Chase and Company

Line assignment has impact on both the revenue and the credit quality of a card portfolio. Low credit lines can suppress activation rate and purchase, while excessive credit lines expose the bank to higher loan loss. We developed a new method for optimizing line assignment at the account level, combining predictive modeling, multi-dimensional segmentation, and optimization techniques. This method assigns credit line based on customers' credit risk, as well as on their balance and revenue sensitivities to credit line. It allows the bank to develop tailored line strategies to achieve multiple financial objectives while meeting various business constraints. We also developed a novel algorithm that solves complex optimization problems in an efficient way. This method can also be applied to other account acquisition and customer management programs, such as credit line increase, price/product optimization, and cross-sell.

"Managing Credit Lines and Prices for Bank One Credit Cards"

Shane P. Pederson Bank One Corporation

This presentation describes a methodology for managing characteristics of a bank's cardholder portfolio in an optimal manner. The annual percentage rate (APR) and credit line of an account are critical factors that influence card usage and bank profitability. Lower APRs and higher credit lines are more attractive to consumers. However, APRs that are too low may reduce bank profitability, while indiscriminate line increases may dramatically increase credit loss exposure. The PORTICO (portfolio control and optimization) system is designed to select price points and credit lines for each cardholder that maximize net present value for the portfolio. PORTICO is developed using Markov decision process methodology. This model applies account-level historical information on purchases, payments, profitability, and delinquency risk to determine pricing and credit line changes.

SESSION VII: Understanding the Dynamics of Ratings

Chair: Dennis Glennon Office of the Comptroller of the Currency
Discussant: Sunil Sharma IMF Institute

"Corporate Credit Risk Modeling and the Macro Economy"

Kasper Roszbach Sveriges Riksbank

We evaluate historical business loan portfolio data from a major Swedish bank for the period 1994 to 2000. First, we estimate a duration model to explain default behavior for the portfolio counterparts. The model takes into account both firm, loan-related, and macroeconomic variables. Examples of the former are various accounting ratios and information on firms' payment behavior. The macro economic stance is captured using an output gap, a measure of the yield curve, and consumers' expectations of future economic developments. Next, we obtain a value-at-risk-type (VaR) portfolio credit risk measure by model-based simulations. The approach allows us to (i) make individual forecasts of default risk conditional on firm and loan characteristics, as well as on prevailing macroeconomic conditions, and (ii) study portfolio credit risk over time. Our results show that macro conditions indeed have important explanatory power for predicting default risk and calculating portfolio credit risk.

"Modeling Mortgage Default and Prepayment as Competing Risks"

Arden Hall Wells Fargo

The hazard model approach to analyzing mortgage prepayment has been standard in the industry for some time. However, other approaches – scoring, roll-rate models, and Merton-type option pricing models, for example – have been more commonly used in modeling default. For some applications, integrating default into a competing risk hazard model can improve the modeling of default risk. We describe the competing risk approach, and discuss implementation issues and implications of this approach for methods for modeling default.

"Testing Simple Markov Structures for Credit Rating Transitions"

C. Erik Larson Office of the Comptroller of the Currency

The measurement of credit quality is at the heart of the models designed to assess the reserves and capital needed to support the risks of both individual credits and portfolios of credit instruments. Historical information on the transition of credit exposures from one quality level, or rating to another is often used to estimate models that describe the probabilistic evolution of credit quality. A popular specification is the simple, time-homogeneous Markov model. While the Markov specification cannot really describe processes in the long run, it may be useful for adequately describing short-run changes in portfolio risk. In this convenient specification, the entire stochastic process can be characterized in terms of estimated transition probabilities. However, the simple homogeneous Markovian transition framework is restrictive. We propose a simple test of the null hypotheses of time-homogeneity that can be performed on the sorts of data often reported. The test is applied to data sets on municipal bonds, commercial paper, and sovereign debt. We find that municipal bond ratings transitions are adequately described by the Markov model for up to 5 years, but not longer; that commercial paper on a 30-day transition scale looks Markovian up to 6 months (the extent of the available data); and that sovereign debt ratings transitions are adequately described by the Markov model (this result may be a result of the limited data information reflected in small sample sizes).

SESSION VIII: Model Validation Methodologies

Chair: **C. Erik Larson** Office of the Comptroller of the Currency
Discussant: **Mark Levonian** Office of the Comptroller of the Currency

"Performance Evaluation for Credit Rating and Default Risk Models"

Jorge Sobehart Citigroup Inc.

We discuss key issues involved in measuring and testing the performance of credit rating and default risk models. Because these models have become important in an increasing number of bank activities, measurement and testing procedures must be flexible and must be applied and interpreted in ways consistent with the different contexts of model use. We review these issues and address the recent criticism of frequently used performance metrics for default risk models such as power curves, rank statistics, and information entropy measures, and highlight the technical flaws in the analysis. We also discuss the adaptation of some of these measures in the context of credit spread estimation. To illustrate we compare the performance of several default prediction models.

"Good Practice in Retail Credit Scorecard Assessment"

David Hand Imperial College, London

The predictive power of scorecards gradually deteriorates over the course of time, so that their performance needs to be monitored. The personal banking industry uses various measures for such monitoring, including the Gini coefficient, the Kolmogorov-Smirnov statistic, the mean difference statistic, and the information value. We examine these measures in detail, showing that they use information irrelevant to the aspect of performance that matters while ignoring information that is relevant. We describe alternative measures that are better matched to the uses to which the scorecards are put. In doing so, we make the distinction between (i) situations in which one of the actions is 'reject,' with the implication that the true outcome class of the 'rejects' is never known—the situation which has stimulated work on reject inference; (ii) situations in which both actions yield outcome information.

"Validating Forecasts of the Joint Probability Distribution of Bond Yields: Can Affine Models Beat Random Walk?"

Yongmiao Hong Cornell University

The term structure of interest rates, which concerns the relationship among the yields of default-free bonds with different maturities, is one of the most widely studied topics in economics and finance. Affine term structure models, first introduced in Duffie and Kan (1996), have become the leading term structure models in the literature due to their rich model specification and tractability. Most existing empirical studies on affine term structure models have primarily focused on in-sample fit of historical bond yields and ignored out-of-sample forecast of future bond yields. Using an omnibus nonparametric procedure for density forecast evaluation developed in this paper, we provide probably the first comprehensive empirical analysis of the out-of-sample performance of affine term structure models in forecasting the joint conditional probability density of bond yields. We show that although it is difficult to forecast the conditional mean of bond yields, some affine models have good forecasts of the joint conditional density of bond yields and they significantly outperform simple random walk models in density forecast. Our analysis demonstrates the potential of affine models for financial risk management in fixed-income markets.

SESSION IX: What Have We Learned? A Panel Discussion.

Chair: **Nicholas Kiefer** Cornell University and The Office of the Comptroller of the Currency

Panel Members

Ashish Dev KeyCorp

Andy Chawla TransUnion LLC

William Lang Federal Reserve Bank of Philadelphia

Martin O'Connor Experian-Scorex

John Straka FreddieMac

Expert Profiles

Peter A. Abken

Peter A. Abken is senior vice president and audit director at Bank of America, responsible for model validation and quantitative analysis. His group evaluates a variety of models across the bank, including consumer and commercial scoring models, risk rating models, trading, and risk management models. He was formerly a financial economist with the OCC and with the Federal Reserve Bank of Atlanta, and holds a Ph.D. in economics from Brown University.

Michel Araten

Michel Araten is managing director of Global Credit Risk Management at J.P. Morgan Chase. He has developed credit risk capital models for global retail, wholesale, and capital markets, and has completed a number of historical studies supporting these models. At Chase, Araten has served as manager of Management Science, group executive in Real Estate Finance, secretary of the Credit Policy Committee, and director of Insurance Income Products. He has been an adjunct lecturer at Columbia University, Fordham Graduate School of Business, and Polytechnic Institute. Araten holds a Ph.D. in operations research, an M.S. in industrial engineering, a B.S. in chemical engineering, and a B.A. in liberal arts, all from Columbia University.

Dennis D. Ash

Dennis Ash is a special advisor to the Federal Reserve Bank of Philadelphia, where he is working on credit risk issues related to Basel II. Ash has also worked at Experian/Scorex, where he was director of Consulting and Analytics and chief statistician, and at Citibank, where he was director of Scoring in Bankcards. He has a master's degree in statistics from Princeton University and a B.S. in mathematics from Case Western Reserve University.

Robert B. Avery

Robert B. Avery is a senior economist in the Division of Research and Statistics at the Federal Reserve Board. He previously was a professor of consumer economics at Cornell University and an assistant professor of economics at Carnegie Mellon University. He has also worked at the Federal Deposit Insurance Corporation. At the Federal Reserve, Avery's research interests include banking and financial institutions, real estate, and consumer finance. Working with other economists, he has published articles on CRA, home mortgage lending, bank branching, and personal business finance. Avery holds a Ph.D. in economics from the University of Wisconsin and a B.A. in economics from the University of Pennsylvania.

Rosalind L. Bennett

Rosalind L. Bennett is a financial economist at the Federal Deposit Insurance Corporation (FDIC). Bennett advises the FDIC's Investment Advisory Group, Financial Risk Committee, and Least Cost Test Policy Board. Her research interests include bank failure resolution, deposit insurance pricing, deposit insurance fund management, and risk management. Bennett holds a B.A. in economics and an M.S. in applied economics from the University of California, Santa Cruz, and a Ph.D. in economics from the University of California, Los Angeles.

Jeffrey A. Brown

Jeffrey A. Brown is the senior deputy comptroller for International and Economic Analysis in the Office of the Comptroller of the Currency. At the OCC, Brown also served as the director of the Risk Analysis Division. He has published research on the causes of bank failure, the condition of real estate markets, the risks of bank lending to real estate activities, bank behavior in reserving for loan and lease losses, and bank cost efficiencies and credit rating. As a policy advisor at the OCC,

Brown has worked on a broad range of issues dealing with risk management, risk measurement, and risk modeling practice. He has participated in the group developing the U.S. interagency supervisory implementation procedures for the internal ratings-based approach to the new Basel Capital Adequacy Framework. Brown holds a PhD. in economics from Brown University.

Mark Carey

Mark Carey is a finance project manager in the Division of International Finance at the Federal Reserve Board in Washington, DC. He focuses on issues in corporate finance, banking, risk management, and capital markets. Current research topics include determinants of the terms of loan and bond contracts, credit risk measurement and management at

both the individual asset and the portfolio level, and issues related to the structure of business debt markets. Carey holds a B.A. from Oberlin College and a Ph.D from Berkeley, both in economics. Between degrees, Carey worked for several technical consulting firms.

Mike Carhill

Mike Carhill joined the Office of the Comptroller of the Currency as a financial economist in the Department of Economic and Policy Analysis in 1991. After serving as Deputy Director from 1995-2003, in December 2003 he was appointed Director of the Risk Analysis Division (RAD). Before joining the

OCC, Carhill served as a staff economist with the Federal Home Loan Bank of Atlanta, and researched the role that interest-rate risk plays in thrift profitability. Carhill holds a Ph.D. in monetary theory from Washington University.

Andy Chawla

Andy Chawla is the director of Regulatory Compliance and Risk Management at TransUnion. Prior to joining TU, Chawla worked as senior vice president and chief credit officer of Triad Financial and as a vice president of Portfolio Management at Bank One. His career includes time with Mitsubishi, Household Financial Services, WFS Financial, and

Citigroup, and as a private consultant. Chawla has extensive experience with acquisitions and retention strategy development, new scorecard and credit policy implementation, collections analytics, and behavior scoring and adaptive control strategy. He holds an M.B.A. from the University of North Carolina.

Elbert Chen
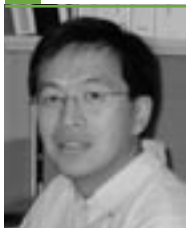
Elbert Chen is the risk manager for Wells Fargo's Business Line and Loans Group. Formerly, he led Wells Fargo Business Direct's Modeling, Forecasting, and Analytics group. He has developed several generations of custom underwriting scorecards while at Wells Fargo, and built several targeting

models while employed by Providian Bancorp. Chen holds an M.A. in economics from the University of California, Berkeley, and a B.S. in economics and electrical engineering from Yale University.

Jonathan Crook

Jonathan Crook is the director of the Credit Research Centre and a professor at the University of Edinburgh. He has published over 20 papers relating to credit, and is the author/editor of four books, two of which relate to credit scoring: *Credit Scoring and its Applications*, and *Credit Scoring and Credit Control.*. A fifth book, jointly edited, *Readings in Credit Scoring*, is due for publication in 2004. In 1999 he was joint winner of the Goodeve Medal for the best paper in any Operational Research Society (UK) journal. He has been a postdoctoral Fulbright Scholar at the University of Virginia and a Visiting Fellow at the European University Institute, Florence, and the University of Warwick, UK. His research interests are in the areas of reject inference, and the demand and supply of credit.

Ashish Dev

Ashish Dev is executive vice president, Risk Management, at KeyCorp. He is group head of Enterprise Risk Management, which includes Economic Capital Allocations, Basel II Coordination & Regulatory relations, Data Warehousing, Credit Underwriting Models, Strategic Analytics & Credit Portfolio Management, and Operational Risk. In addition to developing various risk models, he has supervised major data warehousing and data integrity initiatives, and has led efforts to implement risk-adjusted product pricing, performance measurement and compensation systems in the bank.   Prior to joining KeyCorp in 1999, Dev was head of Quantitative Research and Analysis at Bank One. Dev has a Ph.D. in economics and holds the CFA professional designation.

Ad J. Feelders

Ad J. Feelders is an assistant professor at the Utrecht University Institute of Information and Computing Sciences. He has worked as a data mining consultant for Data Distilleries, where he was in charge of data mining projects for banking, insurance, and retail companies. He has been an assistant professor at the department of Economics of Tilburg University in The Netherlands. He has published several articles on data mining in international conference proceedings and scholarly journals.

Hollis Fishelson-Holstine

Hollis Fishelson-Holstine is vice president of Research and Development at Fair Isaac Corporation. Her area of expertise is in decision analysis, predictive modeling, and optimization to determine optimal business actions. She also has supervised the development of data mining algorithms for automated variable generation and cluster generation, predictive modeling algorithms, and data-based solutions for Internet fraud detection and e-commerce customer conversion prediction. She has taught computer science and statistics at the University of Alaska. Fishelson-Holstine holds an M.S. in statistics from Oregon State University and a B.S. in environmental education from Cornell University.

Robert Geske

Robert Geske is a professor of financial economics at the University of California, Los Angeles, and vice president of CATS Software Inc. Geske is a founding principal and former chief executive officer of LOR/Geske Bock Associates (LOR/GB), which was acquired by CATS. He has published numerous articles in financial journals on the subjects of option pricing, volatility estimation, interest rate risk and inflation, and serves as an associate editor for the *Journal of Portfolio Management.* Geske has been the recipient of a Woodrow Wilson Fellowship and a Fulbright Fellowship. He holds a doctorate in financial economics from the University of California, Berkeley.

Dennis Glennon

Dennis Glennon is a senior financial economist in the Risk Analysis Division at the Office of the Comptroller of the Currency. His research interests are in the areas of credit scoring, credit risk modeling, and bank failure analysis. His current research projects include the application of maximum entropy econometric techniques to bank-failure and loan-default modeling, the development of competing-risk models of SBA loan default and prepayment behavior, and the development of alternative methods of assessing model risk. He actively participates in the supervision of retail lending and mortgage credit-scoring and pricing models. Glennon received his doctorate in economics from the University of Missouri - Columbia.

Greg M. Gupton

Greg M. Gupton is a senior director of research at Moody's KMV and the author of the loss-given-default forecasting model, LossCalc(tm). He also runs DefaultRisk.com, an internet resource for quantitative credit risk modeling and management. Prior to joining Moody's, he worked at JP Morgan on the development of internal credit risk methodologies, including CreditMetrics(tm). Gupton's current research projects include modeling exposure at default, asset volatility, and the validation of default models. Gupton holds a B.A. in accounting from the University of Washington, and a M.S. in industrial administration from Carnegie-Mellon University.

Arden Hall

Arden Hall has been involved in asset/liability management and prepayment modeling since 1984, and carried out one of the first studies to analyze mortgage prepayment options. In his current position at Wells Fargo, he is in charge of prepayment and default modeling of home equity and personal loan products. Prior to joining Wells Fargo, Hall spent 9 years in Corporate Treasury at Bank of America. There he was responsible for developing prepayment models for the bank's mortgage and home equity products. Prior to Bank of America, he was Vice President for Financial Analysis at the Federal Home Loan Bank of San Francisco, responsible for the bank's asset/liability management.

David Hand

David Hand is a professor and head of the Statistics Section at Imperial College London. He has published twenty books on statistics and related areas. He launched the journal *Statistics and Computing* in 1991, and also served a term of office as editor of *Journal of the Royal Statistical Society, Series C*. He was awarded the Thomas L. Saaty Prize for Applied Advances in the Mathematical and Management Sciences in 2001 and the Royal Statistical Society's Guy Medal in Silver in 2002, Hand was elected Fellow of the British Academy, the UK's leading learned society for the humanities and social sciences, in 2003.

M. Nazmul Hasan

M. Nazmul Hasan is a senior financial economist in the Risk Analysis Division at the Office of the Comptroller of the Currency. In his supervisory experience, Hasan has worked on such subjects as credit scoring, risk rating, pricing, and asset valuations. Prior to joining the OCC, Hasan was a senior manager in the Customer Information Management Division at American Express and an assistant professor at Illinois State University. He has published both applied and theoretical research on various topics in econometrics. Hasan holds a master's degree in statistics and a Ph.D. in economics from the University of Illinois at Urbana-Champaign.

Yongmiao Hong

Yongmiao Hong is a professor in the Department of Economics and Department of Statistical Science, Cornell University. His research interests cover nonparametric and nonlinear time series analysis, generalized spectral analysis, financial economet-rics, and the Chinese economy. He received his B.S. in physics and M.A. in economics from Xiamen University. Hong's Ph.D. in economics was granted by UC San Diego.

Nicholas M. Kiefer

Nicholas M. Kiefer is the Ta-Chung Liu professor of economics at Cornell University, where he is a member of the graduate field faculties in econom-ics, statistics and hospitality administration. He is widely known for his theoretical and applied contributions in the econometric modeling of duration data, the estimation of dynamic program-ming models under learning, and financial market microstructure. Kiefer's current research includes applications in financial economics, credit scoring and risk management, consumer trend forecast-ing, and development of quantitative management techniques for the restaurant and retail industries. Kiefer is an internationally recognized expert, having published in excess of 100 journal articles. books, and reviews. He is a Fellow of the Econo-metric Society, and a past recipient of the Guggen-heim Memorial Fellowship.

William W. Lang

William W. Lang is vice president for Retail Risk Analysis in the Federal Reserve Bank of Philadel-phia's Supervision, Regulation and Credit depart-ment. Prior to joining the Federal Reserve Bank of Philadelphia in 2002, he served as deputy director for Special Studies at the Office of the Comptrol-ler of the Currency, and as assistant professor of economics at Rutgers University. Lang's current research interests include applied credit and retail economic capital modeling. He received his Ph.D. from Yale University and his B.A. from the City College of New York.

C. Erik Larson

C. Erik Larson is a senior financial economist in the Risk Analysis Division of the Office of the Comp-troller of the Currency. His present work involves traveling to the largest of our nation's banks and examining the models developed and used by these institutions to measure and manage risk. Larson's research focuses on statistical and econometric issues in the modeling of credit risk and economic capital. Prior to joining the OCC, Larson analyzed and developed individual and corporate income tax policy in the Office of Tax Analysis at The Treasury. He also taught courses on probability, statistics, and econometrics while on the faculty of the University of Southern California School of Business Adminis-tration, and served as a private consultant, specializ-ing in the development of methods to value financial assets. Larson holds a Ph.D. in economics from Cornell and a B.A. from Syracuse University.

Mark Levonian

Mark Levonian is deputy comptroller for Models and Analysis at the Office of the Comptroller of the Currency. Previously, he served as vice president of Banking Supervision and Regulation at the Fed-eral Reserve Bank of San Francisco. In addition to publishing extensively, Levonian has taught finance at San Jose State University and the University of California at Berkeley and has been an advisor or consultant to the International Monetary Fund, the World Bank, and various foreign central banks. He holds a Ph.D. in economics from M.I.T. and a B.A. in economics from the University of California.

Adam Lin

Adam Lin is first vice president of Modeling & Analytics for Bank One Card Services. His responsibilities include the development and application of statistical models for collections strategy. Prior to joining Bank One, he worked on various aspects of credit card risk management for American Express, in both its US and International divisions. Lin holds a Ph.D. in Economics from the University of Arizona.

Kyle Lundstedt

Kyle Lundstedt is a managing director and co-founder of VaRisk, a research firm that builds customized valuation and risk management tools for financial institutions. Prior to founding VaRisk, he was vice president of analytics at the U.S. House Banking Committee. In addition to regularly speaking at various industry events, Lundstedt has published research appearing in both academic and industry journals. He holds a Ph.D. in business administration (finance) from U.C. Berkeley, and a B.A. in economics and political science from Yale University.

Martin O'Connor

Martin O'Connor is vice president of new solutions at Scorex, an Experian company, where he is responsible for the identification and development of new analytical and software solutions in the financial services area. Previously, O'Connor directed the Research and Development/Bureau business unit in the U.K., and managed the consulting unit for the banking sector of Experian. During this time he implemented application and behavioral scoring systems for several large U.K. banks and building societies. Prior to joining Experian, O'Connor taught statistics and economics at the State University of New York at Albany. O'Connor holds an M.A. in statistics and economics from SUNY Albany and a B.A. in mathematics from the University of Wales.

Shane P. Pederson

Shane P. Pederson is a senior manager in the Decision Sciences Group at Bank One Card Services. His work focuses on data mining, experimental design, optimization, and predictive modeling applications in the consumer credit industry. He has also worked as a technical staff member at Los Alamos National Laboratory, and as a member the faculty of the Department of Industrial and Systems Engineering at the Georgia Institute of Technology. Pederson holds a Ph.D. in statistics from the University of Minnesota.

Kasper Roszbach

Kasper Roszbach is an economist at Sveriges Riksbank, the central bank of Sweden. Before joining the Riksbank in 2002, he worked as the deputy director of merger control at the Netherlands Competition Authority, and at De Nederlandsche Bank and ABN Amro Bank. Roszbach's published research deals with credit risk modeling, bank lending policy, information sharing and banking relations. Roszbach holds a Ph.D. in economics from the Stockholm School of Economics, an M.A. from the University of Rochester, and an undergraduate degree from Erasmus University in Rotterdam

Balvinder S. Sangha

Balvinder Sangha is a partner with Ernst & Young's Quantitative Economics and Statistics (QUEST) Group, and is the director of E&Y's Financial Services Economics practice. He specializes in credit risk measurement, risk-based pricing, underwriting, and portfolio management of bank portfolios. Sangha is E&Y's principal analyst in the validation and review of credit assessment models used in consumer, commercial, and mortgage underwriting. He has provid-

ed advisory services to a number of clients relating to their use of economic capital allocation models, credit risk administration, development and use of small business and consumer scorecards, and quantitative early warning (credit deterioration) systems. Sangha holds a Ph.D. and an M.A. in economics from Brown University, and a B.B.A. from Loyola University of Chicago.

Sunil Sharma

Sunil Sharma is chief of the Asian Division at the International Monetary Fund Institute, which provides training in macroeconomic analysis and policy to officials of IMF's member countries and IMF staff. During his career at the IMF, Sharma has served as an economist in the Research department and European divisions. Prior to coming to Washington, Sharma was assistant professor of economics at the

University of California, Los Angeles. His research interests are broad, and he has published numerous papers on various aspects of dynamic economic modeling, both theoretical and applied. Sharma holds a Ph.D. in economics from Cornell University, an M.A. from the Delhi School of Economics, and a B.A. from St. Stephen's College, Delhi.

Tyler Shumway

Tyler Shumway is an associate professor of finance at the University of Michigan Business School. Shumway's research examines the structure and function of financial markets and the pricing of financial securities. Some of his recent work

concerns bankruptcy prediction and the pricing of corporate bonds, the efficient market hypothesis, and the intersection of psychology and finance.. He received his Ph.D. from the University of Chicago.

Jorge R. Sobehart

Jorge R. Sobehart is a vice president and senior analyst at Citigroup Risk Architecture. His current research interests include the probabilistic assessment of credit risk, the development of credit correlation and default risk models, and the development of the analytical methodology for estimating the allowance for loan loss reserves for Citibank's

corporate loan portfolio. Prior to joining Citigroup, Sobehart was a vice president and senior analyst at Moody's Risk Management Services and a member of Moody's standing committee on quantitative tools. Sobehart holds advanced degrees in physics and has postdoctoral experience at the U.S. Los Alamos National Laboratory.

Robert Stine

Robert Stine is a professor of statistics at the Wharton School at the University of Pennsylvania, where he has received numerous awards for excellence in teaching. His research focuses on multivariate statistical methods, statistical computing and graphics, and forecasting. His extensive publications include research on statistical approaches to credit scoring model development, bootstrapping and autoregressive time-series estimators. Current research projects include the application of symbolic computing to problems in forecasting and financial modeling, and use of computer resampling to assess structural equation models. He also consults extensively on statistical modeling applications in industry. Stine has served on the faculty at Princeton University, the University of Michigan and the University of South Carolina. He holds both Ph.D. and M.A. degrees from Princeton University; his B.S. is from the University of South Carolina.

John Straka

John Straka is senior director of Risk Analysis at Freddie Mac, where he leads the modeling team that develops the *Loan Prospector* scoring model. Straka co-authored Freddie's initial study of credit scores, and recently contributed a summary of automated underwriting in the mortgage market to the Journal of Housing Research. He has been a faculty associate with the Johns Hopkins business program, and worked previously for the Social Security Administration and the Congressional Budget Office. Straka holds a Ph.D. in Economics from Cornell University and B.A. in Economics from Williams College.

Halbert White

Halbert White is Chancellor's Associates professor of economics at the University of California, San Diego, and founder of Bates White, LLC, an economics consulting firm. He is a Fellow of the Econometric Society, a Fellow of the American Academy of Arts & Sciences, and a past Guggenheim Fellow. His research interests include econometric theory and applications, finance and financial services, and artificial neural networks. White holds a Ph.D. in economics from M.I.T.

Gary Wilhite

Gary Wilhite is senior vice president in the Risk Management Group of Wachovia Bank. He has been involved with quantitative risk management for over a decade at Wachovia and its predecessor banks. Wilhite oversees the development of commercial loan default probabilities, loss given default estimation, usage given default rates, the bank's allowance for loan losses, economic capital modeling for commercial and consumer credit, and the credit portion of the bank's Basel efforts. He actively participates in a number of industry groups and has published modeling work in trade industry journals. Wilhite holds an M.B.A. from the University of Virginia.

Chunchi Wu

Chunchi Wu is a professor of finance at Syracuse University. While at S.U., Wu has chaired the Finance department and directed the Ballentine Center for the Study of Securities Markets. He is a co-editor for the *Journal of Entrepreneurial Finance and Business Ventures*, and has consulted for the Economic Development Institute at the World Bank. Professor Wu's current research interests are in credit risk analysis, term structure, and market microstructure. He holds a Ph.D. from the University of Illinois at Urbana-Champaign.

Frank Zhao

Frank Zhao manages the credit line optimization team in the decision science group at Chase Card-member Services. Zhao develops quantitative tools and strategies for exposure management programs, such as initial line assignment, credit line increase, credit line decrease, and consumer-level credit cap. He has worked on targeting and pricing of balance consolidation and convenience check products, re-pricing, and activation programs. Zhao holds master's degrees in mathematics, statistics, and business administration.
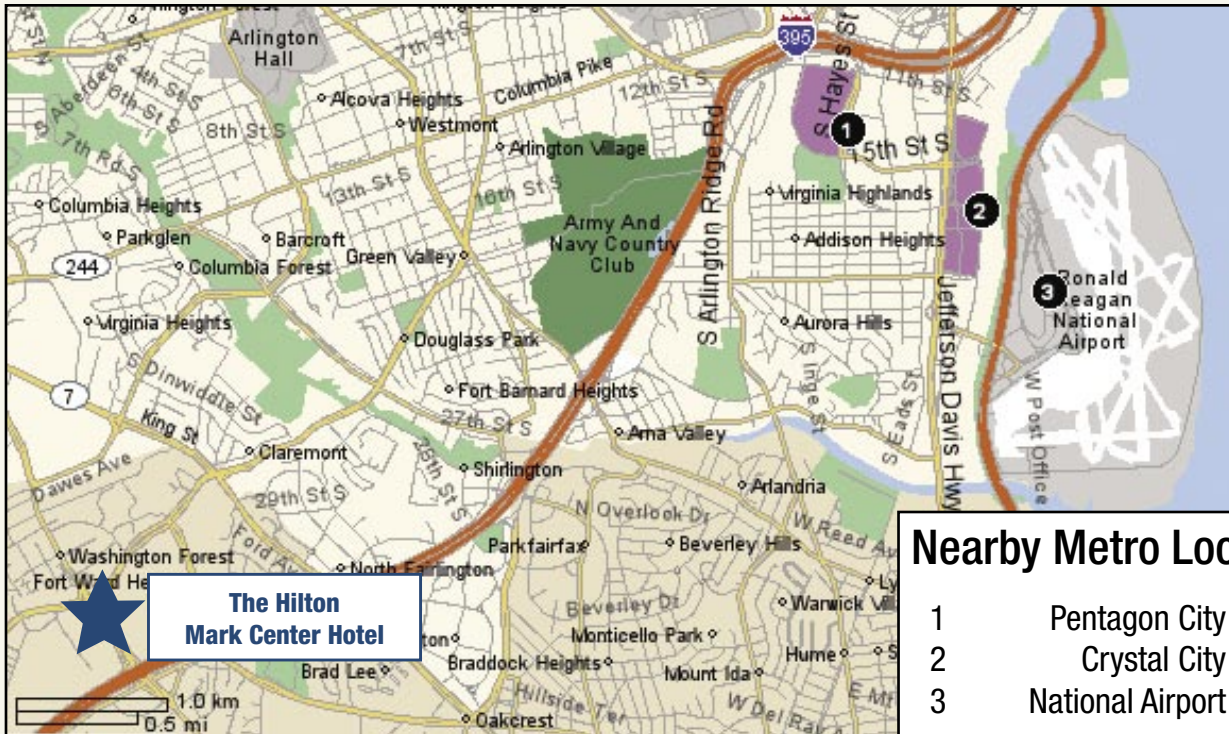
Venue Information

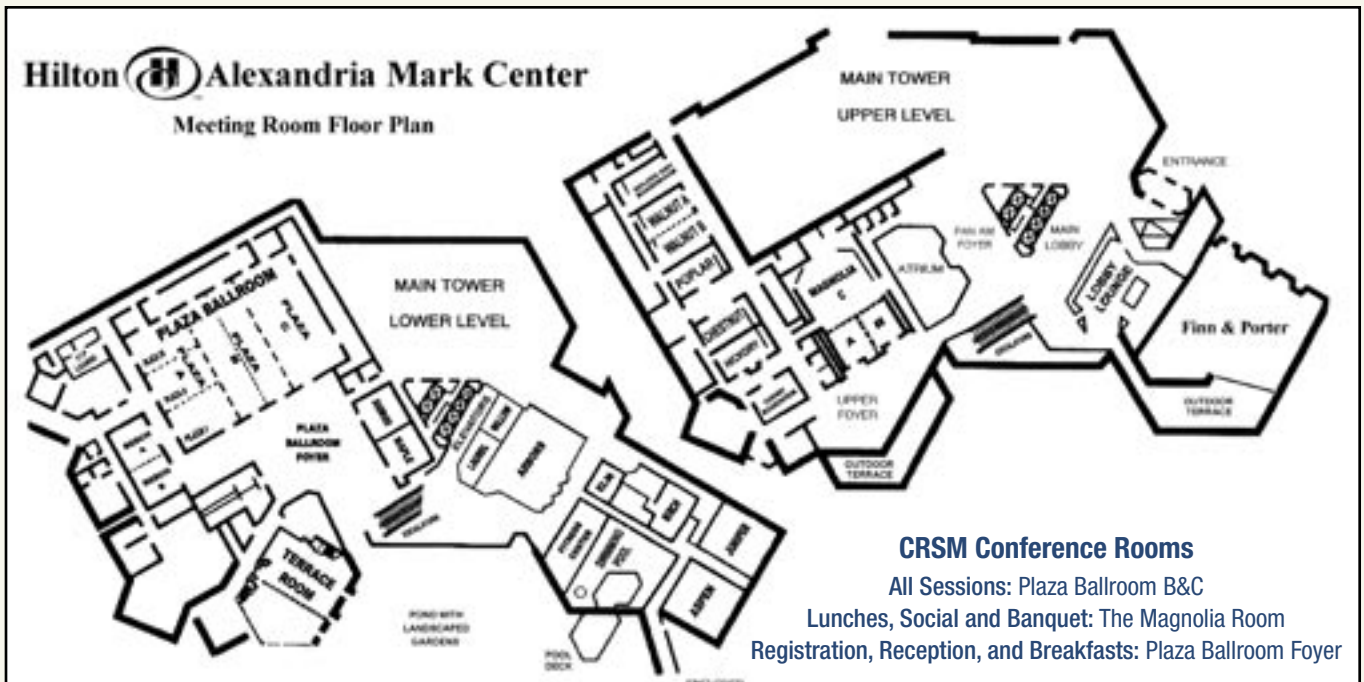## The Hilton Mark Center Hotel

5000 Seminary Rd
Alexandria, VA 22311-1946
Tel: 1-703-845-1010 Fax: 1-703-845-7662

The Hilton Mark Center Hotel

Nearby Metro Locations

1	Pentagon City Station
2	Crystal City Station
3	National Airport Station

Hilton Alexandria Mark Center
Meeting Room Floor Plan

CRSM Conference Rooms
All Sessions: Plaza Ballroom B&C
Lunches, Social and Banquet: The Magnolia Room
Registration, Reception, and Breakfasts: Plaza Ballroom Foyer