# The State of the Art in Credit Portfolio Modeling

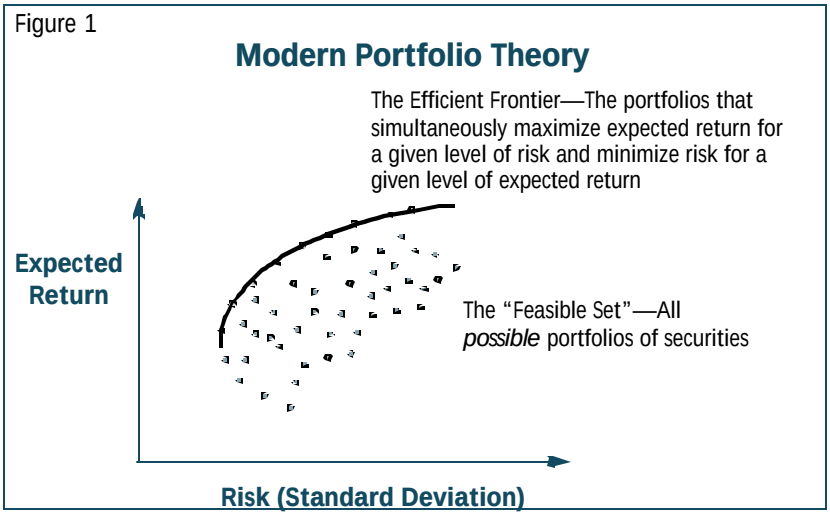
by Charles W. Smithson and Gregory Hayt

This is the second of a series of five excerpts from a forthcoming book *Managing Credit Risk: Toward a Portfolio Approach to Credit Risk Management* by Charles Smithson and Gregory Hayt of Rutter Associates. Future articles will appear in the May, July/August, and October 2001 issues.

Equity investors have enthusiastically embraced the concepts of diversification and asset allocation. Modern portfolio theory (MPT) has transformed equity portfolio management from a philosophy of "picking winners" to one where investors strive to hold an "efficient portfolio." The central feature of MPT is an efficient portfolio that simultaneously maximizes expected return for a given level of risk and minimizes risk for a given level of return.

Recognition of correlation is the key to the benefits of holding a well-diversified portfolio. If the returns of two assets are less than perfectly positively correlated, an investor can reduce the risk for a given level of return or increase expected return for a given level of risk. In marked contrast to the pick-winners philosophy that dominated equity investing through the 1960s, this means that an investor might wish to include a "loser" in the portfolio, as long as that asset has a very low (or negative) correlation with other assets in the portfolio.

Figure 1

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### Challenges to the Implementation of MPT for Portfolios of Credit Assets

While MPT has driven equity portfolio management for more than 30 years, it is still not widely applied to credit assets. The norm for loans and other credit assets is still for a financial institution to originate the asset and then hold it until it matures or defaults. One reason for this is that portfolios of credit assets present more challenges to the implementation of MPT than do portfolios of equities.

Distribution of losses. The mean-variance (that is, normally distributed) environment assumed by MPT is less justifiable for portfolios of credit assets than for portfolios of equities. As is illustrated in Figure 2, the loss distributions for loans and other credit assets are not normally distributed and are not even symmetric. And there is limited data on the historical performance of credit assets from which the appropriate shape of the loss distribution could be estimated. Credit has strong option-like characteristics, and credit assets have more dimensions than equity as well, including uncertain usage of credit lines, uncertain losses in the event of default, collateral, and the ability to restructure assets by changing the terms of the lending agreement.

In addition, credit portfolio management requires more than a mean/variance view of the world. The credit portfolio manager places much more emphasis on extreme outcomes—"tail" events—to determine economic capital and credit rating.

Data limitations. Arguably, the largest obstacle to the application of portfolio theory in banks is the lack of clean, consistent data.

One problem area involves the data on existing and new loans. Financial institutions are making significant investments in order to locate data (often still in original loan documents), to reconcile different systems, clean and validate data, and develop an infrastructure to maintain the data going forward. The fact that data on credit portfolios is so difficult to consolidate into a workable central database reflects the traditional originate-and-hold strategy at most financial institutions in which loans are viewed in isolation rather than as part of a portfolio.

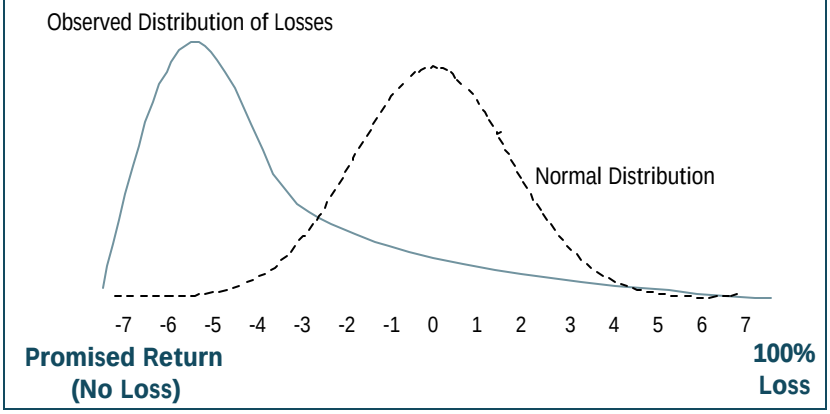
Another problem area involves estimates of expected return, risk, and correlation. For credit assets, these parameters are, themselves, determined by the probability of default (downgrade), the volatility of the probability of default (downgrade), loss in the event of default, and the correlation of defaults (or downgrades). As noted earlier, there is limited data on the historical performance of credit assets from which to estimate these parameters. However, in the case of stand-alone measures of the risk and return of individual credits, there is an increasing array of choices.

Figure 3 (next page) provides a listing of sources of information on probabilities of default for public and private firms. Each of the default models uses proprietary analytics with inputs ranging from financial statements alone, to financial statements plus equity market data, and to systems based entirely on spreads on traded assets.

Figure 4 summarizes sources for loss given default (LGD) and usage of committed facilities by defaulting firms. Of course, large financial institutions have considerable internal data, if they can organize it, on these variables. There also are important industry, academic, and commercial studies that have added to our knowledge through the pooling or collecting of data across institutions.

Figure 1

**Losses from Loans and Other Credit Assets Are Not Normally Distributed**



## First Generation Credit Portfolio Models

The public release of credit portfolio models began in the mid 1990s. KMV released Portfolio Manager™ in 1993. The RiskMetrics Group (RMG) released its CreditMetrics™ methodology (and the CreditManager™ software package) in 1997. Also in 1997, Credit Suisse First Boston introduced its CreditRisk+™. McKinsey introduced CreditPortfolioView™ in 1998. During the same period, many firms had or were developing internal models for credit portfolio management. Many of the internal models addressed assets that were not covered by the initial releases of the public models, including middle market corporate lending and consumer lending.

Figure 3

**Sources of Standalone Risk Estimates for Credit Assets**

| Vendor | Product | Description |
|---|---|---|
| KMV | Credit Monitor®/ CreditEdge™ | Expected Default Frequency™ (EDF™) credit measures for public firms updated monthly/daily. Private Firm Model® also available. |
| Kamakura Corporation | KRM—cr™ | Default probability derived from credit spreads |
| Loan Pricing Corporation | Risk Rater™ | Default probability and expected loss for commercial loans |
| Moody's | RiskCalc™ | Default probabilities for public or private firms |
| Standard & Poor's | CreditPro™ | Historical marginal and cumulative default rates by industry and geography |
| Standard & Poor's | CreditModel™ | Implied credit ratings for public or private firms |
| EnronCredit.com | Enron Cost of Credit™ | Default probability estimates coupled with historical recovery data |

Figure 4

**Sources of Data on Loss Given Default and Usage of Committed Lines**

| Source | Study or Database? | Description of Data |
|---|---|---|
| Altman & Kishore (96) | Recovery study | Recovery on bonds organized by seniority and industry |
| Carty & Lieberman (96) (Moody's) | Default and recovery study | Recovery data by seniority; Post default default secondary market prices |
| Loan Pricing Corporation | Loan Loss | Historical loss data for a large sample of credit assets |
| S&P/Portfolio Management Data | Loss/Recovery Database | Historical data for a large sample of credit assets |
| Asarnow & Marker (95) | Study of usage of committed credit lines | Usage by credit rating and loss given default |

These four models are implementations of three broad approaches:

1. Asset volatility approach. The risk of default or downgrade is modeled in terms of the value of a firm's assets relative to its liabilities. These models are also called *structural models* because the risk of default/downgrade is derived from a formal model of credit risk at the firm level.

2. Actuarial approach. The risk of default and the loss given default are assumed to fit certain distributions. This assumption makes it possible to calculate the distribution of portfolio losses analytically. In some ways, this approach is closest to the original mean/variance approach of Markowitz, which assumes normally distributed asset returns and yields closed form results for portfolio risk and security risk (Beta).

3. Factor model approach. The probability of default is assumed to depend on the state of such user-defined factors as GDP, unemployment, commodity prices, and so forth. These models are quite general in that no underlying theory determines which factors are most appropriate or what weights should apply to

changes in each factor. This lack of formal structure makes them very flexible and extremely transparent, since the risk of default is linked explicitly to systematic variables and a firm-specific component.

Figure 5 provides an overview of the four widely-discussed credit portfolio models. The first row identifies the approach employed—both Portfolio Manager and CreditManager are asset volatility models, CreditRisk+ is an actuarial approach, and CreditPortfolioView is a factor model approach. CreditRisk+ is the only credit portfolio model that deals only with default; the others consider both default and downgrades. The user supplies probabilities of default (downgrade) to CreditManager and CreditRisk+. While Portfolio Manager could use any probabilities of default, it is most likely that they would come from KMV's Credit Monitor. In CreditPortfolioView, the probabilities of default are determined by simulated macro factors. In all of the models, the user supplies the expected loss given default to the model.

Not surprisingly, the models differ in the way that they deal with the correlation of defaults (downgrades). Correlation in Portfolio Manager is obtained by a factor model of asset returns, which, in turn, drives changes in the EDF measures (default probabilities) of the obligors. CreditManager uses a similar idea. Obligors are allocated to different equity indexes based on geography and industry. These allocations, together with the correlation of the equity indexes, drive the correlation of implied asset values and, ultimately, the correlation of defaults and downgrades. In CreditRisk+, default correlation is created via two effects:

1. Obligors can be allocated to different segments, with the segments themselves being independent of one another.
2. Each obligor is also assigned a default rate volatility.

The segment allocation and default rate volatility imply a correlation between default rates for any pair of obligors. In CreditPortfolioView, default (downgrade) correlation enters the model through the correlation of the chosen macro factors and estimated factor weights. For this purpose, obligors are grouped into industry and geographic segments that share common factors and weights.

## Second Generation Credit Portfolio Models

This year, significant new releases of the CreditManager product from RMG and the Portfolio Manager and Credit Monitor products from KMV are expected. In addition to those early entrants, credit risk is the focus of relatively new products from Kamakura Corporation and Algorithmics.

Web and server-based applications. The first generations of credit portfolio models were designed to reside on PCs or workstations as stand-alone applications. While centralized applications are still the norm, more products will be available either over the web or through a client/server link.

KMV's Credit Edge™ is accessed over the Web and is targeted at the

Figure 5

### Overview of Four Credit Portfolio Models

| | KMV Portfolio Manager | RMG CreditMetrics (CreditManager) | CSFB CreditRisk+ | McKinsey CreditPortfolioView |
|---|---|---|---|---|
| Approach | Asset Volatility | Asset Volatility | Actuarial Model | Factor Model |
| Considers effects of default and downgrades? | Both | Both | Default Only | Both |
| Probability of default | Endogenous (from Credit Monitor) or Exogenous | Exogenous | Exogenous | Endogenous |
| Loss given default | Exogenous | Exogenous | Exogenous | Exogenous |
| Correlation | Asset Correlation via a factor model | Equity (index) correlation via a factor model | Default correlation via segments and default volatility | Default/migration correlated via macro factor model |

active portfolio manager. Users receive EDF and stock price information that is updated daily. The interactive format allows users to track company-specific news, set EDF-driven alerts on companies in their portfolio, capture current financial data, and be informed of corporate filings.

RMG's CreditManager will be available as a server application this year. The idea is that CreditManager users may, themselves, have clients who could access the CreditManager model for their portfolios through the server model.

These Web and server-based applications reflect, in part, the increased use of credit models by hedge funds and institutional investors. These clients are more active managers with smaller portfolios than banks for which the speed of updates and other interactive features are likely to have increased value.

CDOs. Although CDOs are portfolios of credit assets, they have proved difficult to model in the first generation of credit models. Those models provide relative risk contributions for the underlying assets and the overall distribution of losses. As such, they can be used to compare collateral in different CDOs and to model the equity risk. What the first generation models don't do well is model the risk and return of individual tranches, which depend on the specific rules governing the priority of cashflows, asset tests, hedges, and so forth.

First released in 2000, RMG's CDO Model is specifically designed for originators and investors in CDOs. To evaluate the risk and pricing of specific tranches, users describe a transaction's structure (for example, the rules for cash flow allocation and asset tests) as well as the assets comprising the collateral. The CDO Model departs from the CreditManager approach, because it models time-to-default over multiple periods rather than default (or rating change) up to a fixed horizon. KMV has not released a stand-alone CDO product but works with clients on a consulting basis to model the specific structure of CDO cash flows using analytic tools developed around its Portfolio Manager product.

Correlated severity. First-generation credit portfolio models have treated the uncertainty in the recovery, or the loss given default, as a random variable, but one that is uncorrelated with the default rate. However, historical data on default rates and recoveries suggests that the distribution of recoveries is different in high default years than it is in low default years. It is possible to capture the dependence between default rates and recoveries evidenced in the data with a credit portfolio model, and it is likely that this will become a feature of commercial and proprietary models in the future. ❐

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State-of-the-art credit risk models take into account the economic fundamentals of the data generating processes. For example, it is now common to include the life cycle of nancial products from origination to payoff, default, or maturity while con-trolling for the current state of the economy.Â  We compute credit portfolio default rates and credit portfolio loss distributions using analytical and Monte Carlo simulationâ€“based approaches, and show the reader how correlations can be estimated using internal data. The tenth chapter presents marginal loss given default (LGD) models and LGD models that condition on the selecting default event. The eleventh chapter discusses exposure at default (EAD) models, which are similar in structure to LGD models. Trends in portfolio management. The State of the Art in. Credit Portfolio Modeling by Charles W. Smithson and Gregory Hayt.Â  As such, they can generation credit portfolio models information that is updated daily. be used to compare collateral in have treated the uncertainty in The interactive format allows different CDOs and to model the the recovery, or the loss given users to track company-specific equity risk. What the first genera- default, as a random variable, but news, set EDF-driven alerts on tion models dont do well is one that is uncorrelated with the companies in their portfolio, cap- model the risk and return of indi- default rate. A credit portfolio is an investment portfolio comprised of debts, like home and car loans. Private investors can build credit portfolios, but more commonly they are held by banks and other financial institutions. Typically, other types of investments are held as well to diversify risk, making the chances of catastrophic investment failures less likely.Â  Unlike market risk, there is scarcity and reliability of credit risk data to be one of the key impediments to the sound design and predictive capability of credit risk models. Credit risk models are influenced by constant shifts in market variables, economic environment, business line products and services, and credit quality; 2. Legacy and outdated IT systems.