




# A comparative analysis of current credit risk models ☆

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## Abstract

The new BIS 1998 capital requirements for market risks allows banks to use internal models to assess regulatory capital related to both general market risk and credit risk for their trading book. This paper reviews the current proposed industry sponsored Credit Value-at-Risk methodologies. First, the credit migration approach, as proposed by JP Morgan with CreditMetrics, is based on the probability of moving from one credit quality to another, including default, within a given time horizon. Second, the option pricing, or structural approach, as initiated by KMV and which is based on the asset value model originally proposed by Merton (Merton, R., 1974. *Journal of Finance* 28, 449–470). In this model the default process is endogenous, and relates to the capital structure of the firm. Default occurs when the value of the firm's assets falls below some critical level. Third, the actuarial approach as proposed by Credit Suisse Financial Products (CSFP) with CreditRisk+ and which only focuses on default. Default for individual bonds or loans is assumed to follow an exogenous Poisson process. Finally, McKinsey proposes CreditPortfolioView which is a discrete time multi-period model where default probabilities are conditional on the macro-variables like unemployment, the level of interest rates, the growth rate in the economy, ... which to a large extent drive the credit cycle in the economy.

## Introduction

BIS 1998 is now in place, with internal models for market risk, both general and specific risk, implemented at the major G-10 banks, and used every day to report regulatory capital for the trading book. The next step for these banks is to develop a VaR framework for credit risk. The current BIS requirements for “specific risk” are quite loose, and subject to broad interpretation. To qualify as an internal model for specific risk, the regulator should be convinced that “concentration risk”, “spread risk”, “downgrade risk” and “default risk” are appropriately captured, the exact meaning of “appropriately” being left to the appreciation of both the bank and the regulator. The capital charge for specific risk is then the product of a multiplier, whose minimum volume has been currently set to 4, times the sum of the VaR at the 99% confidence level for spread risk, downgrade risk and default risk over a 10-day horizon.

There are several issues with this piecemeal approach to credit risk. First, spread risk is related to both market risk and credit risk. Spreads fluctuate either, because equilibrium conditions in capital markets change, which in turn affect

credit spreads for all credit ratings, or because the credit quality of the obligor has improved or deteriorated, or because both conditions have occurred simultaneously. Downgrade risk is pure credit spread risk. When the credit quality of an obligor deteriorates then the spread relative to the Treasury curve widens, and vice versa when the credit quality improves. Simply adding spread risk to downgrade risk may lead to double counting. In addition, the current regime assimilates the market risk component of spread risk to credit risk, for which the regulatory capital multiplier is 4 instead of 3.

Second, this issue of disentangling market risk and credit risk driven components in spread changes is further obscured by the fact that often market participants anticipate forthcoming credit events before they actually happen. Therefore, spreads already reflect the new credit status when the rating agencies effectively downgrade an obligor, or put him on “credit watch”.

Third, default is just a special case of downgrade, when the credit quality has deteriorated to the point where the obligor cannot service anymore its debt obligations. An adequate credit-VaR model should therefore address both migration risk, i.e. credit spread risk, and default risk in a consistent and integrated framework.

Finally, changes in market and economic conditions, as reflected by changes in interest rates, the stock market indexes, exchange rates, unemployment rates, etc. may affect the overall profitability of firms. As a result, the exposures of the various counterparts to each obligor, as well as the probabilities of default and of migrating from one credit rating to another. In fact, the ultimate framework to analyze credit risk calls for the full integration of market risk and credit risk. So far no existing practical approach has yet reached this stage of sophistication.

During the last two years a number of initiatives have been made public. CreditMetrics from JP Morgan, first published and well publicized in 1997, is reviewed in the next section. CreditMetrics' approach is based on credit migration analysis, i.e. the probability of moving from one credit quality to another, including default, within a given time horizon, which is often taken arbitrarily as 1 year. CreditMetrics models the full forward distribution of the values of any bond or loan portfolio, say 1 year forward, where the changes in values are related to credit migration only, while interest rates are assumed to evolve in a deterministic fashion. Credit-VaR of a portfolio is then derived in a similar fashion as for market risk. It is simply the percentile of the distribution corresponding to the desired confidence level.

KMV Corporation, a firm specialized in credit risk analysis, has developed over the last few years a credit risk methodology, as well as an extensive database, to assess default probabilities and the loss distribution related to both default and migration risks. KMV's methodology differs somewhat from CreditMetrics as it relies upon the “Expected Default Frequency”, or EDF, for each issuer, rather than upon the average historical transition frequencies produced by the rating agencies, for each credit class.

Both approaches rely on the asset value model originally proposed by Merton (1974), but they differ quite substantially in the simplifying assumptions they require in order to facilitate its implementation. How damaging are, in practice, these compromises to a satisfactory capture of the actual complexity of credit measurement stays an open issue. It will undoubtedly attract many new academic developments in the years to come. KMV's methodology is reviewed in Section 3.

At the end of 1997, Credit Suisse Financial Products (CSFP) released a new approach, CreditRisk+, which only focuses on default. Section 4 examines briefly this model. CreditRisk+ assumes that default for individual bonds, or loans, follows a Poisson process. Credit migration risk is not explicitly modeled in this analysis. Instead, CreditRisk+ allows for stochastic default rates which partially account, although not rigorously, for migration risk.

Finally, McKinsey, a consulting firm, now proposes its own model, CreditPortfolioView, which, like CreditRisk+, measures only default risk. It is a discrete time multi-period model, where default probabilities are a function of macro-variables such as unemployment, the level of interest rates, the growth rate in the economy, government

expenses, foreign exchange rates, which also drive, to a large extent, credit cycles. CreditPortfolioView is examined in Section 5.

From the actual comparison of these models on various benchmark portfolios, it seems that any of them can be considered as a reasonable internal model to assess regulatory capital related to credit risk, for straight bonds and loans without option features.<sup>1</sup> All these models have in common that they assume deterministic interest rates and exposures. While, apparently, it is not too damaging for simple “vanilla” bonds and loans, these models are inappropriate to measure credit risk for swaps and other derivative products. Indeed, for these instruments we need to propose an integrated framework that allows to derive, in a consistent manner, both the credit exposure and the loss distribution. Currently, none of the proposed models offers such an integrated approach. In order to measure credit risk of derivative securities, the next generation of credit models should allow at least for stochastic interest rates, and possibly default and migration probabilities which depend on the state of the economy, e.g. the level of interest rates and the stock market. According to Standard & Poor's, only 17 out of more than 6700 rated corporate bond issuers it has rated defaulted on US \$4.3 billion worth of debt in 1997, compared with 65 on more than US \$20 billion in 1991. In Fig. 1 we present the record of defaults from 1985 to 1997. It can be seen that in 1990 and 1991, when the world economies were in recession, the frequency of defaults was quite large. In recent years, characterized by a sustained growth economy, the default rate has declined dramatically.

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## Section snippets

### CreditMetrics<sup>2</sup> and CreditVaR I<sup>3</sup>

CreditMetrics/CreditVaR I are methodologies based on the estimation of the forward distribution of the changes in value of a portfolio of loan and bond type products<sup>4</sup>...

### KMV<sup>15</sup> model

The major weakness of CreditMetrics/CreditVaR I is not the methodology, which is rather appealing, but the reliance on transition probabilities based on average historical frequencies of defaults and credit migration. The accuracy of CreditMetrics/CreditVaR I calculations relies upon two critical assumptions: first, all firms within the same rating class have the same default rate, and second, the actual default rate is equal to the historical average default rate. The same assumptions also...

### CreditRisk+ model

CreditRisk+<sup>29</sup> applies an actuarial science framework to the derivation of the loss distribution of a bond/loan portfolio. Only default risk is modeled, not downgrade risk. Contrary to KMV, default risk is not related to the capital structure of the firm. In CreditRisk+ no assumption is made about the causes of default: an obligor *A* is either in default with ...

### CreditPortfolioView<sup>33</sup>

CreditPortfolioView is a multi-factor model which is used to simulate the joint conditional distribution of default and migration probabilities for various rating groups in different industries, for each country, conditional on the value of macroeconomic factors like the unemployment rate, the rate of growth in GDP, the level of long-term interest rates, foreign exchange rates, government expenditures and the aggregate savings rate.<sup>34</sup>...

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