Stress-testing a credit portfolio with correlations and strategically managing portfolio limits

Alexis Hamar, Credit Portfolio Management Specialist at Moody’s Analytics, takes a look at the predictive capabilities of modelling portfolio management/economic capital during the crisis, as a benchmark to the credit default swap (CDS) market.

The first step is to compare the factors used to measure risk in CDS portfolios (i.e., unexpected loss) as modelled and predicted using market data as at January 2008, against the risk levels observed in the CDS market for the period January 2008 to May 2009.

The next step is to compare the model’s results against actual risk contributions. This involves three phases: 1) building 100 CDS portfolios as at January 2008, 2) producing ex-ante and ex-post portfolio valuations (directly modelled unexpected loss; empirical unexpected loss; weekly CDS returns with portfolio valuations and actual volatility), and 3) calculating rank correlations based on the various parameter hypotheses used (probability of default and correlations), and classifying the differences between predicted and actual portfolio valuations.

The methodology of Moody’s Analytics uses correlations to stress-test credit portfolios. It defines this as the process of adversely varying a model’s inputs and then analysing the impact of the corresponding outputs. In the context of a credit portfolio, the extent to which inputs are varied will reflect unfavourable macroeconomic conditions directly relating to a market crash, a natural disaster, or a political event, etc. The turmoil on the financial markets in 2008 and 2009 clearly demonstrates the need for stress-testing that is not only more reliable and effective, but also more flexible and predictive.

Correlations are the cornerstone of modern dynamic management of portfolios and economic capital: correlations of asset returns between debtors, correlations of asset returns and recoveries (i.e., correlations between probability of default (PD) and loss given default (LGD)), correlations between credit asset classes (retail, SMEs, property development, corporate), correlations between risks (credit market, i.e., interest rates-default risk) and correlations embedded in structured products.
During the financial crisis, these correlations often attracted criticism and were measured inaccurately, if at all. Not enough attention has been paid in the past—and this continues to be the case—to measuring them at the level of either debtors or asset classes, and by extension risk families. This parameter is often the subject of debate with regulators and clients.

The crisis also raised a number of other issues, including integration between the inter-credit and intra-credit segments and a more comprehensive integration of market, credit and liquidity risks.

In addition to the crucial information produced by correlations, the other major objective in relation to credit portfolios is to generate "conditional" loss distributions for a group of future states and situations.

Constructing loss distributions based on random exposure samples is conditional upon systematic and idiosyncratic factors based on a macroeconomic scenario (GDP, unemployment rate, the performance of the CAC 40).

**Methodology of Moody's Analytics for stress-testing correlations**

Our approach is based on determining econometric relationships between the probability of default (PD), loss given default (LGD) and correlations with a series of macroeconomic variables. Once these relationships have been established, we then stress these parameters to generate the conditional loss distribution. There are three steps in this approach.

1. Establish the relationships between the macroeconomic variables (GDP, unemployment rate, inflation, etc.) and the time series of the variance \(^1\) and the underlying factorial returns in a multi-factorial correlation model. During this first step, the macroeconomic variables, which are a fundamental component of stress-testing, are also selected.

2. Establish the relationship between the factorial returns/variances and the probability of default using multi-variant econometric models which vary by country and industry. Once the probability of default is correlated with the loss given default, we can then calculate a conditional probability of default; i.e., a conditional LGD.

3. Apply the economic scenarios. By applying a stress scenario comprising several macroeconomic variables, as selected in step 1, we obtain a conditional loss distribution from the PD, LGD and correlations subjected to shock. To understand the change in portfolio risk metrics (expected loss, unexpected loss, capital) for a credit portfolio of large (listed) names held by a financial institution as the result of a financial and/or economic shock during the 4th quarter of 2008, we start by defining the analysis period (as at the end of Q4 2007; i.e., pre-2008 crisis), then apply the financial and/or economic shocks (Q4 2008 forecast) to the portfolio risk factors.

In this second step, the sensitivities \(^2\) of these time series of factorial returns/variance in PD, LGD and RSQ (R-squared) are calibrated using empirical findings from previous crises.

In the first two steps, we need to estimate the empirical relationships not only between macroeconomic variables and factorial returns/variances, but also between factorial returns/variances and PD, LGD and RSQ. These relationships must take into account the results of the stress scenarios. They can be estimated by "weighting" the sensitivity of relevant observations (e.g., distance to default (DD), expected default frequency (EDF), LGD and RSQ.

\(^1\) Each debtor has its own factorial market returns and variances based on its weightings: factors such as country and sector (corporate or SME), region and type of property (property development), region and type of product (retail). Factorial variance at market level includes these systematic factors, which impact a borrower.

\(^2\) The sensitivities of PD, LGD and RSQ to factorial variance and returns are calibrated in relation to a given historic shock. Calibration is performed once for each historic shock and enables the level of sensitivity for each country and sector to be identified.
By modifying the weighting, we can establish relationships for various stress test scenarios; e.g., moderate in 2000 or extreme in 2008.

**Setting and strategically managing limits as part of portfolio management: the importance of including risk families**

The Basel II and Solvency II \(^3\) directives, which set out the capital adequacy requirements for credit, operational and market risk, have shown the importance of including risk families within portfolio management in terms of conformity. This also applies to reporting, since senior management and shareholders need to know the institution’s overall risk exposure. Another vital component of active management is an integrated risk overview.

In practice, financial institutions very often assess risk families separately, then aggregate them. Risk aggregation techniques are generally less sophisticated than those used for individual risks. There are two ways to incorporate risk families. The more traditional top-down approach is to establish the loss distribution for each risk family, both separately and aggregated—Each risk family’s losses are determined based on its marginal loss distribution, then aggregated using correlations. This produces a complete overview of the portfolio’s loss distribution. The second approach—bottom-up—consists of evaluating the loss based on the underlying risk sources, then aggregating the result.

The bottom-up approach of Moody’s Analytics, which combines correlations between interest rates (stochastic) with default risk, uses a two-dimensional lattice model \(^4\), enabling the integration of credit and market risk to be measured.

The portfolio limits inherit the inadequacies of the associated risk systems. Overly tight or generous limits result in risk being over- or under-estimated. The limits have to be connected to the portfolio strategy. In the first instance, limits must be set according to a stress scenario and using the aggregation approach (top-down or bottom-up) chosen. This enables risk tolerance to be defined so that performance monitoring can be planned, and identifies the applicable risk metrics (economic capital, risk level based on distribution tail (tail risk), with associated loss probability).

Within a limit-management strategy, therefore, two approaches apply. The top-down approach is based on pre-existing systems and models. Although it is adequate in most cases, it can sometimes over- or under-estimate risk.

\(^3\) Solvency II also requires insurance risks (life/non-life) to be measured and integrated.

\(^4\) The lattice model is based on credit migration and used for valuing complex exposure where the cash flow structures depend on credit quality. The lattice model can also be used for valuing instruments and their embedded options (early redemption, dynamic drawdown, grid pricing, term-out, etc.).
The bottom-up approach offers a more specific and granular vision of risk integration. It can also be used to better understand portfolio distortions, as well as to calibrate the correlation parameters for the top-down approach.

Stress-testing is therefore a more objective gauge of a risk model because it ‘shocks’ resistance throughout the model, using parameters such as probability of default, loss given default and inter- and intra-class/risk correlations. That said, it is crucial to choose the right macroeconomic variables for the complex exercise of stress-testing.

**AUTHOR**

Alexis Hamar is a Portfolio Management & Valuation Specialist at Moody's Analytics, responsible for the Southern Europe, Nordic and Benelux regions. Over the past 11 years, Alexis previously worked at various consultancy and software companies, implementing and designing risk solutions at several major financial institutions, then at SAS Institute as Head of the French Risk practice, before joining Moody's KMV, a leading financial software solution provider in the credit risk area. To contact Alexis Hamar, please call Manuela Gebhard at +44 (0)207-772-1547 or via e-mail at stress-testing@moodys.com.

This article has been written on the basis of a presentation given by the author at Moody’s Analytics Stress Testing Forum held in Paris, France on February 9, 2010. For more information or to attend similar events, please contact us at stress-testing@moodys.com.