

averaged or otherwise summarized to construct a "typical" or representative obligor for each grade. Then, the bank maps that representative obligor to the reference data. For example, if the bank uses a default model, the default probability associated with that typical obligor will serve as the grade PD in the application stage. Alternatively, the bank may map the typical obligor to a particular external rating grade based on quantitative and qualitative characteristics, and assign the long-run default rate for that rating to the internal grade in the application stage.

Either grade mapping or obligor mapping can be part of the quantification process; either method can produce a single PD estimate for each grade in the application stage. However, in the absence of other compelling considerations, banks should use obligor mapping for two reasons:

- First, default probabilities are nonlinear under many estimation approaches. As a result, the default probability of the typical obligor—the result of a grade mapping approach—is often lower than the mean of the individual obligor default probabilities from the obligor mapping approach. For example, consider a bank that maps to the S&P scale and uses historical S&P bond default rates. For ease of illustration, suppose that one internal grade contains only three obligors that individually map to BB, BB–, and B+. The historical default rates for these three grades are 1.07, 1.76, and 3.24 percent, respectively (based on 1981–2001 data). Using obligor mapping, those rates would be assigned directly to the three obligors, yielding a mean PD of 2.02 percent for the grade. Using grade mapping, the grade PD would be only 1.76, because the grade's typical obligor is rated BB–.

- Second, a hypothetical obligor with a grade's average characteristics may not represent well the risks presented by the grade's typical obligor. For example, a bank might observe that obligors with high leverage and low earnings variability have about the same default risk as obligors with low leverage and high earnings variability. These two types of obligors might both end up in the same grade, for example, Grade 6. If so, the typical obligor in Grade 6 would have moderate leverage and moderate earnings variability—a combination that might fail to reflect any of the individual obligors in Grade 6, and that could easily result in a PD for the grade that is too low.

A bank electing to use grade mapping instead of obligor mapping should be especially careful in choosing a

"typical" obligor for each grade. Doing so typically requires that the bank examine the actual distribution of obligors within each grade, as well as the characteristics of those obligors. Banks should be aware that different measures of central tendency (such as mean, median, or mode) will give different results, and that these different results may have a material effect on a grade's PD; they must be able to justify their choice of a measure. Banks must have a clear and consistent policy toward the calculation.

S. The mapping must be based on a robust comparison of available data elements that are common to the portfolio and the reference data.

Sound mapping practice uses all common elements that are available in the data as the basis for mapping. If a bank chooses to ignore certain common variables or to weight some variables more heavily than others, those choices must be supported. Mapping should also take into account differences in rating philosophy (for example, point-in-time or through-the-cycle) between any ratings embedded in the reference data set and the bank's own rating regime.

A mapping should be plausible, and should be consistent with the rating philosophy established by the bank as part of its obligor rating policy. For a bank that uses grade mapping, levels and ranges of key variables within each internal grade should be close to values of similar variables for corresponding obligors within the reference data.

The standard allows for use of a limited set of common variables that are predictive of default risk, in part to permit flexibility in early years when data may be far from ideal.

Nevertheless, banks will eventually be expected to use variables that are widely recognized as the most reliable predictors of default risk in mapping exercises. In the meantime, banks relying on data elements that are weak predictors must compensate by making their estimates more conservative. For example, leverage and cash flow are widely recognized to be reliable predictors of corporate default risk. Borrower size is also predictive, but less so. A mapping based solely on size is by nature less reliable than one based on leverage, cash flow, and size.

*Example 1.* In estimating PD, a bank relies on observed default rates on bonds in various agency grades for PD quantification. To map its internal grades to the agency grades, the bank identifies variables that together explain much of the rating variation in the bond sample. The bank then conducts a statistical analysis of those same variables within its portfolio of obligors, using a multivariate

distance calculation to assign each portfolio obligor to the external rating whose characteristics it matches most closely (for example, assigning obligors to ratings so that the sum of squared differences between the external grade averages and the obligor's characteristics is minimized). This practice is broadly consistent with the standard.

*Example 2.* A bank uses grade mapping to link portfolio obligors to the reference data set described by agency ratings. The bank looks at publicly rated portfolio obligors within an internal grade to determine the most common external rating, does the same for all grades, and creates a correspondence between internal and external ratings. The strength of the correspondence is a function of the number of externally rated obligors within each grade, the distribution of those external ratings within each grade and the similarity of externally rated obligors in the grade to those not externally rated. This practice is broadly consistent with this standard, but would require a comparison of rating philosophies and may require adjustments and the addition of margins of conservatism.

S. A mapping process must be established for each reference data set and for each estimation model.

Banks should never assume that a mapping is self-evident. Even a rating system that has been explicitly designed to replicate external agency ratings may or may not be effective in producing a replica; formal mapping is still necessary. Indeed, in such a system the kind of analysis involved in mapping may help identify inconsistencies in the rating process itself.

A mapping process is needed even where the reference obligors come from internal historical experience. Banks must not assume that internal data do not require mapping, because changes in bank strategy or external economic forces may alter the composition of internal grades or the nature of the obligors in those grades over time. Mappings must be reaffirmed regardless of whether rating criteria or other aspects of the ratings system have undergone explicit changes during the period covered by the reference data set.

Banks often use multiple reference data sets, and then combine the resulting estimates to get a grade PD. A bank that does that must conduct a rigorous mapping process for each data set.

Supervisors expect all meaningful characteristics of obligors to be factored directly into the rating process; this should include characteristics like the obligor's industry or physical location. But in some circumstances, certain effects related to industry, geography, or other factors are not reflected in rating assignments or default estimates. In such cases, it may be appropriate for banks to capture the impact of the