Foundation IRB Capital Charge:

Probability of default is most commonly associated with the Basel II IRB approach to credit risk. Under the IRB or internal ratings based approach, probability of default is one of the key inputs required to compute a regulatory capital charge. All institutions are expected to derive PD estimates for all borrowers based on their own realized experience. Using our sample of 40 financial institutions and their Merton based probability of default estimates, we have derived the capital requirement based on the foundation IRB approach.

There is a linear relationship between probability of default and the resulting capital charge requirement, which means that lending to institutions with the highest PDs requires that highest capital requirement.

The IRB function uses a number of risk parameters, namely PD or probability of default, LGD or loss given default, EAD or exposure at default, and M or maturity.

Our calculations are based on an LGD of 45%, an EAD of 100% and a maturity of 2.5 years.
The capital requirement is calculated using the following formula:

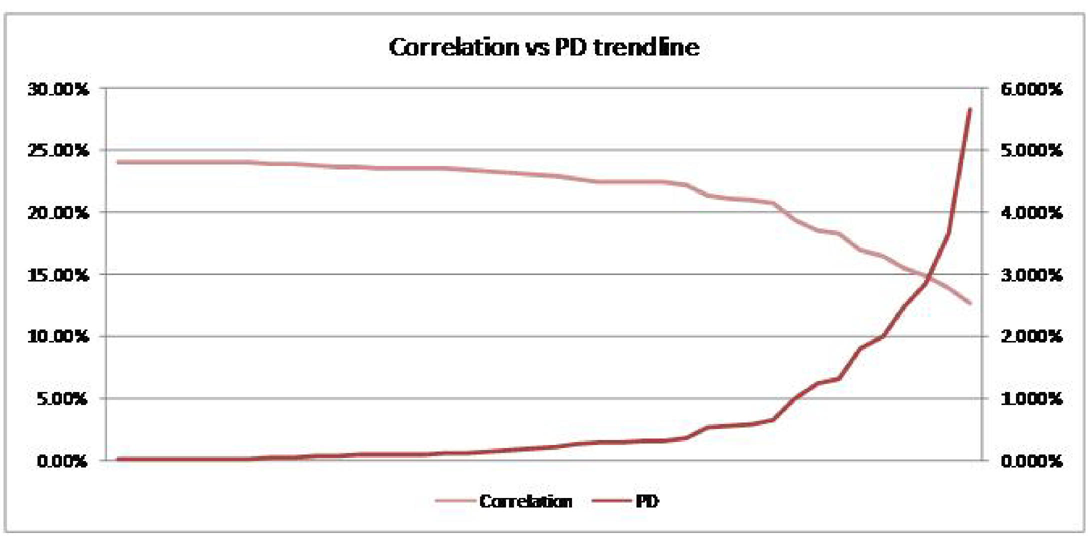
Capital Requirement (K) =

$$\mathbf{LGD} \times \mathbf{N}\left[(\mathbf{1-R})^{-0.5} \times \mathbf{G(PD)} + \left(\frac{\mathbf{R}}{\mathbf{1-R}}\right)^{0.5} \times \mathbf{G(0.999)}\right] - \mathbf{PD} \times \mathbf{LGD} \times \mathbf{Maturity\ Adjustment}$$

In the above formula, the required inputs are LGD, PD and R. R or asset correlationis calculated using the following formula:

Correlation (R) = $\mathbf{0.12} \times \frac{(1-e^{(-50 \times PD)})}{(1-e^{(-50)})} + \mathbf{0.24} \times \mathbf{1} - \frac{(1-e^{(-50 \times PD)})}{(1-e^{(-50)})}$

This formula takes PD as an input. R appears in three different places in the capital requirement formula and is has a significant impact on capital charge.



Asset correlations are presented separately for the sample institutions.

Maturity Adjustment in Credit Portfolios:

A key component of the Basel II IRB capital charge function is the 'maturity adjustment'. As the name suggests, the adjustment takes into account the maturity of the loan, but in addition the probability of default of the borrower is also considered. The resulting maturity adjustment or factor is then multiplied by the other components of the function to calculate a regulatory capital charge.

Maturity adjustment = $[\mathbf{1} - \mathbf{1.5} \times \mathbf{b}\,(\mathbf{PD})]^{-\mathbf{1}} \times [\mathbf{1} + (\mathbf{M} - \mathbf{2.5}) \times \mathbf{b}\,(\mathbf{PD})]$

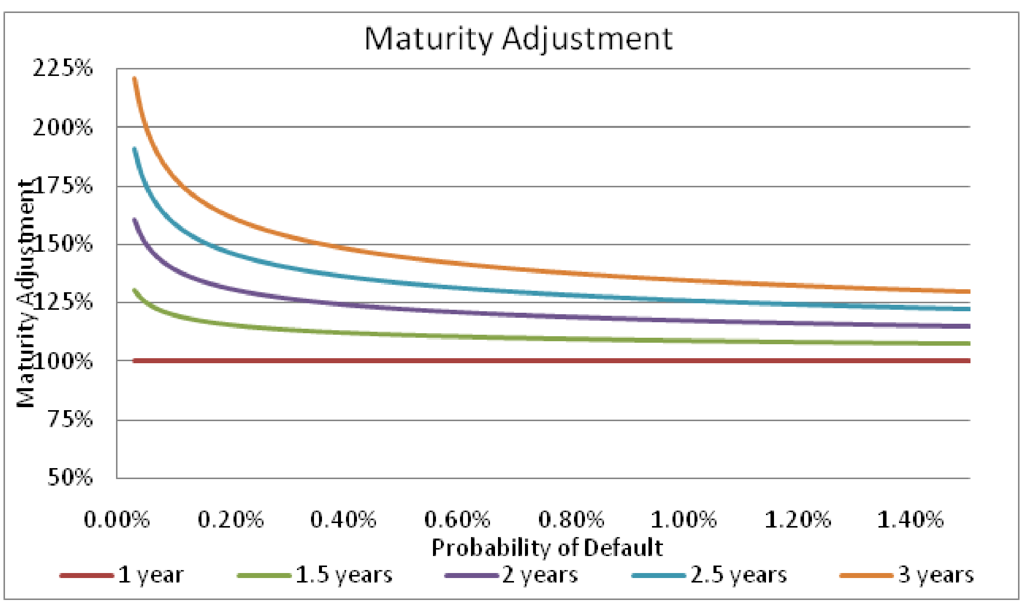
The maturity adjustment formula takes the probability of default of the borrower (PD) and the maturity of the loan (M) as an input. Under the foundation IRB approach, the input for maturity has been set to 2.5 years for all loans by the regulator, however this is replaced by the actual maturity when using advanced approaches.

In addition to PD and maturity (M), the formula is comprised of a number of constants and the function b(PD) which is defined as:

b(PD) = $[\mathbf{0.11852} - \mathbf{0.05478} \times \mathbf{log}(\mathbf{PD})]^{\mathbf{2}}$

Generally speaking, longer term credit obligations are riskier than short term obligations since there is a greater 'margin' for downgrades or the likelihood of credit rating downgrade is higher. The maturity adjustment therefore increases with maturity, which results in an increased capital charge.

PD on the other hand is inversely related to the maturity adjustment. Just like longer term credits have a greater chance of being downgraded lower PDs have a greater chance of increasing. Hence, the impact of probability of default on the maturity adjustment is most severe with low PDs. It is interesting to note that this is not a liner function instead the slope of the maturity adjustment function decreases as PD increases, suggesting that a small change in PD at lower levels will have a greater impact on the maturity adjustment compared to a small change in PD at higher levels.



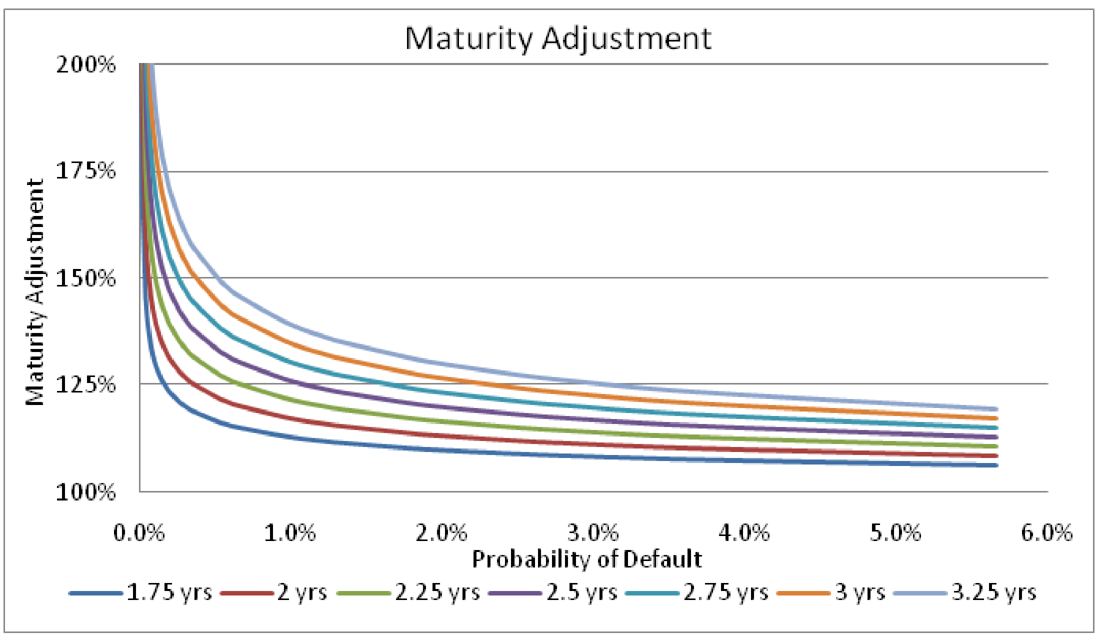
The graph above is a plot of the Basel II foundation IRB approach maturity adjustment for probability of default estimates ranging from 0.03% to 1.5%. In addition, for the same data set, additional curves for maturities ranging from 6 months to 3 years have also been generated.

The relationship between PD and maturity and the impact on the maturity adjustment and the resulting impact on capital charge is evident. For maturity equal to 1 year, the maturity adjustment is equal to 100% or 1 at all PD levels, which implies that the maturity adjustment will have a negligible impact on the capital charge for loans with maturity close to one year.

In addition, maturities of 1.5 years, 2 years, 2.5 years and 3 years have also been included. For institutions using the foundation IRB approach, only an estimate for PD is required since a standard maturity of 2.5 years for all facilities has been set by the regulator. However, with the advanced approaches, actual maturity is used. We have done a similar exercise for a sample of financial institutions. The results of this exercise are presented in the next section.

Industry Study:

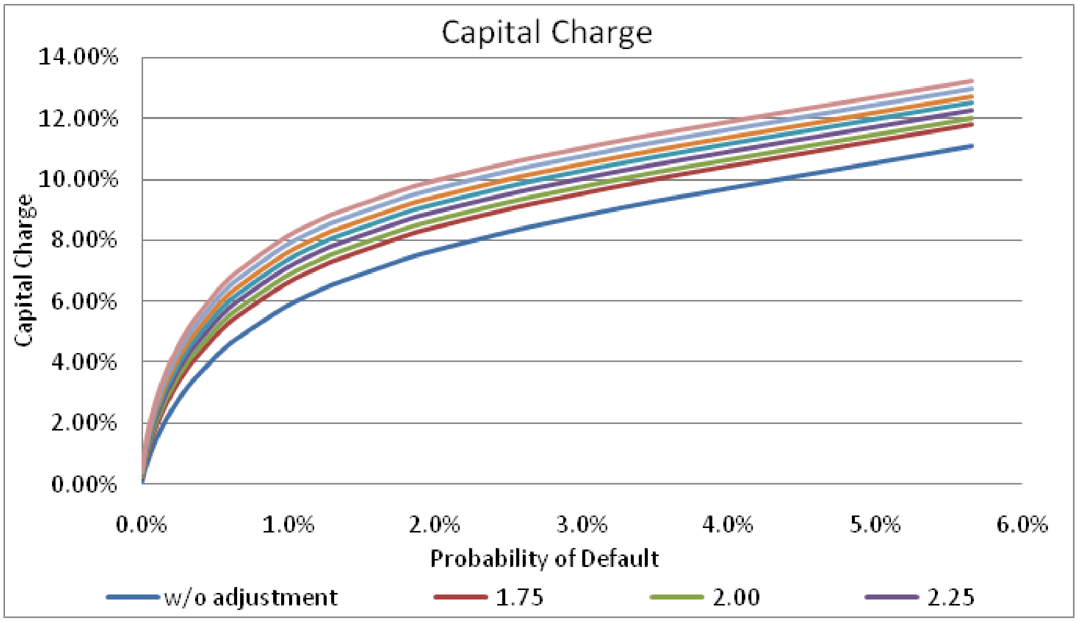
Using a sample of 40 financial institutions, we have computed maturity adjustments using one year PD PDs and maturities ranging from 1.75 years to 3.25 years. For institutions with the lowest or most favorable probability of default in the range of 0.03%, we observe a maturity adjustment in the range of 180% to 200%. For more risky institutions on the other hand, with PDs closer to 1%, the adjustment drops sharply to approximately 120%.



While it may seem counterintuitive that the maturity adjustment is both higher and more sensitive for lower PDs, but considering that the lower PDs result in a lower capital makes the impact of high maturity adjustment less severe, at lease in absolute terms.

The graph below displays the capital charge for 40 financial institutions, based on the foundation IRB approach. We have used an LGD (loss given default) of 45% and a confidence interval of 99.9%.

The key variable here is the maturity adjustment. The capital charge has been computed without the effect of the maturity adjustment, in addition to different maturities ranging from 1.75 years to 3.25 years.



The capital charge function shares a similar characteristic with the maturity adjustment function, in which the slope of the capital charge function decreases as PD increases.

To summarize, the maturity adjustment penalizes high quality loans more than low quality ones. As a result, the capital charge after incorporating the maturity adjustment whether using foundation or advanced approaches increases as probability of default increases, but the sensitivity and the impact on regulatory capital is most severe for counterparties with the lowest probability of default.

Probability of Default Calculators

Introduction

Obligor risk rating is a quantitative measure of the risk associated with a customer. It is derived by assigning credit scores based on objective and subjective factors. Credit scores aim to translate a customer's financial position, the industry dynamics and the economic factors involved to a score that is comparable across customers and sectors. This forms the basis of probability of default estimates.

Probability of default is the likelihood that a customer will default, given the actual realized experience of customers with similar credit scores. Facility risk ratings further refine the risk rating framework by calculating PDs by customers and products as specified by the central bank. This paper documents the methodology used to assign customer credit scores and probability of default computation.

Definitions:

Customer Behaviour:
A schedule of customer payment information, including amount received, amount outstanding, payment due date and payment received date.

Credit Update:
Any instance of a predefined event. Credit updates are ranked in terms of severity of negative behaviour (with 1 representing the highest risk of default), and are generated from customer behaviour.

Credit Event:
A credit event is defined as any instance of a customer moving from one credit update to a higher ranked credit update.

Default:
Any credit event is considered a default.

Probability of Default (PD):

Probability of default is a function of credit events and credit updates.

Scoring Elements:

A scoring element can be any information about a customer that is used in predicting default.

Scoring Engine:

A fully configurable engine used to convert raw scoring elements to a customer score.

Sample Window:

Historical period over which payment behaviour is analyzed in order to compute probability of default

Scoring Engine:

Scores can be computed using customer specific information such as industry, sub industry, sector, length of relationship, time since incorporation in addition to financial information.

The first step involves determining which elements to use in the scoring process. The system may be configured to use a different set of scoring elements for each sector. This allows the user to configure the scoring engine to mimic the banks existing scoring methodology by not only having the ability to include or exclude scoring elements, but also determine the weight of each element in order to fine tune the scores by means of a feedback loop.

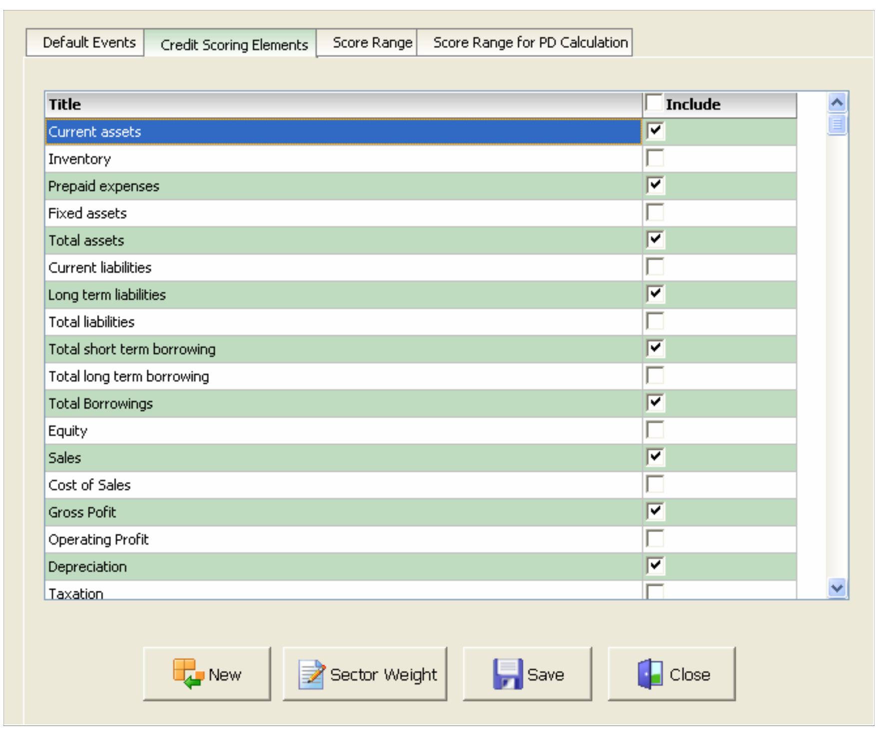
Next, each attribute or scoring element is scaled and converted to a customer score. The buckets used to scale the weighted scoring elements to customer scores are defined for each scoring element, depending on the sensitivity of graduation required.

Once the scoring elements are weighted and scaled, the final customer score is simply the sum of scores across all scoring elements.

Customer scores serve as a link between PD estimates and customers. Probability of default is calculated for range of scores, and customers, whether existing or new relationships are assigned PDs depending on their individual credit scores.

Probability of default is calculated on a consolidated as well as facility wise basis. In addition, PDs may be computed using number of credit events and credit updates, or amount outstanding for credit events and credit updates.

Finally, PD can be grouped not only by scores, but by any scoring element. This is covered under feedback loop.



Payment Behaviour:

Payment behaviour is captured for each customer on a facility wise and consolidated basis. The date on which a payment was due and the date on which it was subsequently received, and the amount that was due and the amount of payment received is in used to determine customer behaviour. Payment behaviour may be captured at any frequency, be it monthly, quarterly, semi annually or annually.

Using this information and the definition of default, a grid (A) is generated displaying the number of credit updates within the sample window at the desired frequency.

The next step involves the transition from credit updates to credit events. Any update that is ranked higher than the previous update is marked as a credit event. The number of credit events is displayed on a second grid (B).

The same process is repeated a second time, however all credit updates, the amounts outstanding are determined and accumulated for each period within the sample window.

Similarly, total amount outstanding for credit events is also calculated.

Probability of Default:

$$P\ (\text{Default}) = \frac{\text{Number of credit events}}{\text{Number of credit updates}}$$

$$P\ (\text{Default}) = \frac{\text{Amount outstanding for credit events}}{\text{Amount outstanding for credit updates}}$$

PDs are computed using credit events and credit updates corresponding to groups of customers with similar scores. The definition of PD given above may be directly applied to the PD for a given period for a score range. The overall PD is calculated using total credit events and the total credit updates for all periods for a given score range. The same methodology applies to PDs calculated by amount outstanding.

Start Date 01/01/2005 | Frequency Quarterly | Compute PD By: (•) Number of Defaults ( ) Outstanding Exposure

End Date 31/12/2006 | Facility Consolidated

Probability of Default | Event Tracking | Generate

( ) No. of Defaults ( ) Total Updates (•) Probability of Default

Score Range	31/03/2005	30/06/2005	30/09/2005	31/12/2005	31/03/2006	30/06/2006	30/09/2006	31/12/2006	Total
90-100	9.52%	8.70%	8.33%	2.94%	3.13%	14.29%	46.15%	9.38%	10.11%
80-90	13.04%	11.36%	3.85%	6.25%	4.65%	5.56%	13.04%	6.98%	7.32%
70-80	22.58%	7.32%	13.33%	13.79%	10.42%	6.98%	3.33%	7.50%	9.63%
60-70	17.24%	11.63%	11.32%	11.63%	12.96%	8.16%	3.57%	6.38%	9.89%
50-60	10.45%	7.41%	6.76%	12.73%	15.56%	7.27%	5.56%	5.66%	8.88%
40-50	14.06%	9.68%	17.78%	11.84%	10.23%	4.35%	9.62%	12.31%	10.94%
30-40	15.87%	7.46%	8.11%	12.50%	14.29%	11.69%	12.35%	6.59%	10.96%
20-30	15.94%	11.84%	7.14%	7.21%	11.58%	6.90%	21.67%	11.11%	11.01%
10-20	8.87%	12.15%	11.54%	9.28%	15.96%	5.38%	8.42%	11.69%	10.37%
-100-10	15.05%	13.54%	17.65%	16.13%	9.35%	12.36%	12.77%	12.50%	13.41%

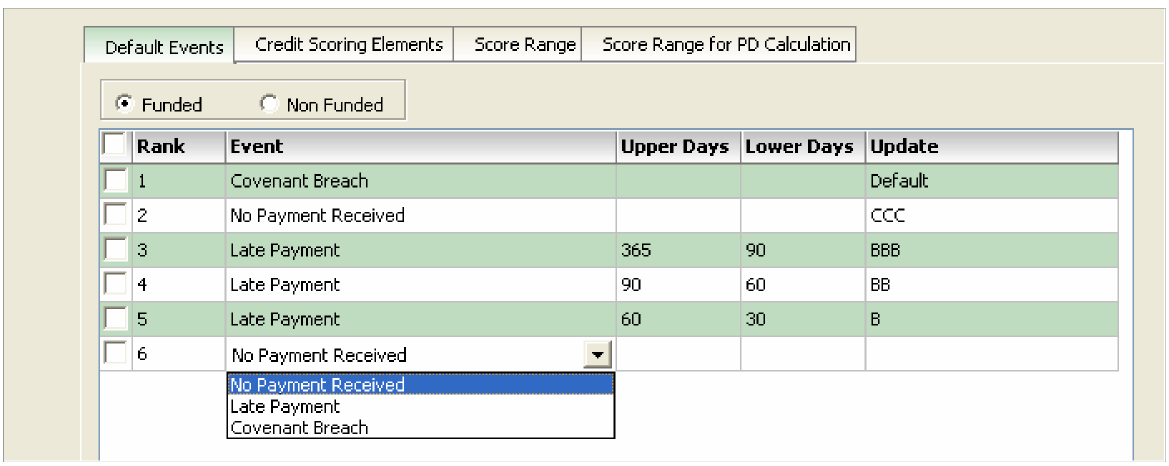
Feedback Loop:
Overall probability of default increases with deteriorating scores. Any inconsistency in this pattern suggests a need to calibrate and fine tune the scoring model.

The built in feedback loop is used to determine the predictive quality of each scoring element in isolation, and forms the basis of selection and weight assignment for scoring parameters.

The steps involved in calculating PDs are repeated for each scoring element; however credit events and credit updates are filtered by attribute score range as opposed to total customer score range. PDs are then computed using only those customers whose attribute scores fall within a given range.

Default Definition:
The definition of default is user defined, and provides the flexibility of extending the Basel II definition to any number of days past due, with incremental tracking, as well as definitions for non payments and covenant breaches. Alchemy ORR can be configured and used for IRB PD estimates and capital charge calculation or internal analysis and loan pricing.

Separate default definition for funded and non funded exposures may be accommodated.



Rank	Event	Upper Days	Lower Days	Update
1	Covenant Breach			Default
2	No Payment Received			CCC
3	Late Payment	365	90	BBB
4	Late Payment	90	60	BB
5	Late Payment	60	30	B
6	No Payment Received			

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Process Flow 1.0