A transitions-based framework for estimating expected credit losses

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Outline

Overview of LLF

Model mechanics

Probability of default model

Exposure at default

Loss given default

Summary
Overview of LLF

Historical Data
- Macroeconomic
  - Unemployment
  - House Prices
  - Interest Rates
- Loan
- Collateral
- Borrower
- Standard Financial Statements (SFS)

User-Defined Inputs
- Macroeconomic Scenario
- Static Balance Sheet Assumption (On/Off)
- Cure Rate Override (On/Off)
- Modification Algorithm (On/Off)
- Future Default Flow
- Time to Repossession
- Collateral Value Haircuts
- Repo Sale Expenses

Probability of Default Model
- Transition Matrix Model
- Sustainable Modification Algorithm

Loan-Loss Forecasting Model
- PD assigned to each loan
- Exposure at Default
- Loss Given Default

Model Outputs
- Performing Stock
- Default Stock
- Default Flow
- Cure Flow
- Interest Payments
- LT Cures
- Expected Losses
Flows for a hypothetical performing loan

Hypothetical loan with a $t = 0$ balance of €100,000, a constant set of parameters: $PD$ of 5%, $PCur$ of 10% and an amortisation rate of 2%. $PB$ refers to performing balance, $DS$ to default stock in each year. $PD$ and $PCur$ will vary at the loan level and will derive from the loan-level multi-state model’s coefficients. $REPO$ refers to the $t = 1$ default stock that has not cured by $t = 3$ and is thus repossessed.
Probability of default model

Probability of default overview

- Aim of this framework is to model *transitions* at the *loan level*.
- A traditionally-used logit model will not give us the desired effects.
- Move to a model where loans can move into and out of default.
- Markov Multi-State Model (MSM) enables this type of estimation. Loans are given a zero-one status in each time period (performing or default).
- The impact of covariates on transition probabilities can be estimated.
- Predicted probabilities can be interpreted as the one-year transition *PD* and *PCure*. 

Gaffney, Kelly, McCann
Lando and Skodeberg (JBF 2002) propose a continuous-time transition matrix model as an improvement on the discrete/cohort methods more commonly used.

Industry standard models such as JP Morgan’s Creditmetrics and McKinsey’s CreditPortfolioView use a “cohort method” where the one-year transition probability between state $A$ and state $B$ is

$$p_{AB} = \frac{N_{AB}}{N_A} \quad (1)$$

Weakness: if no loans start the year in $A$ and finish the year in $B$, then $p_{AB}$ is estimated to be zero.

This issue becomes increasingly more important as one estimates the probability of a rare event.
A generator matrix $\Lambda$ leads to probabilities in the form

$$P(t) = \exp(\Lambda t)$$

(2)

All transition probabilities in all time periods are a function of the generator.

The entries of the generator are the maximum likelihood estimates

$$\lambda_{ij} = \frac{N_{ij}(T)}{\int_0^T Y_i(s) ds}$$

(3)

$Y_i(s)$ is the number of firms in state $i$ at time $s$, making $\int_0^T Y_i(s) ds$ the total “firm-years” spent in $i$. 
### Table: Covariates included in PD models

<table>
<thead>
<tr>
<th>Factor</th>
<th>Comments</th>
<th>ROI</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank ID</td>
<td>Intercept adjustment for bank-specific effects for Banks 2, 3 and 4. All coefficients are relative to baseline of Bank 1.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Buy-to-Let</td>
<td>Intercept adjustments for buy-to-let mortgages. Baseline is Primary Dwelling Houses.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Interest Rate Type</td>
<td>Intercept adjustments for interest rate type effects for Standard Variable Rate and Tracker mortgages. All coefficients are relative to baseline of fixed rate mortgages.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Vintage</td>
<td>Vintage (i.e. loan age) is measured in months since the mortgage was issued. Both linear and natural-logged terms enter into the functional form of the model.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Interest Rate</td>
<td>Current interest rates on the mortgage.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time in Default</td>
<td>Time (in months) since loan entered into Default state.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Current Loan-to-Value</td>
<td>Current loan-to-value at the property level.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Unemployment</td>
<td>National unemployment rate is converted to regional by the model.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Figure: Variation in $PCure$ as a function of Time Since Default, ROI model
Figure: The role of housing equity in \( PD \) and \( PCure \), ROI model
Exposure at default

- Explicit default and cure transitions between expected-value performing and delinquent balances at $t = 1, 2, 3$.
- $PD$ share of performing balance flows to default; $PCure$ vice-versa.
- Time-since-delinquency cohorts have different $PCure$.
- Amortisation rate schedules are calculated using interest rate, term, fixed-rate period and interest-only period.
- Prepayment rate is input by the user.
- Balance-sheet assumption: new lending as a share of total amortisation and prepayments (dynamic) or adding these back to each loan, with the same risk profile (static).
Delinquent loan outcomes: cure or liquidation.
- Each year, loan begins to perform with probability $PCure$.
- After a certain time based on policy/circumstances, loan is foreclosed on. Explicit, unlike a logit model.
- LGD depends on both cure rates and loss given liquidation ($LGL$), or LGD net of cures.
- $LGL$ not estimated econometrically, but calculated.
- Main factor is indexed LTV, using future amortised balance and house price forecast (from scenario).
- Also accounts for fire-sale discount and repossession costs.
Covariates affect transitions into and out of default.
Continuous Time, one-year $PD$ model replaces logit lifetime $PD$.
Time since default affects $PCure$, so the starting point matters.
Realistic curing and time to liquidation replace annual roll rate.
Precise timing of losses within a horizon (e.g. three years).
Loan-by-loan variation of $EAD$, $PD$ and $LGD$ more granular than portfolio-level models.