Residential Mortgage Portfolio Risk Analytics
Agenda

Why are mortgages complicated to model?

- Many (many) scenarios are required to capture the behavior of mortgages in different states of the world
- Loan-level behaviors are not homogenous
- Single period analysis cannot generally be used for path-dependent instruments like mortgages

How did we model residential mortgages?

- Overview and economic modeling

Modeling it this way permits one to:

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Conclusion
Loan level modeling in different economies

Same loan in different economies exhibits different behavior and correlations
Using Aggregate Pool Statistics I

Consider two pools drawn from this population: one **homogeneous** and one **barbelled**

(but both with approximately the same mean CLTV and FICO)

<table>
<thead>
<tr>
<th>FICO Score</th>
<th>Combined LTV</th>
<th>Low &lt;70</th>
<th>Medium [70,80)</th>
<th>High [80,85)</th>
<th>Very High &gt;=85</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low &lt; 710</td>
<td>2.4</td>
<td>4.9</td>
<td>5.5</td>
<td>9.7</td>
<td></td>
</tr>
<tr>
<td>Medium [710,750)</td>
<td>1.0</td>
<td>3.2</td>
<td>3.5</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>High [750,775)</td>
<td>0.5</td>
<td>1.5</td>
<td>1.7</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Very High &gt;= 775</td>
<td>0.1</td>
<td>0.7</td>
<td>0.9</td>
<td>1.8</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>FICO</th>
<th>CLTV</th>
<th>Def. rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homogeneous</td>
<td>746</td>
<td>77.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Barbell</td>
<td>738</td>
<td>75.0</td>
<td>4.9</td>
</tr>
</tbody>
</table>

Residential Mortgage Portfolio Risk Analytics - Nov 2010
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Conclusion
Multi-period Simulation and path dependence

- Home prices start at 100 and end, 10 years later, at 134.
- Scenario 1: home price appreciation of 3% per year for 10 years
- Scenario 2: home price depreciation of 20% over 3 years followed by a gain over the next 7 years

Multi-period simulation is valuable due to strong path dependency.
Why are Mortgages Complicated to Model?

- If loan-level data is available, it may be preferred because
  - A single loan can behave very differently in different economic scenarios.
  - Different loan types behave very differently in the same economic scenario.

- Drivers of mortgage performance, including prepayment and default, are strongly *path dependent*.

- Mortgages have many embedded options, including
  - the option to prepay (call)
  - the option to walk away from the loan (put).

- The terms of these options do not generally average out analytically.
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Conclusion
It is helpful to distinguish between the different dimensions of portfolio analysis.

<table>
<thead>
<tr>
<th>Basis of analysis</th>
<th>Level of analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single path</td>
<td>Loan-level</td>
</tr>
<tr>
<td></td>
<td>MPA Macro scenario</td>
</tr>
<tr>
<td>Simulated</td>
<td>Aggregate-level</td>
</tr>
<tr>
<td>distribution of</td>
<td>MPA full loss-</td>
</tr>
<tr>
<td>paths</td>
<td>distribution</td>
</tr>
<tr>
<td></td>
<td>analysis</td>
</tr>
<tr>
<td></td>
<td>N/A</td>
</tr>
</tbody>
</table>
Our model is an analytic tool for assessing the credit risk of a portfolio of residential mortgages (RMBS & whole loans).

The model comprises loan-level econometric models for default, prepayment, and severity.

These models are integrated through common dependence on local macroeconomic factors, which are simulated at national and local (MSA) levels.

This integration produces correlation in loan behaviors across the portfolio.

Because we use a multi-step Monte Carlo approach, the model can be combined with an external cash flow waterfall tool and used for simulation of RMBS transactions.

The models also use pool-level performance to update the output in real-time.
Mortgage Modeling: Overview II

FACTORS

- Economic Data (simulated or scenario)
- Loan Level Pool Data (User data)
- Supplemental user data (loan level override, pool performance, etc.)

MODELS

- Default
- Severity
- Prepayment

OUTPUT

POOL LEVEL E(L)

LOAN LEVEL E(L)
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In addition to generating the full loss distribution, it is possible to estimate losses under MEDC or user-defined scenarios.
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Conclusion
Scenario Analysis using Observable Macro-economic Factors

Observable macro-economic factors facilitate insightful what-ifs.
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Conclusion
US Jumbo RMBS Performance

Delinquent loan pipeline makes up a key part of future losses.
Modeling Seasoned Mortgage Pools: Delinquent loans

- We categorize delinquent loans into: 30, 60, and 90+ Days Past Due.

- Default and prepayment hazard rates differ substantially between delinquent loans and current loans.

- Each delinquency status has different default and prepayment behavior.

- Explicitly modeling delinquent loans permits much finer analysis than “roll-rate” approaches for portfolio monitoring.

Delinquent loans behave very differently than current loans.
Realized performance can, on occasion, be very different than predicted due to unobservable differences in underwriting, servicing, borrower characteristics, etc.

It is important to incorporate individual components of the realized performance, namely default, prepayments, and severity, separately.

In the majority of cases, the predicted and observed behaviors generally agree closely. In some cases, however (e.g., table below), the pool-performance information can be valuable.

<table>
<thead>
<tr>
<th>Portfolio</th>
<th>Without mid-course update</th>
<th>With mid-course update</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15.2</td>
<td>13.7</td>
<td>Good originator</td>
</tr>
<tr>
<td>2</td>
<td>19.6</td>
<td>23.7</td>
<td>Severity higher than expected</td>
</tr>
<tr>
<td>3</td>
<td>22.9</td>
<td>17.3</td>
<td>Conservative originator</td>
</tr>
<tr>
<td>4</td>
<td>29.7</td>
<td>14.4</td>
<td>Retail. Good underwriting</td>
</tr>
</tbody>
</table>

Pool-level idiosyncratic behavior can be useful in future projection.
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Single-loan Loss Histogram with different Rescission Assumptions on Primary Mortgage Insurance (PMI)

- Original Balance: $250,000
- FICO: 605
- State: CA
- Loan Type: IO ARM
- Doc Type: Full income – No assets
- LTV: 90

» occurrences of no default not shown for either data set (14% each)
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PD based tranching approach (VaR)

A tranche has adequate capitalization for a predefined PD value, \( PD_R \) if:

\[
\text{Tranche } PD = P(L > A) = \int_A^1 f_L(L) \cdot dL \leq PD_R
\]

Where,

- \( A \equiv \) tranche attachment point
- \( L \equiv \) loss rate on the portfolio
- \( f_L(\cdot) \equiv \) pdf of the collateral loss rate

PD-based CE is equivalent to VaR with \( \alpha = PD_R \) (the target default rate).
**Tail risk contribution**

- Tail risk contribution (TRC) is a *portfolio referent* risk measure for an individual loan.
- It measures how much capital the loan uses up in the tail of the distribution.

\[ TRC_i = E[L_i \mid L_p > VaR_\alpha] , \]

- \( TRC_i \) = tail risk contribution for the \( i^{th} \) loan
- \( L_i \) = loss on the \( i^{th} \) loan
- \( L_p \) = loss on the portfolio
- \( VaR_\alpha = 1 - \alpha \) VaR level for the portfolio,
- i.e., the capital required to support the portfolio

- The TRC of a loan depends on its correlation with the other loans in a portfolio.
- TRC indicates which loans increase or decrease the capital (“attachment point”) for a specific VaR, and is useful for:
  - Portfolio construction
  - Loan pricing
  - Hedging
### Tail Risk Contribution to VaR

- **TRC** is the contribution a loan makes to the tail risk of a portfolio.

<table>
<thead>
<tr>
<th></th>
<th>EL</th>
<th>99.5% VaR Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original portfolio</td>
<td>4.0%</td>
<td>12.6%</td>
</tr>
<tr>
<td>With 100 highest EL loans removed</td>
<td>2.9%</td>
<td>10.2%</td>
</tr>
<tr>
<td>With 100 highest contributors to VaR removed</td>
<td>3.1%</td>
<td>9.7%</td>
</tr>
</tbody>
</table>

Tail risk of a loan is often different than its stand-alone risk.
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<table>
<thead>
<tr>
<th>A-1</th>
<th>A-2</th>
<th>A-3</th>
<th>A-4</th>
<th>A-5</th>
<th>X</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B-2</td>
<td></td>
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<tr>
<td></td>
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<td></td>
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<td>B-3</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>B-4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B-5</td>
<td></td>
</tr>
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Modeling This Way Permits One To…

- Generate full loss distribution and losses for MEDC and/or user defined scenarios.
- Conduct scenario analysis using observable macro-economic factors.
- Conduct validations using realized economies to-date.
- Use the same framework to evaluate seasoned portfolios and new originations:
  - Model delinquent loans differentially than current loans, and
  - Incorporate realized performance to-date into future projections of defaults, prepayments, and severity (combine pool and loan-level approaches)
- Calculate PD-based and EL-based VaR and tranche attachment points.
- Calculate the tail risk contribution for each loan and thus help in managing the tail risk of a portfolio of mortgage loans.
- Provide collateral loss distribution and the cash flows that can be combined with a waterfall engine to produce tranche-level loss distributions.
Conclusion

- Modeling at the loan level significantly improves detail in estimating losses.
- Modeling each loan behavior (default, prepayment, and severity) separately provides substantial flexibility in calibration and specification.
- Prepayment can have a dominant effect in determining the distribution of losses during periods of home price appreciation and/or falling interest rates.
- The state of the local and national economy significantly impacts the performance of pools.
- Default, prepayment, and severity appear to be correlated through their joint dependence on common economic factors.
- The multi-step approach to simulation offers advantages when assets have path dependent behavior, as in the case of mortgages.
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