Moody's Research Labs

Residential Mortgage Portfolio Risk Analytics

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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:

- ✓ Generate full collateral loss distribution and losses for *MEDC and user-defined scenarios*
- ✓ Use actual or simulated *macro-factors directly* (scenario analysis, historical validation)
- ✓ Model seasoned pools and new issuance in one framework (*using pool-level & loan-level data*)
- ✓ *Explicitly* model primary and pool-level mortgage insurance
- ✓ Perform tranching, VaR, and capital allocation using *tail risk contribution* of loans
- ✓ Generate *full loss distributions* for individual tranches of an RMBS or RMBS portfolios

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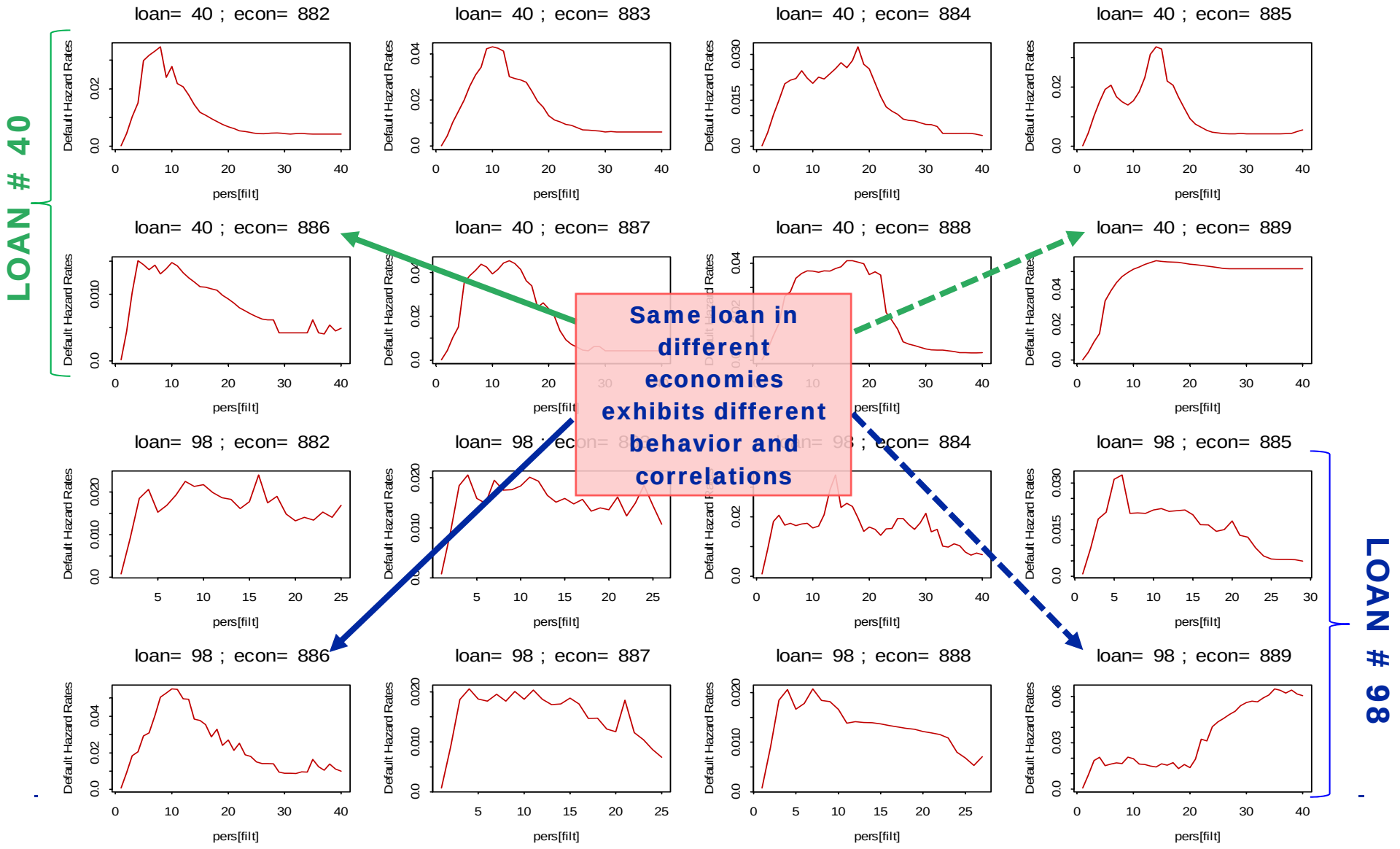
Loan level modeling in different economies



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)

FICO SCORE	Combined LTV: Low <70	Medium [70,80)	High [80,85)	Very High >=85
Low < 710	2.4	4.9	5.5	9.7
Medium [710,750)	1.0	3.2	3.5	7.0
High [750,775)	0.5	1.5	1.7	4.0
Very High >= 775	0.1	0.7	0.9	1.8

	FICO	CLTV	Def. rate
Homogeneous	746	77.5	2.5
Barbell	738	75.0	4.9

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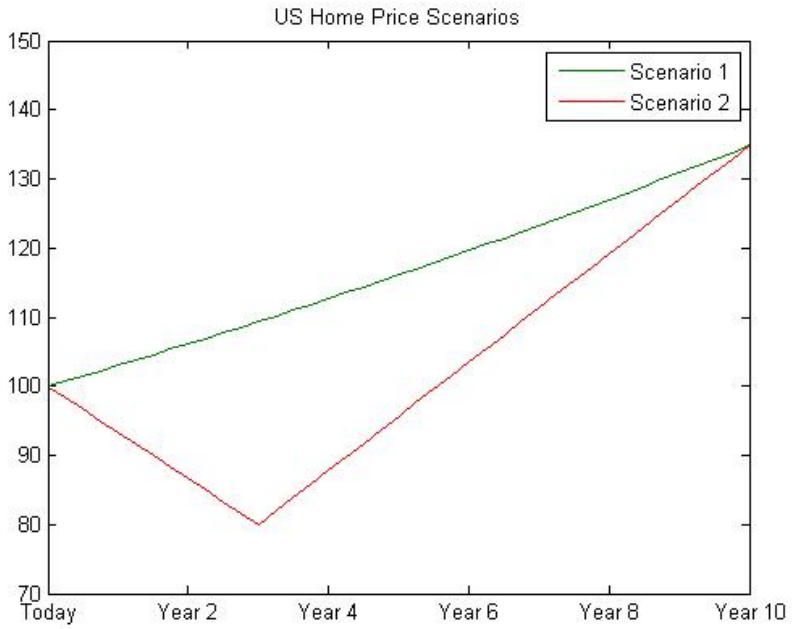
Multi-period Simulation and path dependence

- **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**



Pool	EL (Scenario 1)	EL (Scenario 2)
1	9.0	15.8
2	6.6	10.3
3	6.0	9.0
4	7.0	11.5
5	1.6	2.1

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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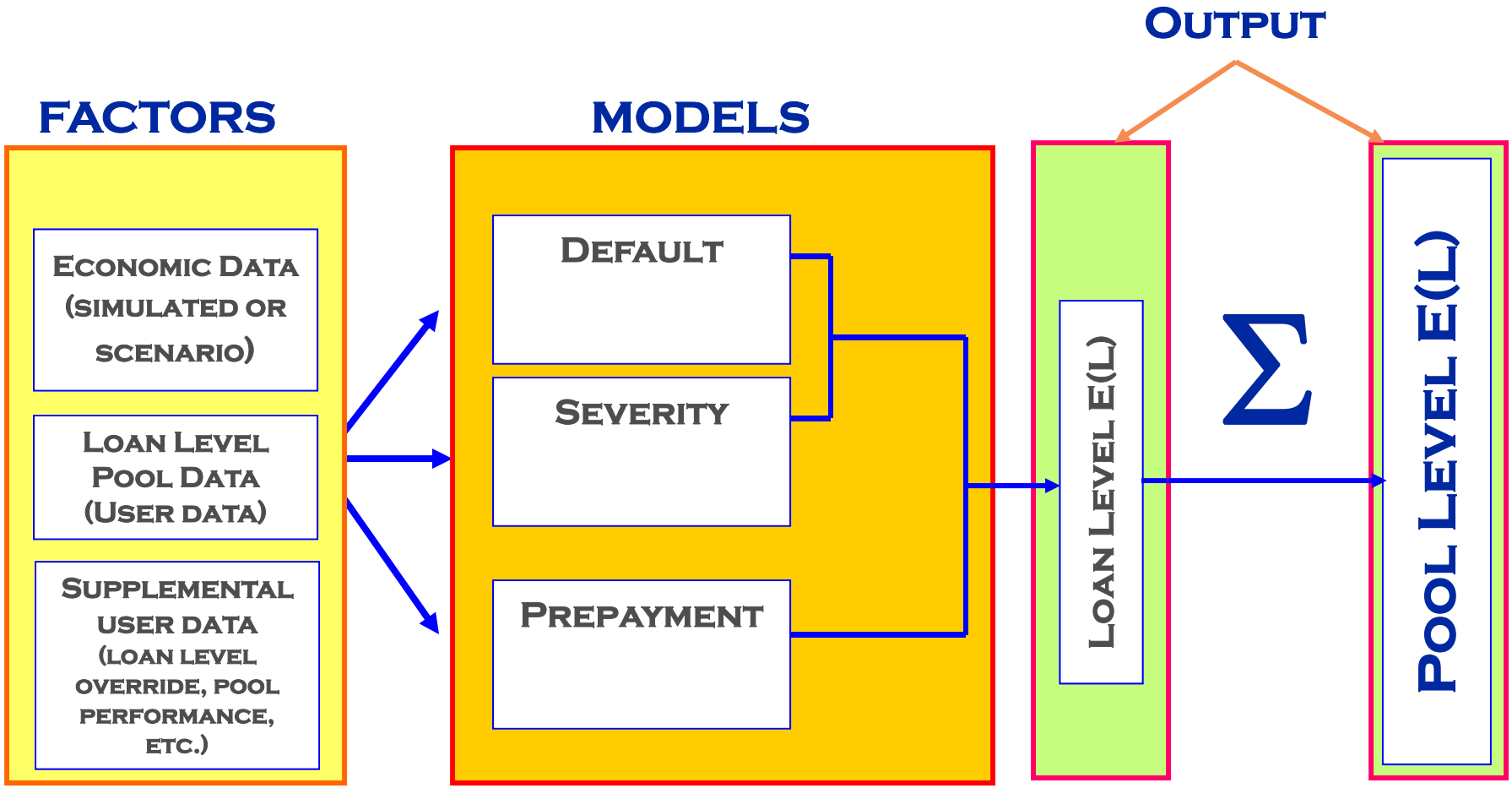
It is helpful to distinguish between the different dimensions of portfolio analysis

Basis of analysis	Level of analysis: Loan-level	Level of analysis: Aggregate-level
Single path	MPA Macro scenario	
Simulated distribution of paths	MPA full loss-distribution analysis	N/A

Overview I

- 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 macro-economic 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



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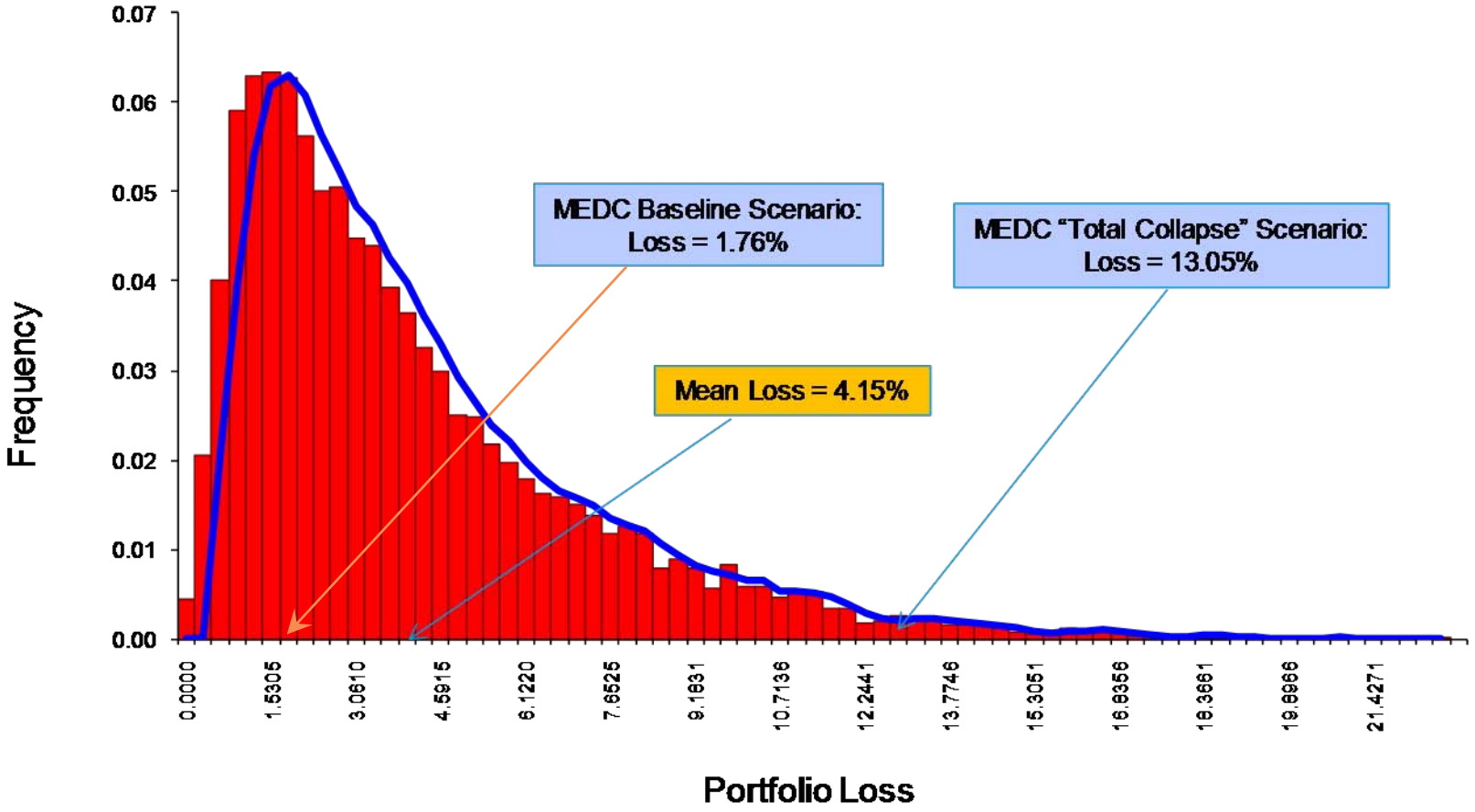
A Mortgage Portfolio Loss Distribution



In addition to generating the full loss distribution, it is possible to estimate losses under *MEDC or user-defined scenarios*.

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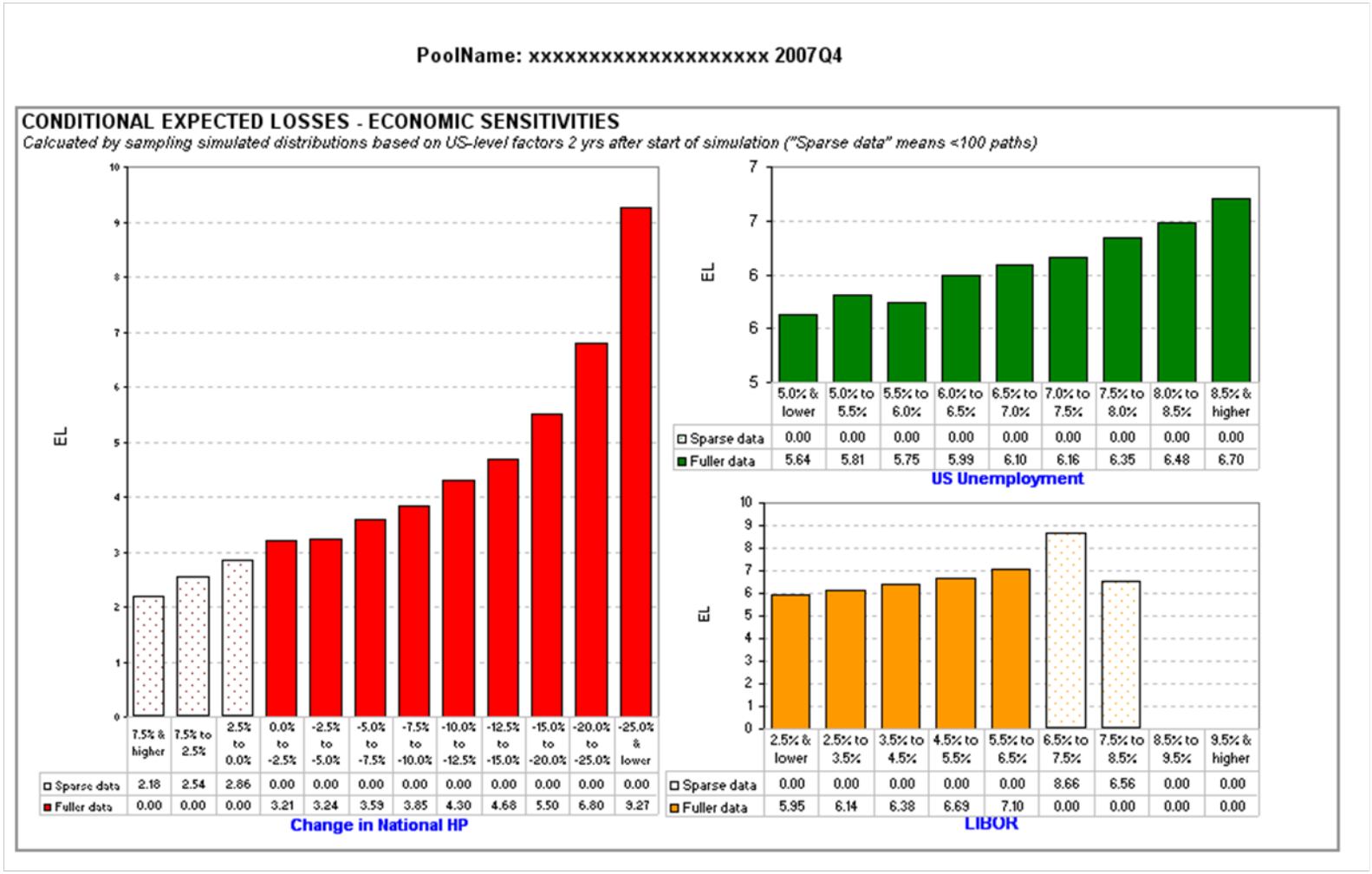
Scenario Analysis using Observable Macro-economic Factors



Observable macro-economic factors facilitate insightful what-ifs.

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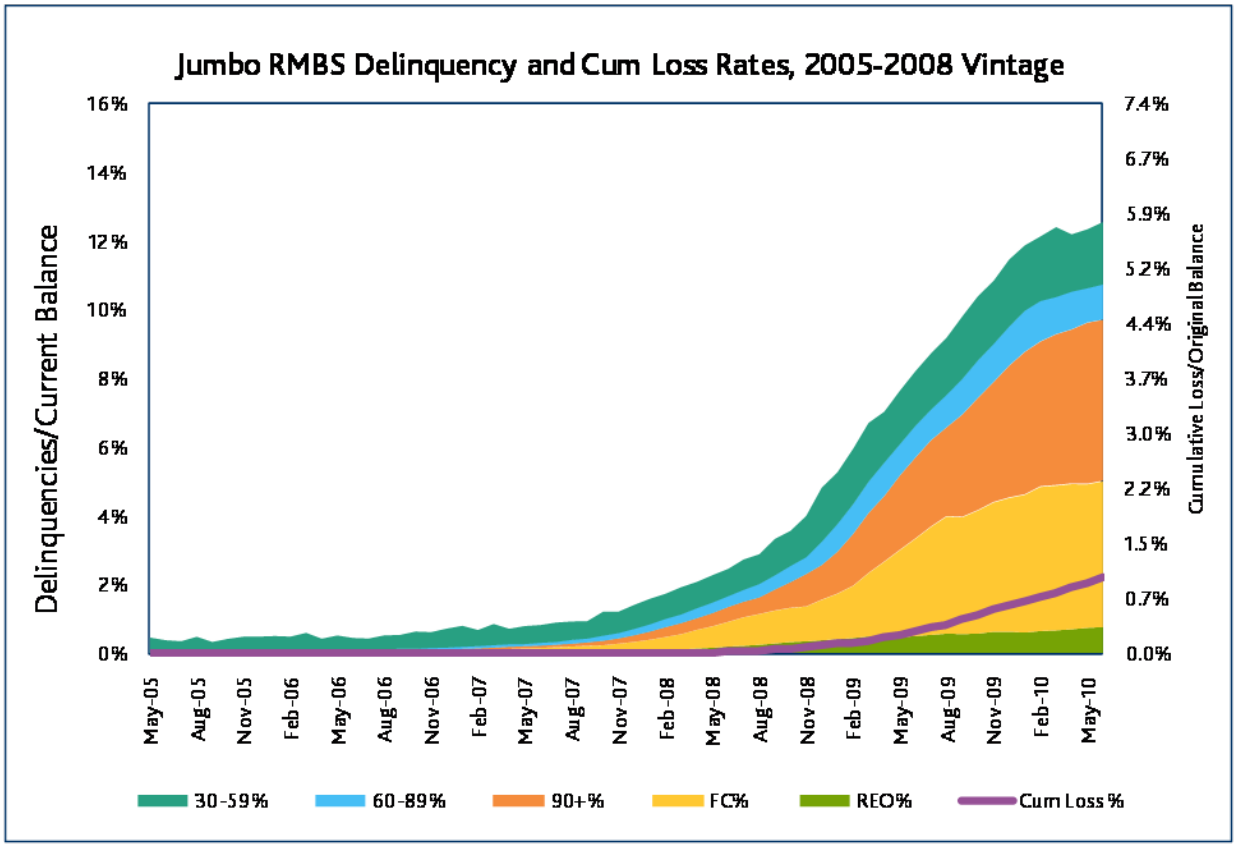
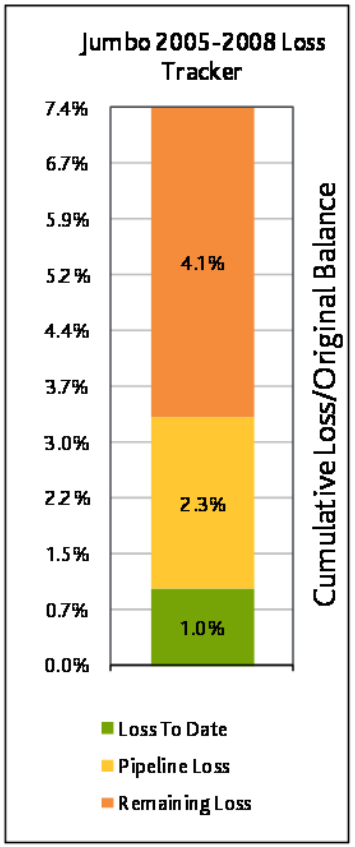
US Jumbo RMBS Performance

Source: Moody's Investors Service





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.

Modeling Seasoned Loans: Incorporating pool-specific Realized Performance To-date

- 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.

Portfolio	Without mid-course update	With mid-course update	Comments
1	15.2	13.7	Good originator
2	19.6	23.7	Severity higher than expected
3	22.9	17.3	Conservative originator
4	29.7	14.4	Retail. Good underwriting

Pool-level idiosyncratic behavior can be useful in future projection.

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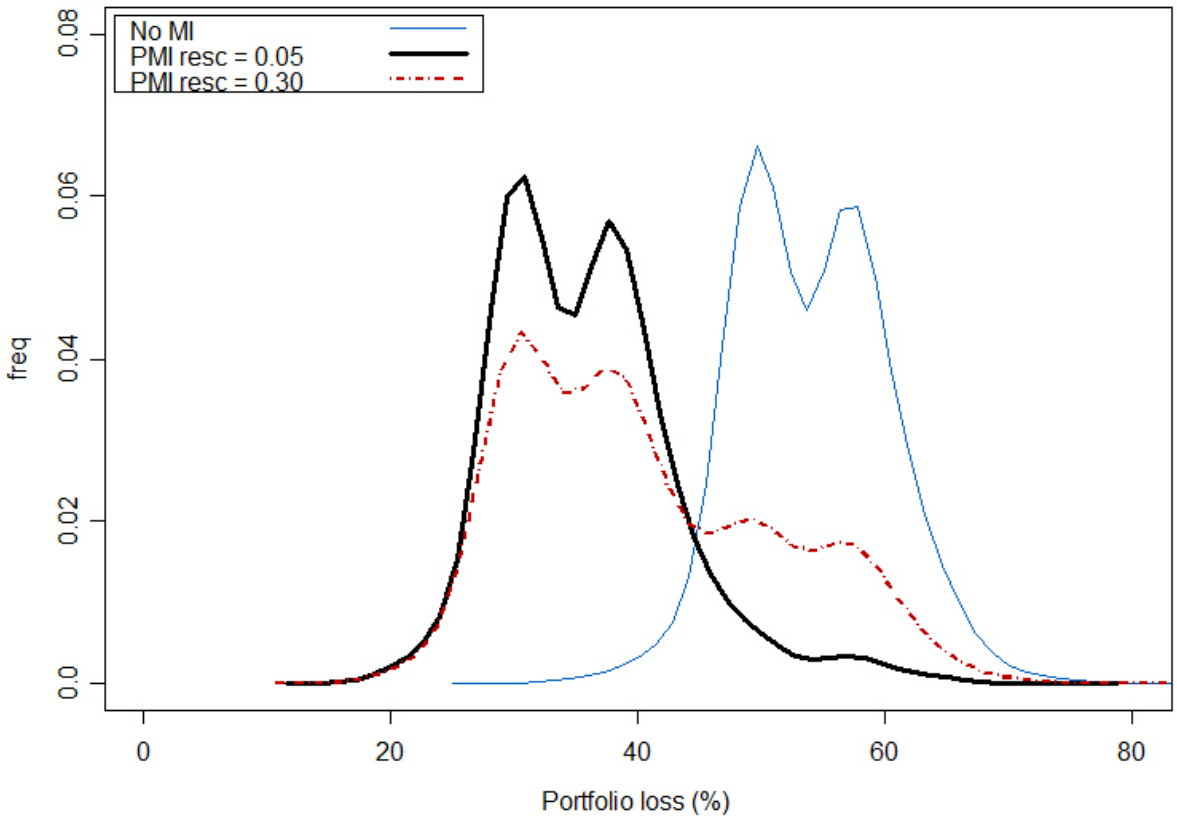
Single-loan Loss Histogram with different Rescission Assumptions on Primary Mortgage Insurance (PMI)



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:

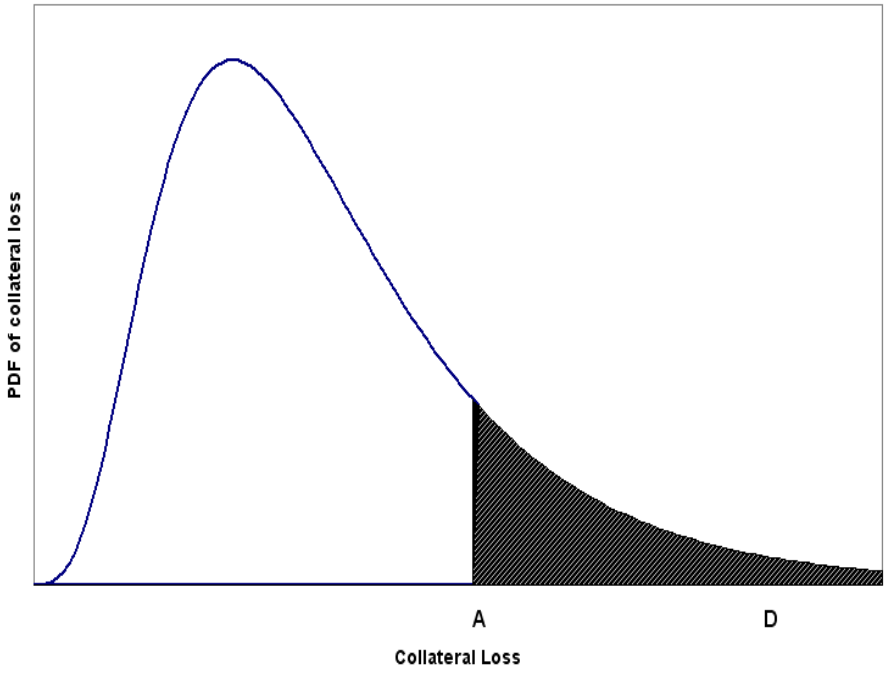
$$\begin{aligned} Tranche\ PD &= P(L > A) \\ &= \int_A^1 f_L(L) \cdot dL \\ &\leq PD_R \end{aligned}$$

- 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,

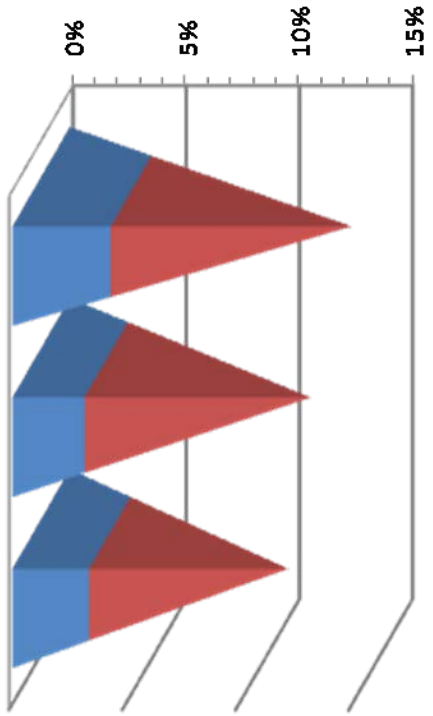
i.e., the capital required to support the portfolio

- 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.**

	EL	99.5% VaR Level
Original portfolio	4.0%	12.6%
With 100 highest EL loans removed	2.9%	10.2%
With 100 highest contributors to VaR removed	3.1%	9.7%



Tail risk of a loan is often different than its stand-alone risk.

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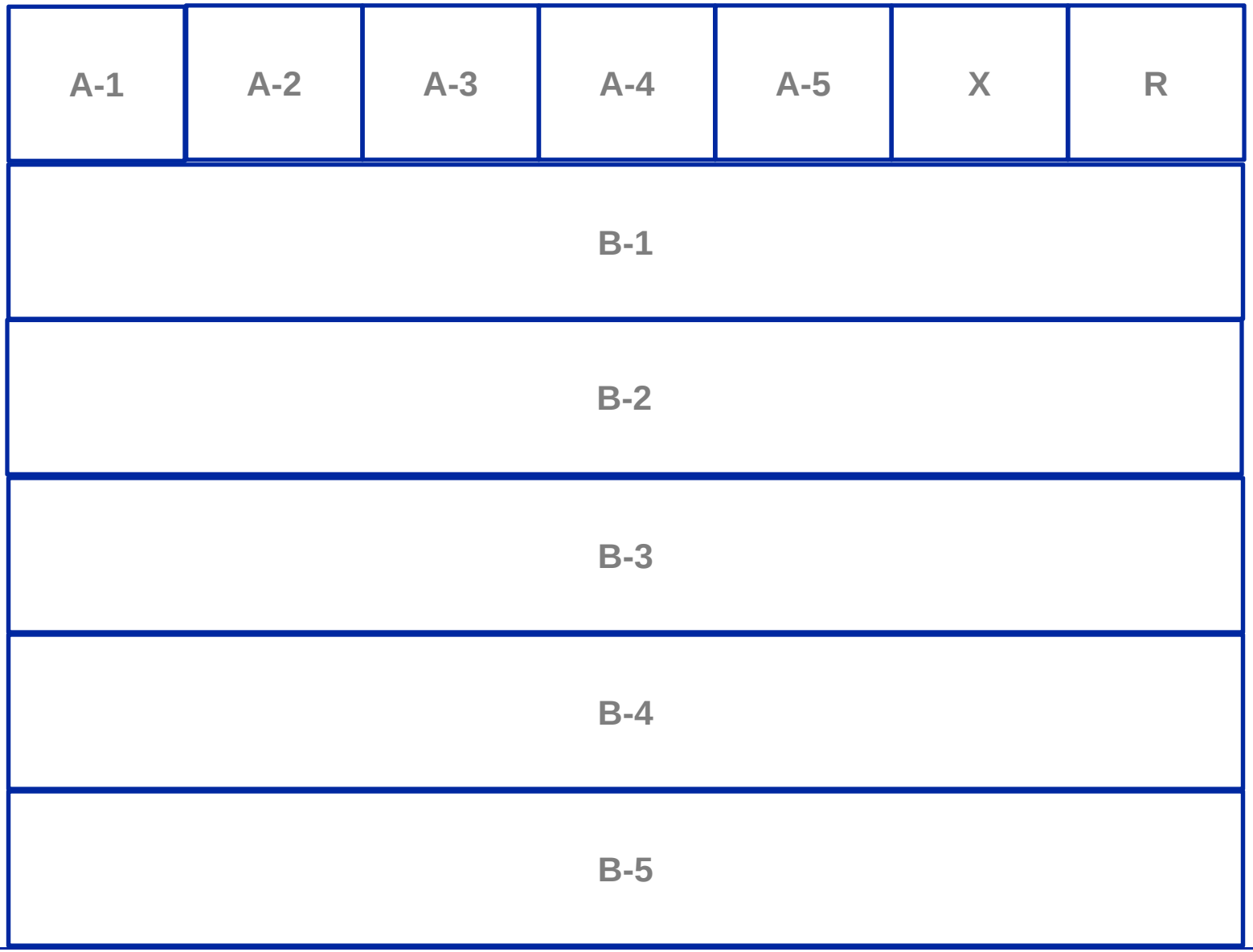
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A-4
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B-1
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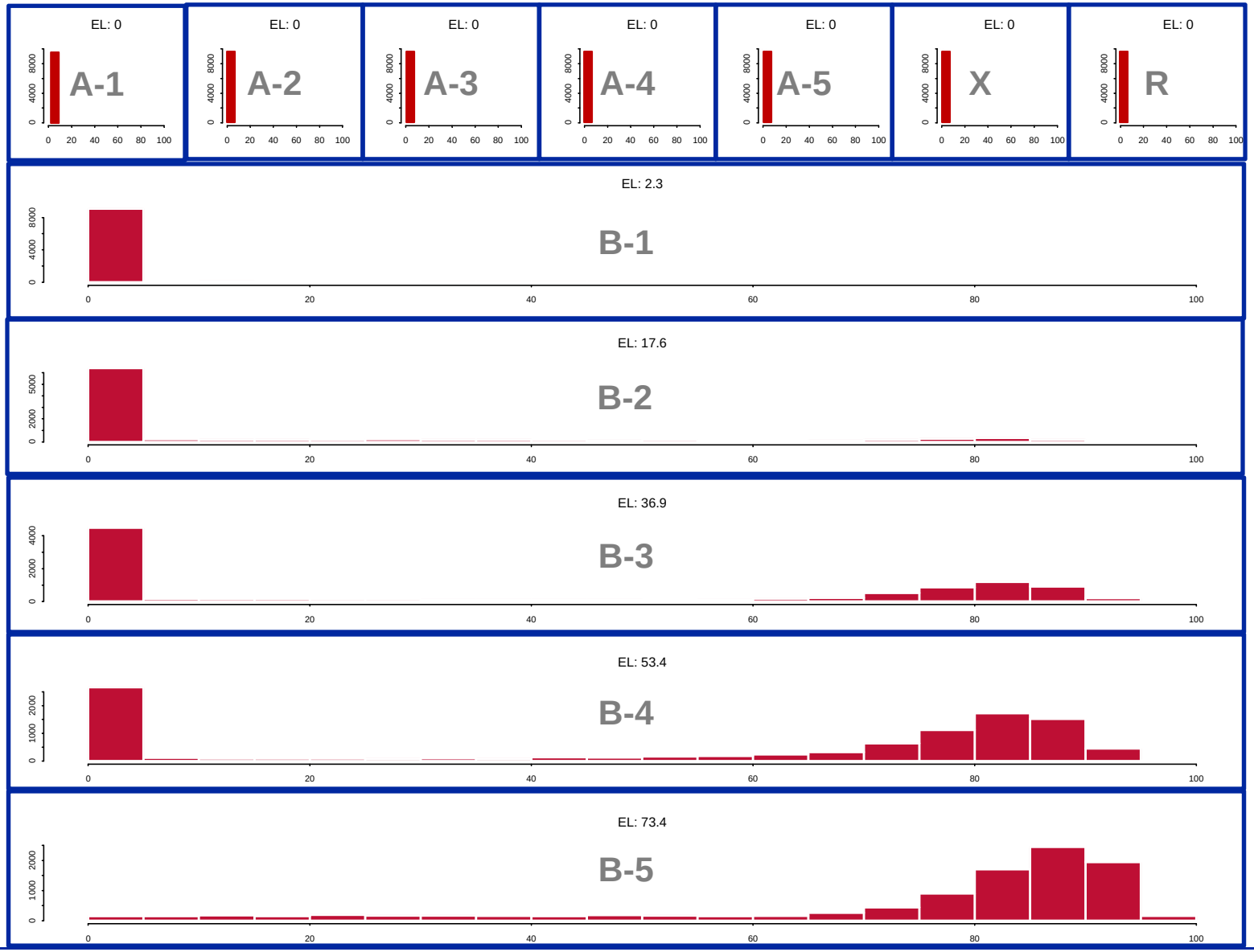
B-5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B-1
EL: 17.6
B-2
EL: 36.9
B-3
EL: 53.4
B-4
EL: 73.4
B-5

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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