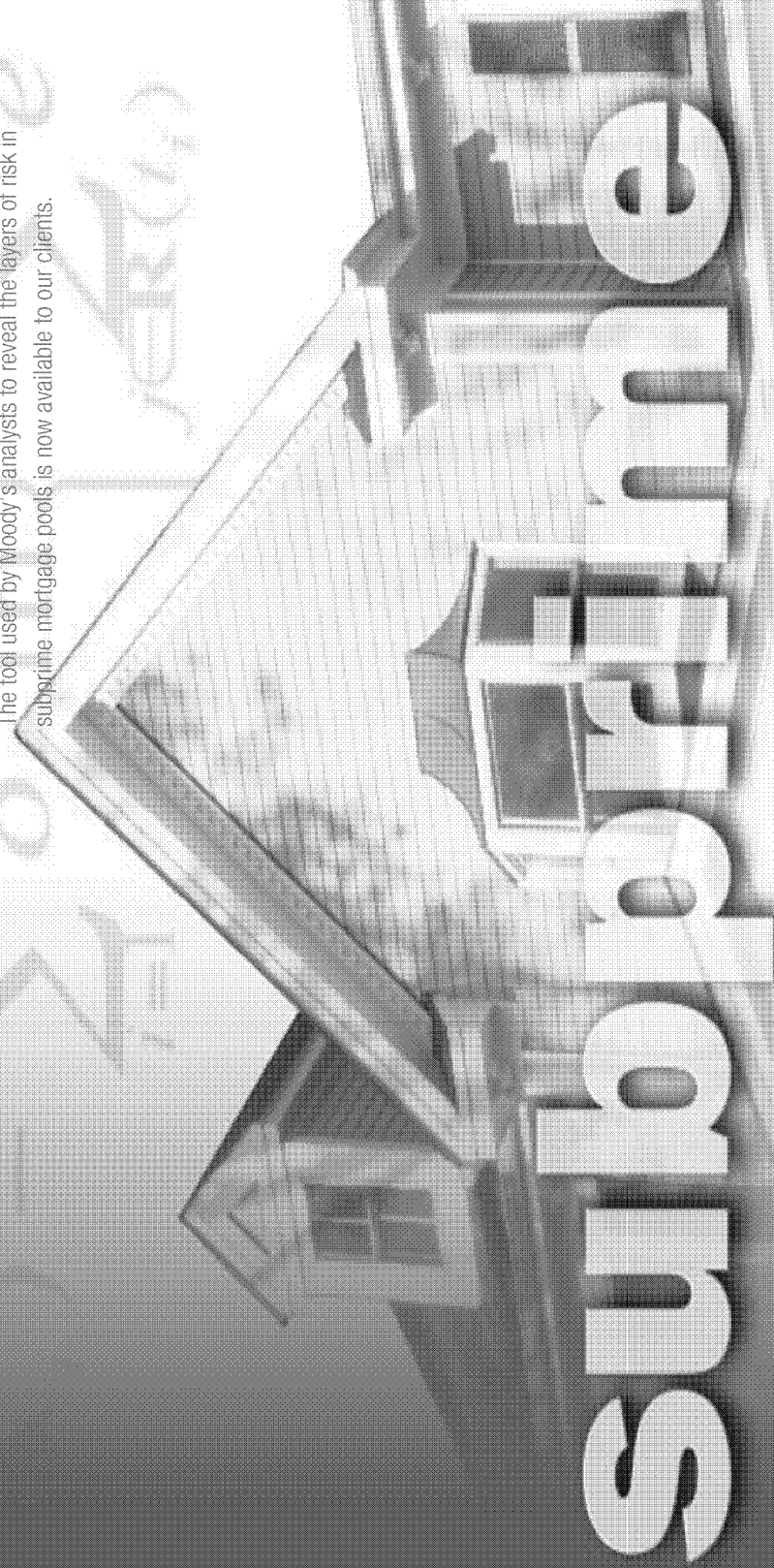


Introducing

Moody's Mortgage Metrics Subprime

just became more transparent.

The tool used by Moody's analysts to reveal the layers of risk in subprime mortgage pools is now available to our clients.



Moody's Investors Service

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by Moody's Investors Service
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MIS-OCIE-RMBS-0001711

Moody's Mortgage Metrics Subprime



Jody Rasch
Vice President
Asset Finance Group
New Products
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Moody's Investors Service

Agenda

- Motivation for the New Model
- How Moody's Analysts Use the Product
- Model Analytics
- Client Perspective – Bank of America
- Data Collection and Cleaning Process
- Live Demo



Moody's Investors Service

Key Contacts

- **Analysts**
 - **Warren Kornfeld** **Managing Director**
 - **Navneet Agarwal** **Vice President**
 - **Shachar Gonen** **Associate Analyst**
- **Modeling Team**
 - **Roger Stein** **Managing Director**
 - **Jody Rasch** **Vice President**
 - **Joe Skor** **Vice President**
 - **Thom King** **Vice President**
 - **Victor Xu** **Assistant Vice President**
 - **Norah Qian** **Assistant Vice President**
 - **Xiaolin Cheng** **Analyst**
- **Sales and Marketing**
 - **Mark McKenna** **Vice President**
 - **Kelly Slicklein** **Assistant Vice President**
 - **Berrak Dogruer** **Associate Product Strategist**



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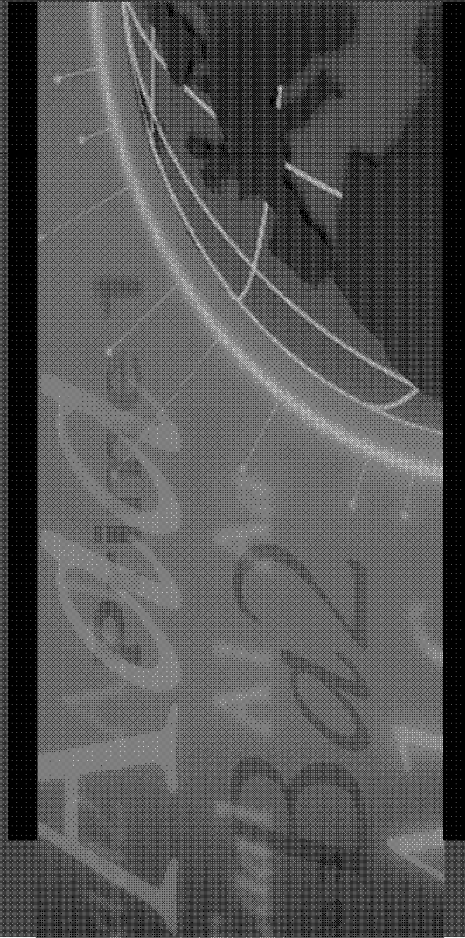
Why we Developed the Model

- **Previous sub-prime model**
 - Built on older data
 - Some key factors were adjusted outside the model
- **Did not give the transparency of the Moody's Mortgage Metrics Prime Model**
 - Model was not publicly available
 - Did not give the markets sufficient analytical detail



Moody's Investors Service

Moody's Mortgage Metrics Subprime Functionality



Navneet Agarwal
Vice President /
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Agenda

- Objective
- Data overview
- Sensitivities to economic factors
- User outputs
- Increased precision



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Objective

- **Transparency**
 - Provide the markets sufficient analytical detail
- **Improve utility**
 - Incorporate supplemental analyses
 - Improve analytics



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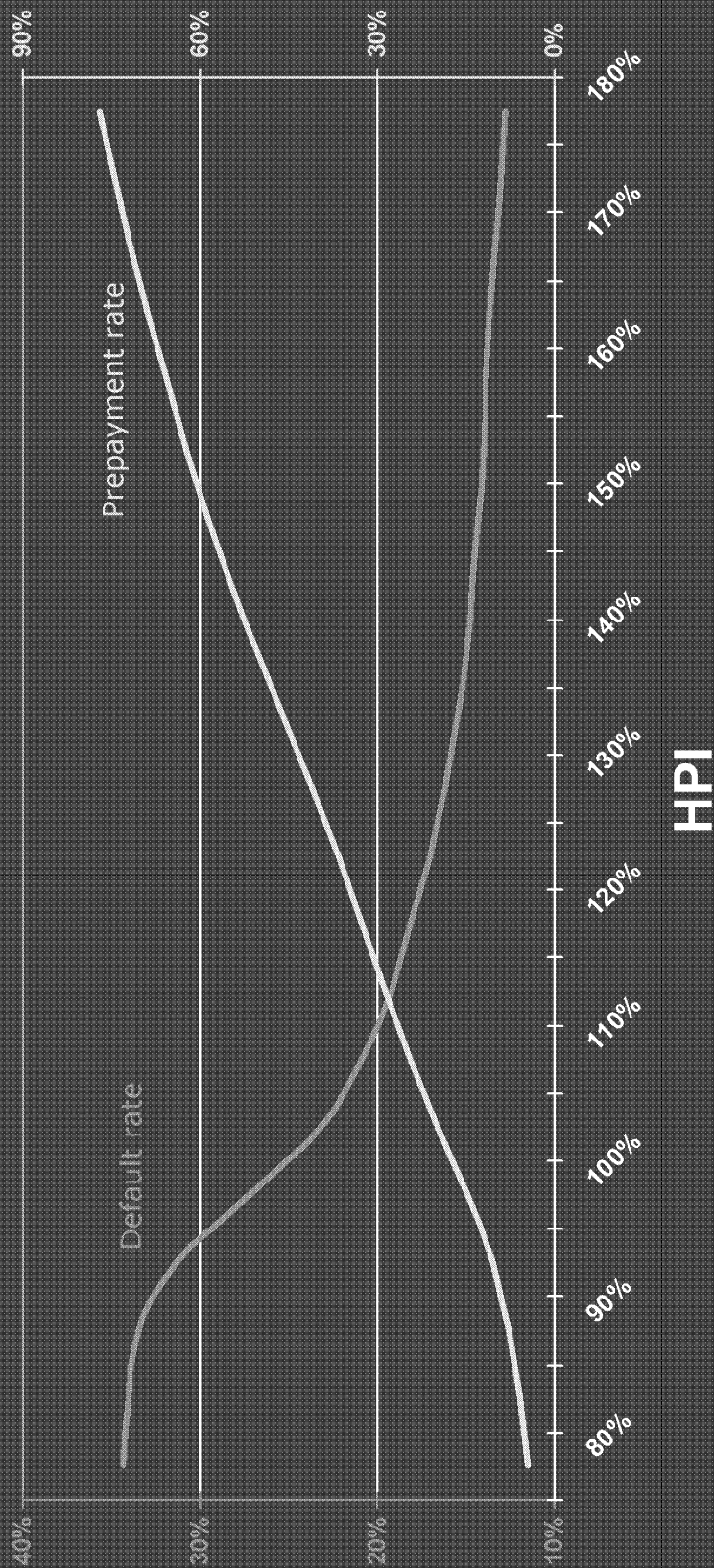
The Database

- **Large, clean database**
 - Two million subprime loans
 - Comprehensive
- **Supplemental analyses: interest only loans and simultaneous seconds**



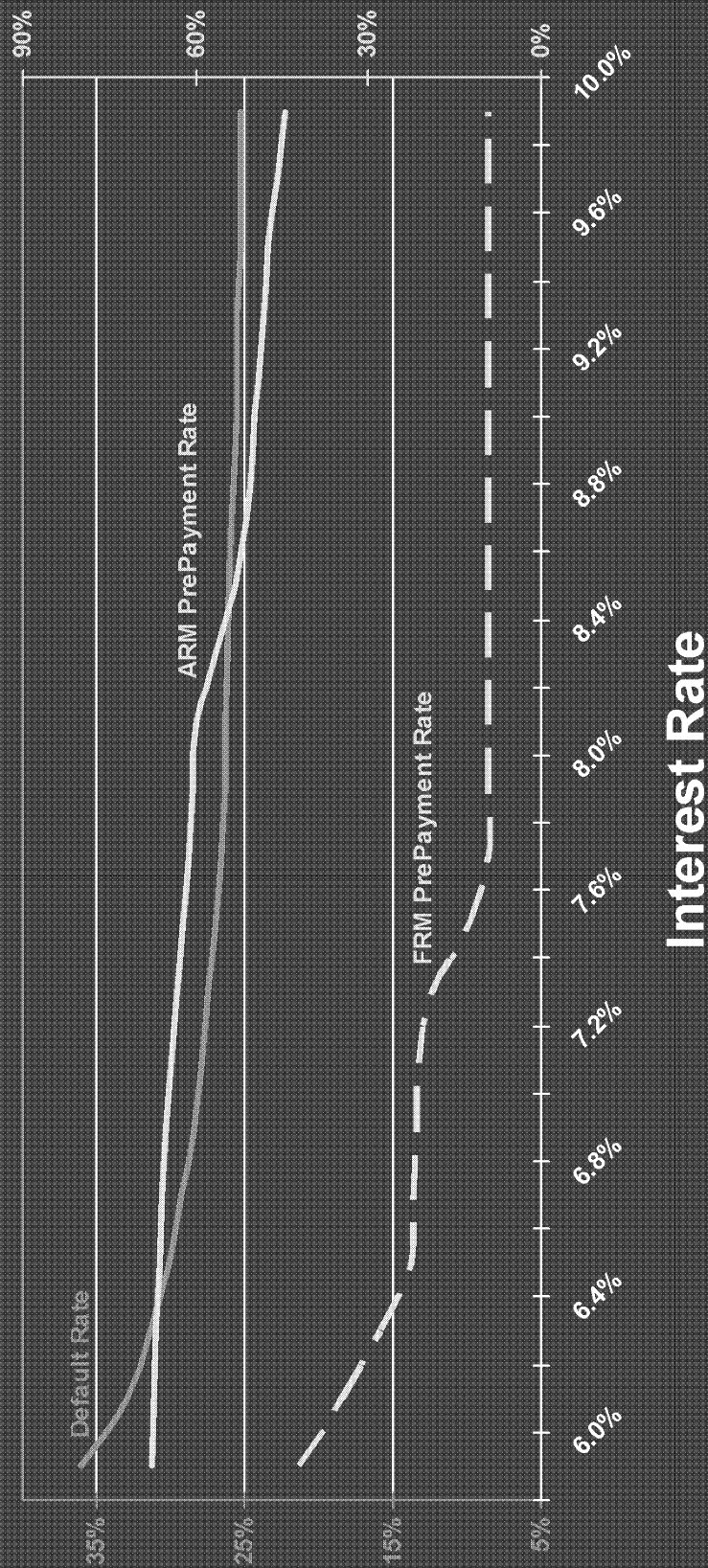
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Moody's Mortgage Metrics Subprime Sensitivity to HPI



Moody's Investors Service

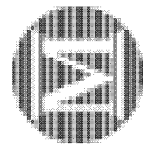
Moody's Mortgage Metrics Subprime Sensitivity to Interest Rates



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Pool Level Output

Pool Summary	Pool Name	Pool ID	Pool Size
Moody's Investors Service	Moody's Investors Service	Moody's Investors Service	Moody's Investors Service



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Moody's Mortgage Metrics Subprime - ver 1.1.1

Occur	Ownr	Invest	Secor	Total	CLTV
					88.8
					83.8
					86.1
					88.6

Rating Summary

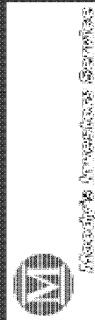
Rating	Count	Percentage	Weighted Average	CLTV
Aaa	28.09			88.8
Aa2	20.69			83.8
A2	14.83			86.1
Baa2	10.18			88.6
Ba2	7.26			
B2	5.50			
Loss	5.50			

Moody's Rating	Moody's Weighted Average	Moody's CLTV	Moody's Loss
Aaa	28.09	88.8	5.50
Aa2	20.69	83.8	5.50
A2	14.83	86.1	5.50
Baa2	10.18	88.6	5.50
Ba2	7.26		5.50
B2	5.50		5.50
Loss	5.50		5.50



Moody's Investors Service

Riskiest and Largest



Top 5 Riskiest Loans

Moody's Mortgage Metrics Subp

Moody's Mortgage Metrics Subp

Riskiest Loans

Loan ID	Loss	Loan Amount	Orig Appr Amt	Updated Appr Amt	Loan Amount	Orig Appr Amt	Updated Appr Amt
6699585	20.76	41,239	55,000	55,000	41,239	55,000	55,000
601768164	20.41	71,907	80,000	80,000	71,907	80,000	80,000
601767967	19.89	51,916	65,000	65,000	51,916	65,000	65,000
601767977	19.60	53,913	60,000	60,000	53,913	60,000	60,000
601780644	19.54	42,733	57,000	57,000	42,733	57,000	57,000

Loan ID	Loss	Loan Amount	Orig Appr Amt	Updated Appr Amt
6687321	9.87	999,476	1,250,000	1,250,000
6695049	3.81	979,518	1,400,000	1,400,000
6688770	7.55	960,000	1,200,000	1,200,000
310000553	10.34	959,323	1,200,000	1,200,000
6698941	4.74	930,596	1,163,902	1,163,902

Largest Loans

Loan ID	Loss	Loan Amount	Orig Appr Amt	Updated Appr Amt
6687321	9.87	999,476	1,250,000	1,250,000
6695049	3.81	979,518	1,400,000	1,400,000
6688770	7.55	960,000	1,200,000	1,200,000
310000553	10.34	959,323	1,200,000	1,200,000
6698941	4.74	930,596	1,163,902	1,163,902

Jr Ratio	Lien Pos	FICO	DTI	Ins.	Zip	State
0.0%	1	533	11.0		50220	IA
0.0%	1	676	21.0		37406	TN
0.0%	1	575	42.0		19805	DE
0.0%	1	644	46.0		29127	SC
0.0%	1	534	16.0		48227	MI

Jr Ratio	Lien Pos	FICO	DTI	Ins.	Zip	State
0.0%	1	627	53.0		60622	IL
0.0%	1	555	15.0		33308	FL
0.0%	1	678	45.0		91325	CA
0.0%	1	685	43.0		80108	CO
0.0%	1	680	40.0		92782	CA



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Loan by Loan



Moody's Mortgage Metrics Subprime -



Moody's Mortgage Metrics Subprime			
Loan ID	Aaa	Loss	Loan Amount
6699585	89.29	20.76	41,239
601768164	87.89	20.41	71,907
601767967	85.81	19.89	51,916
601760644	84.36	19.54	42,733
601710564	79.99	18.61	65,467
320000281	79.33	18.28	110,121
601775281	76.23	17.50	55,912
310000150	75.95	17.60	59,791
601783923	75.69	17.37	72,900

Loan ID	Aaa	Loss	Loan Amount	Orig Apprl Amt	Updated Apprl Amt
6699585	89.29	20.76	41,239	55,000	80,000
601768164	87.89	20.41	71,907	80,000	65,000
601767967	85.81	19.89	51,916	60,000	60,000
601760644	84.36	19.54	42,733	57,000	57,000
601710564	79.99	18.61	65,467	85,000	85,000
320000281	79.33	18.28	110,121	551,000	73,500
601775281	76.23	17.50	55,912	80,000	80,000
310000150	75.95	17.60	59,791	88,000	88,000
601783923	75.69	17.37	72,900		

Moody's Mortgage Metrics Subprime			
DTI	Ins.	Zip	State
11		50220	IA
21		37406	TN
42		19805	DE
46		29127	SC
16		48227	MI
48		61080	IL
45		6802	CT
37		48505	MI
40		62052	IL
41		29204	SC

DTI codes have been mapped to



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Precise Quantification of Layered Risk



Moody's Mortgage Metrics Subprime - ver 1.1.1

Rating Summary	Credit Enhancement
Aaa	29.96
Aa2	22.07
A2	15.81
Baa2	10.84
Ba2	7.73
B2	5.86
Loss	5.86

Pool Summary	
Wtd. Avg. Gross Margin	5.75%
Wtd. Avg. Rate	8.50%
Wtd Avg CLTV / LTV	80.3 / 80.3
Wtd Avg 1st LienCLTV / 1st LienLTV / JrCLTV	80.3 / 80.3 / 0
% 1st Lien	100.00%
% 1st Liens with Jr Liens	0.00%
1st Lien LTV > 80%	10.6%
Full Doc	0.0%
Purchase	100.0%
Wtd. Avg. DTI	0.0
Wtd. Avg. FICO	582.0
Wtd. Avg. Original Term/Wtd. Avg. Seasoning	360 / 0
Wtd. Avg IO Term / IO%	24 / 100%



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Precise Quantification of Layered Risk

FICO	%	LTV	CLTV	1st Lien LTV	%	FICO	DTI	%	FICO
> 840	0.0%	0.0	0.0	> 95	0.0%	0.0	Null	0.0%	0.0
> 820	0.0%	0.0	0.0	> 90	0.0%	0.0	0	100.0%	582.0
> 800	0.0%	0.0	0.0	> 85	10.6%	593.7	> 0	0.0%	0.0
> 780	0.0%	0.0	0.0	> 80	0.0%	0.0	> 20	0.0%	0.0
> 760	0.0%	0.0	0.0	> 75	82.0%	579.0	> 30	0.0%	0.0
> 740	5.4%	79.3	79.3	> 70	1.2%	629.8	> 35	0.0%	0.0
> 720	5.3%	80.5	80.5	> 65	6.2%	591.6	> 40	0.0%	0.0
> 700	5.4%	79.7	79.7	> 60	0.0%	0.0	> 45	0.0%	0.0
> 680	5.3%	79.9	79.9	> 55	0.0%	0.0	> 50	0.0%	0.0
> 660	5.4%	79.1	79.1	<= 55	0.0%	0.0	> 55	0.0%	0.0
> 640	8.6%	84.0	84.0	Total	100.0%	582.0	> 60	0.0%	0.0
> 620	5.4%	79.7	79.7				> 65	0.0%	0.0
> 600	5.4%	79.9	79.9				> 70	0.0%	0.0
> 580	5.3%	80.7	80.7				Total	100.0%	582.0
> 560	5.4%	79.7	79.7						
> 540	5.4%	79.9	79.9						
> 520	5.3%	80.8	80.8						
> 500	5.4%	79.0	79.0						
> 480	5.4%	79.5	79.5						
> 460	5.5%	80.8	80.8						
> 440	5.5%	80.0	80.0						
<= 440	10.9%	80.6	80.6						
Null or 0	0.0%	0.0	0.0						
Total	100.0%	80.3	80.3						

1st Lien CLTV	%	FICO	Term	%	FICO	LTV	CLTV
> 95	0.0%	0.0	40 Year	0.0%	0.0	0.0	0.0
> 90	0.0%	0.0	35 Year	0.0%	0.0	0.0	0.0
> 85	10.6%	593.7	30 Year	100.0%	582.0	80.3	80.3
> 80	0.0%	0.0	25 Year	0.0%	0.0	0.0	0.0
> 75	82.0%	579.0	20 Year	0.0%	0.0	0.0	0.0
> 70	1.2%	629.8	15 Year	0.0%	0.0	0.0	0.0
> 65	6.2%	591.6	10 Year	0.0%	0.0	0.0	0.0
> 60	0.0%	0.0	Total	100.0%	582.0	80.3	80.3
<= 55	0.0%	0.0					
Total	100.0%	582.0					

- Clean state concentration: 83% CA, 7% FL, 4% NY, 3% NJ
- Layered state concentration: 83% CA, 7% FL, 4% NY, 4% NJ



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Precise Quantification of Layered Risk

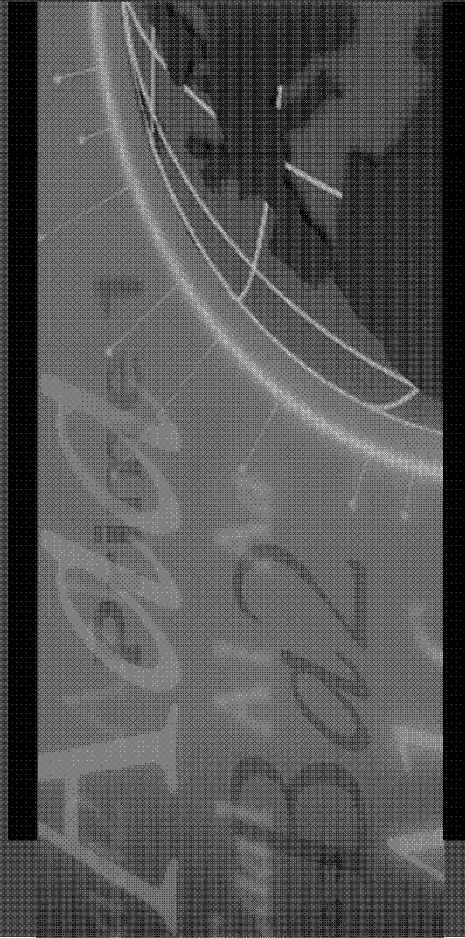
	Layered Risk	Clean
WA FICO	583 ←	582
FICO <620	59.09%	59.36%
FICO >660	26.98%	26.70%
WA LTV	80.33%	80.33%
WA CLTV	80.41%	80.33%
Simultaneous Seconds	4.10% ←	0%
Full Doc	46.11% ←	47.17%
Purchase	99.38%	100%
Investor	1% ←	0.00%
Single Family	99% ←	100%
CA	80% ←	83%
FL	7%	7%
State 3	4%	4%
State 4	4% ←	3%
State 5	4% ←	3%
Aaa	30.77	29.96
EL	6.07	5.86



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Moody's Mortgage Metrics Subprime

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Team Managing Director
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Rating Summary

Rating	Value
Aaa	24.86
Aa2	18.48
A2	13.39
Baa2	9.32
Ba2	6.65
B2	5.04
Loss	5.04

Credit Enhancement

Subprime	# of loans	Abs CE	Mean Loss
	250	24.86	5.04
	0	N/A	N/A
	250	24.86	5.04
	250	24.86	5.04

Microstrategy
Moody's.com
Contact us
Exit
Version 1.1.0

Moody's Mortgage Metrics Subprime

Progress

When you are ready to run the simulations, press the Next button. This could take several minutes.

Agenda

- **Factor selection and model estimation**
- **Simulation of loss distribution**
- **Model performance**



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The Model



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Moody's Mortgage Metrics for Subprime is a Combination of Models

- **Econometric models of loan behavior**
 - **Prepayment models (ARM and Fixed models)**
 - **Default model**
 - **Severity model**
- **Econometric models of the state of the economy**
 - **Unemployment**
 - **HPI**
 - **Interest rate for various reference rates**
- **A simulation framework that integrates these across a mortgage portfolio to produce a loss distribution for the mortgage pool**
- **A tranching tool that matches expected losses to Moody's guidelines**
- **Supporting validation results suggest good predictive power and intuitive relationships between inputs**



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Modeling Process

- **Collection and scrubbing** of historical data (borrower-specific, loan specific, macro-economic, etc.)
- **Estimation** and calibration of econometric models for **loan behavior**
 - Prepayment
 - Default
 - Severity
- **Validation** of econometric models from historical loan and macro data
- **Estimation**, calibration and validation of **macro-economic** models and
- Integration of macro-economic and loan models in **simulation**
- **Calibration** of simulation



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Factor Selection and Model Estimation



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Selection Criteria

- 1) Is the factor available for a large number of mortgages and is its construction objective?**
- 2) Does the variable effectively distinguish between behaviors?**
- 3) Is the relationship between the variable and behavior as expected?**



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Variable	Default	Prepay	Severity
FICO	X		X
Prepay penalty		X	
Purpose	X	X	X
Occupancy Type	X	X	X
Property type	X	X	X
Documentation type	X	X	X
Loan Amount	X	X	X
CLTV	X	X	X
Borrowers Equity		X	
Unemployment Rate	X		
Burnout		X	

Borrower Equity

$$beq = \text{AppraisalAmt} * (\text{HPI}(t) / \text{HPI}(0) - \text{activePrinBal})$$



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Variable	Default	Prepay	Severity
Region	X	X	X
Current mortgage rate (on loan)	X	X	X
Age	X	X	X
HPI	X	X	X
Carry cost			X
Teaser rate	X		
Seasonality		X	X
Amortization term	X		
Loan type	X	X	
Appraisal amount		X	X
Current market rate	X	X	
Mortgage Premium	X	X	

Mortgage premium
$MP = (\text{currentMtgrate} - \text{SubprimeMktrate}) / \text{currentMtgrate}$



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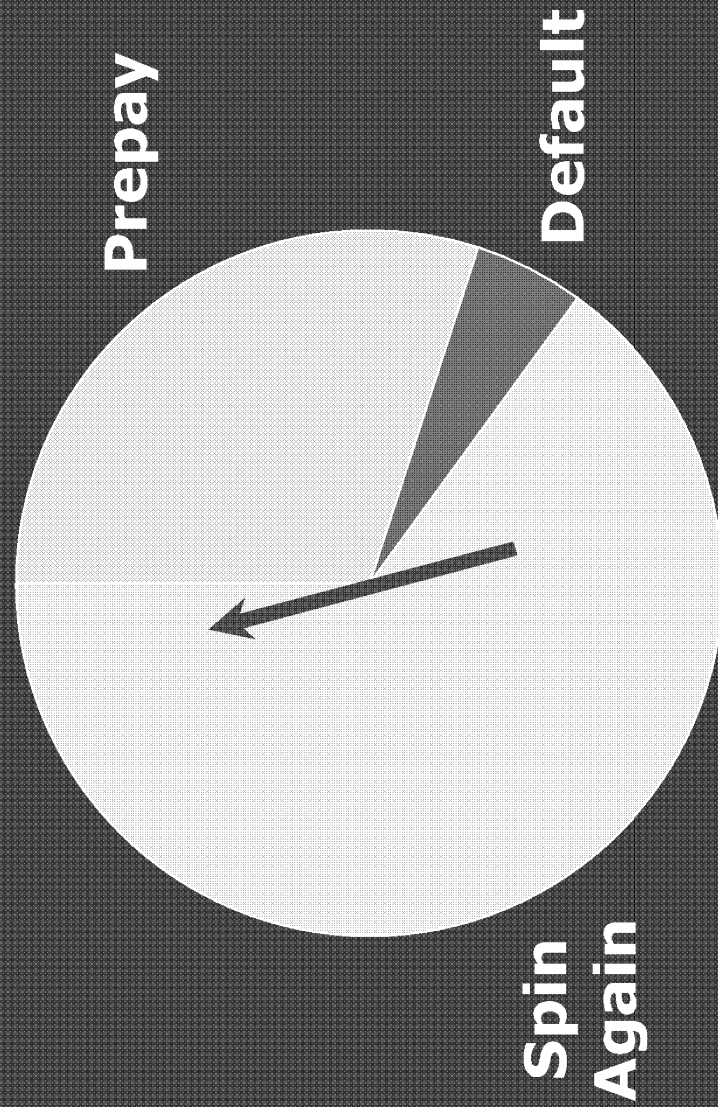
Simulation of Loss Distribution

28



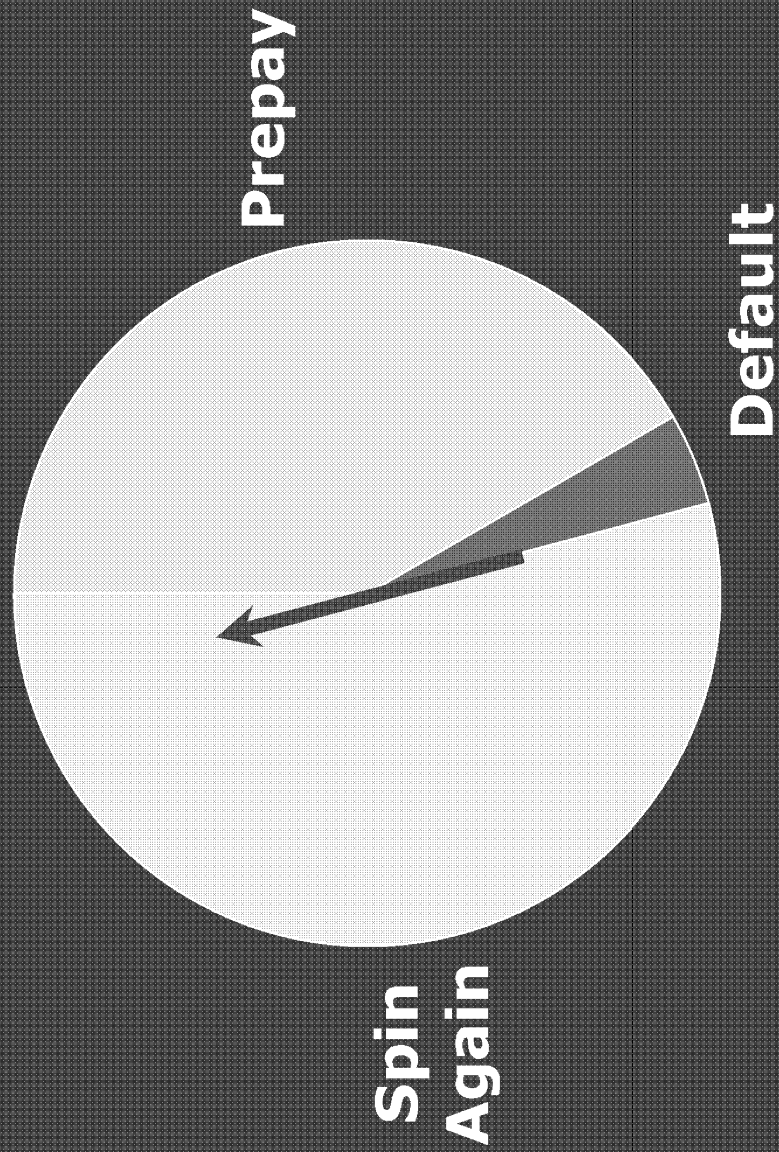
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A Simplified View of the Key Processes



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A Simplified View of the Key Processes



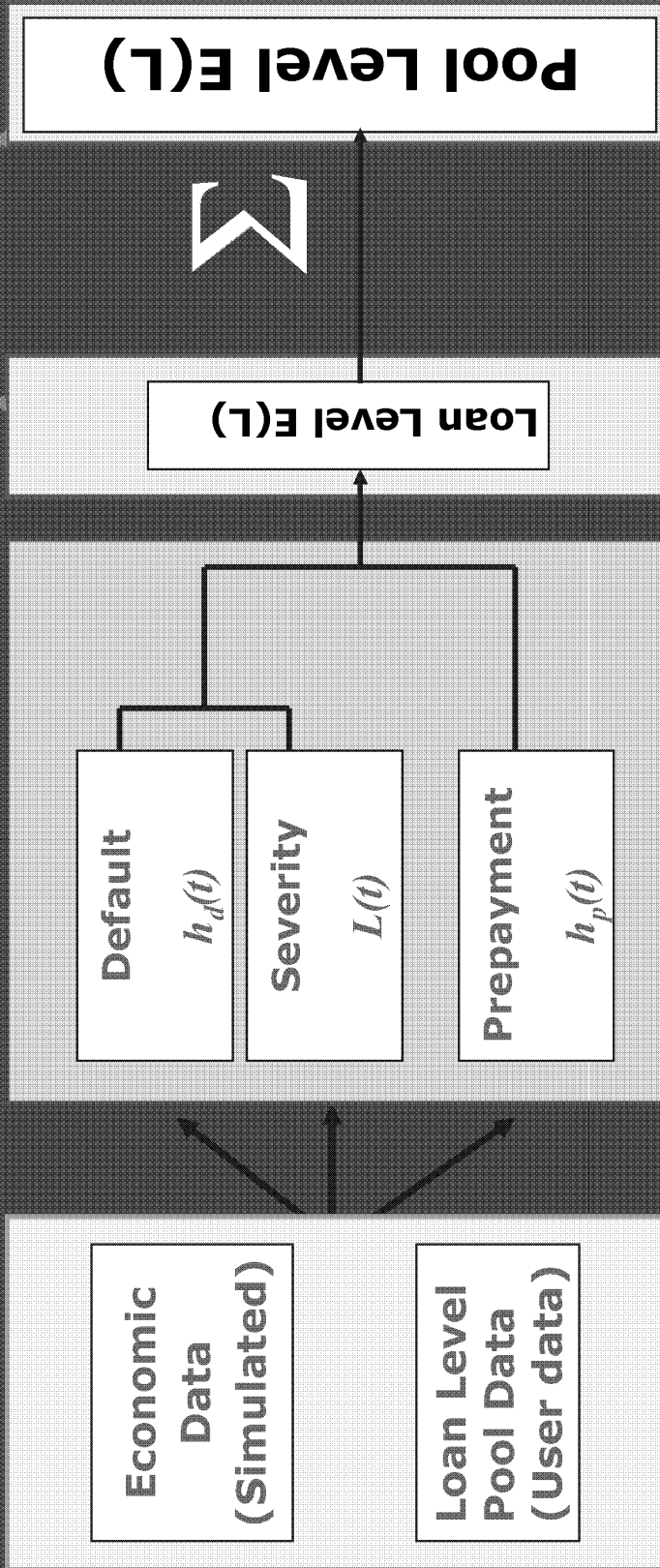
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Model Overview

Output

FACTORS

MODELS



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The Models

- Data transformations (parametric and non-parametric)
- **Prepayment** is modeled in a **hazard rate framework** (2 models) with baselines that differ by loan type and prepayment penalty within each model

$$h_p(t) = h_0(t)e^{\beta f(x)}$$

where $f(x)$ are the transformed factors

- **Default model** has similar functional form

$$h_p(t) = h_0(t)e^{\beta'g(x)}$$

- **LGD model** uses **Beta-transformed OLS**

$$L(t) = \text{Beta}^{-1}(\delta q(x))$$

- Note that we have simplified the notation above: factors are not identical across models



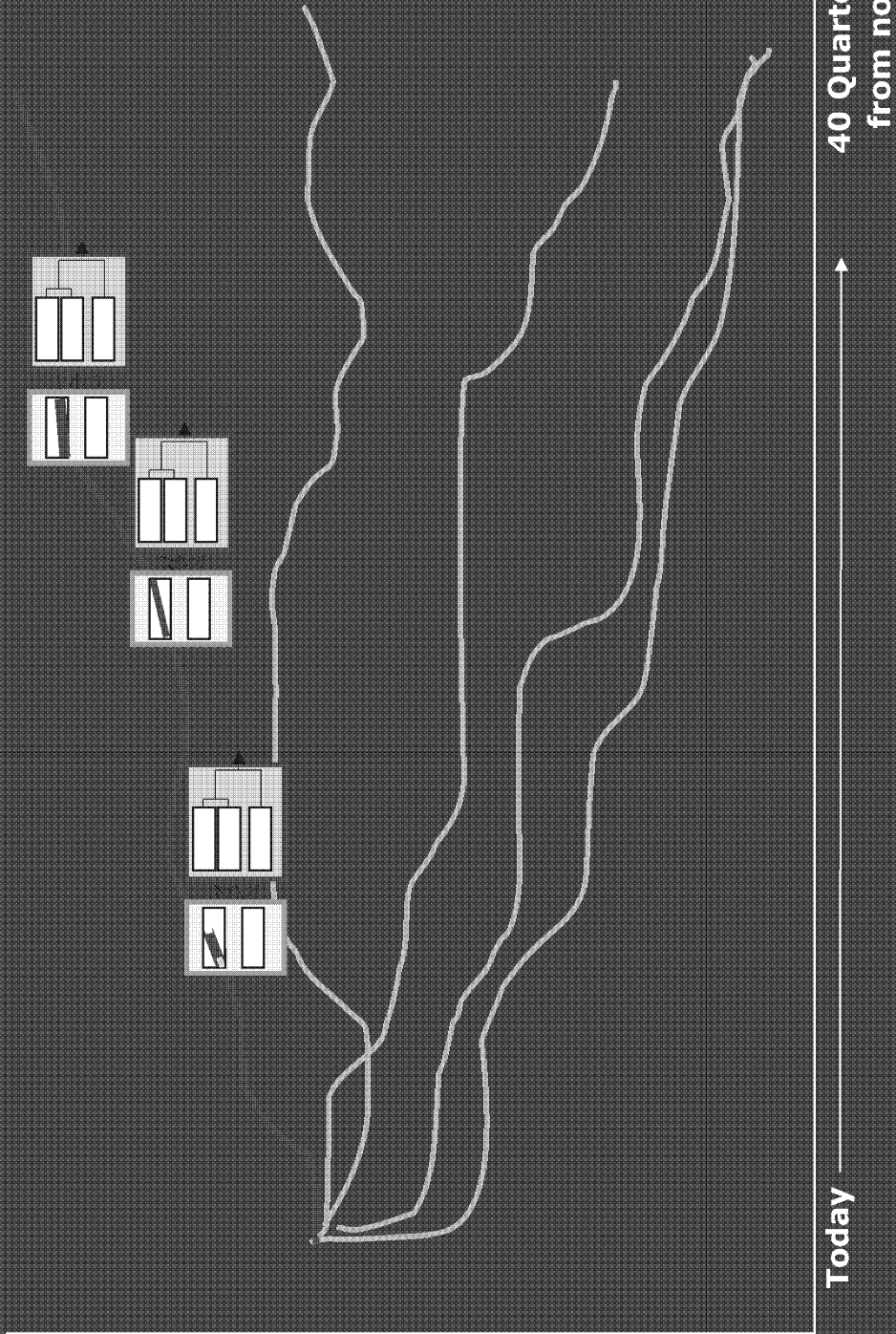
The Simulations

- **Econometric Cross-sectional and time Series** models of unemployment (UNP), HPI, long- and short- rates and Subprime rate
- State-specific HPI and UNP paths
- **Simulation algorithm**
 - For each iteration (1250)
 - Generate jointly one realization of each economic series (40 quarters)
 - For each quarter
 - For each loan
 - » Calculate $h_p(t), h_d(t), L(t)$ using data from pool tape and simulated economic series
 - Sum losses for pool in period 40
 - Integrate losses (probability weighted) across iterations to estimate loss distribution



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Simulating economic environments



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Model Performance

13



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Walk-Forward testing is one of the approaches we use

➤ **Provides a test of model overfitting and measures the out-of-sample performance.**

- Estimate the model on the data up to a certain point in the past and score the future year (relative to that point).
- Advance the cutoff for the estimation by one year and estimate the next year.
- Continue in this manner until the data is exhausted.
- Combine the scored "out-of-sample" subsamples and calculate performance statistics

➤ **Tests both model and modeling approach.**

➤ **Simulates the way in which models are used in practice.**

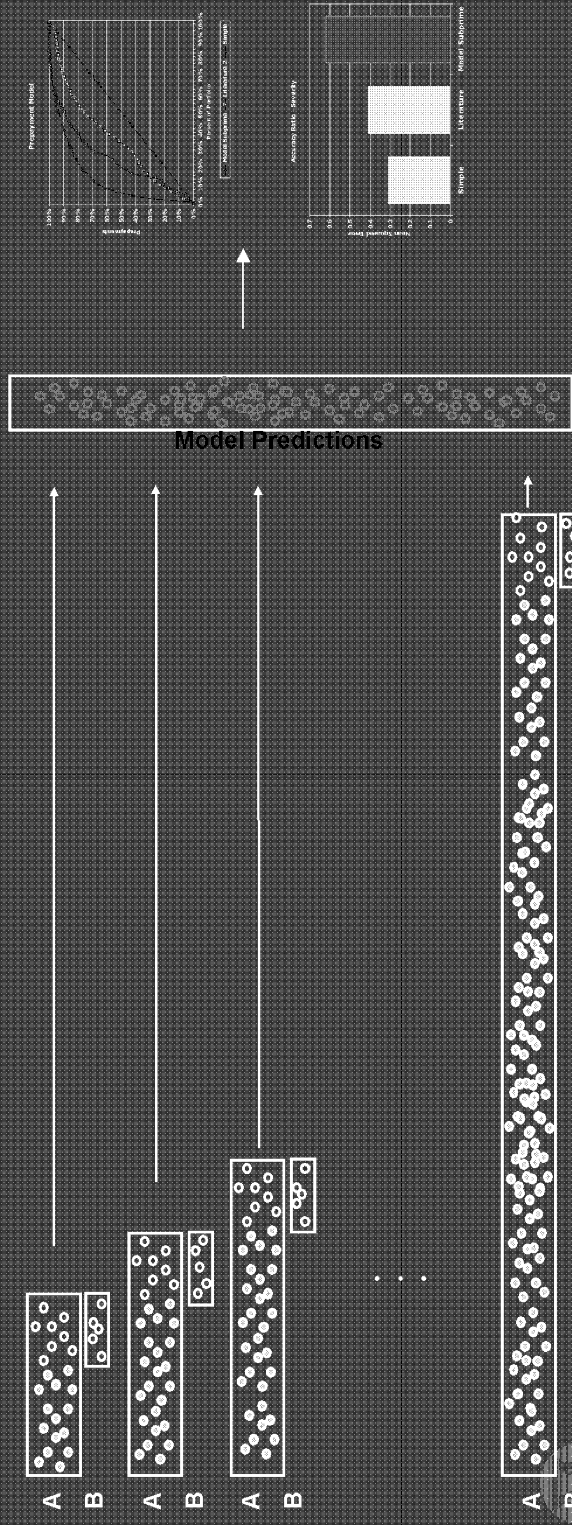


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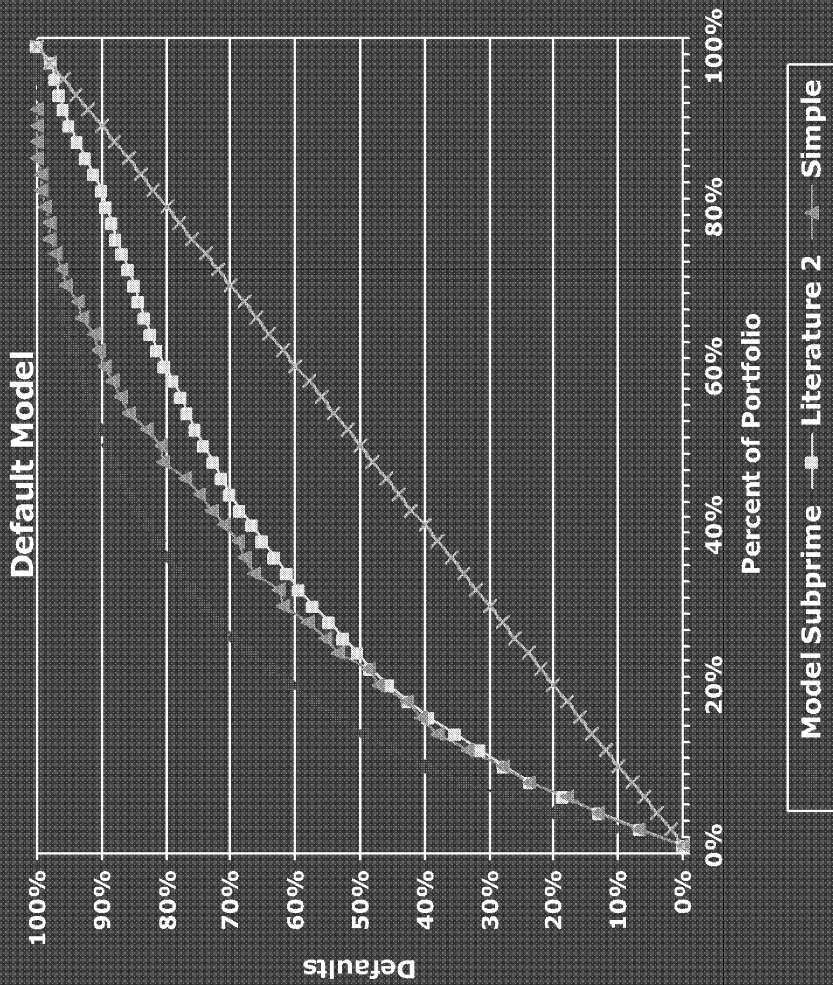
Training set of mortgages taken at t_0 Validation set of original mortgages in training sample but taken at t_1

Validation set of new mortgages not in training sample & taken at t_1

1999 2000 2001 2006



Default Model Out of Sample Power Curve



AR

Model Subprime
 Literature 0.35
 Simple 0.43

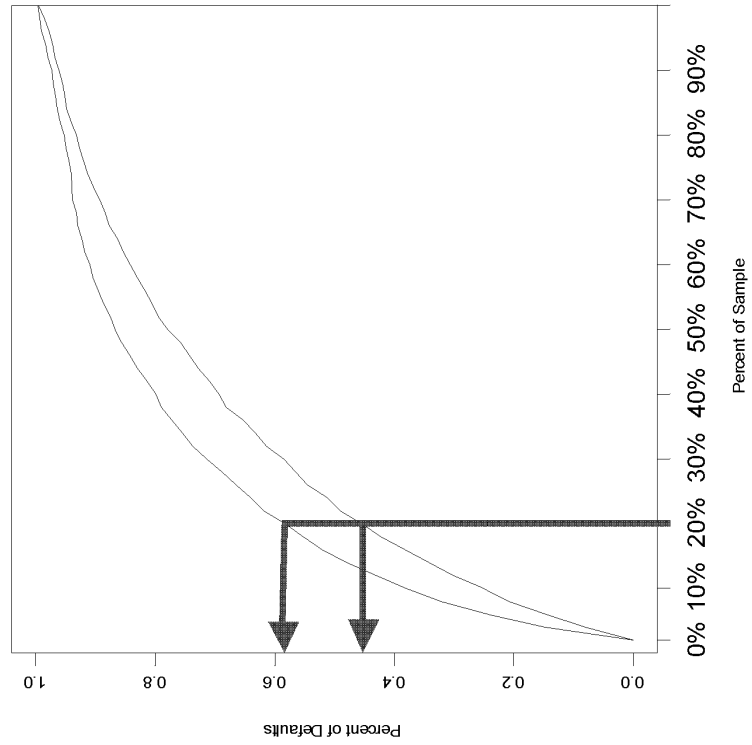
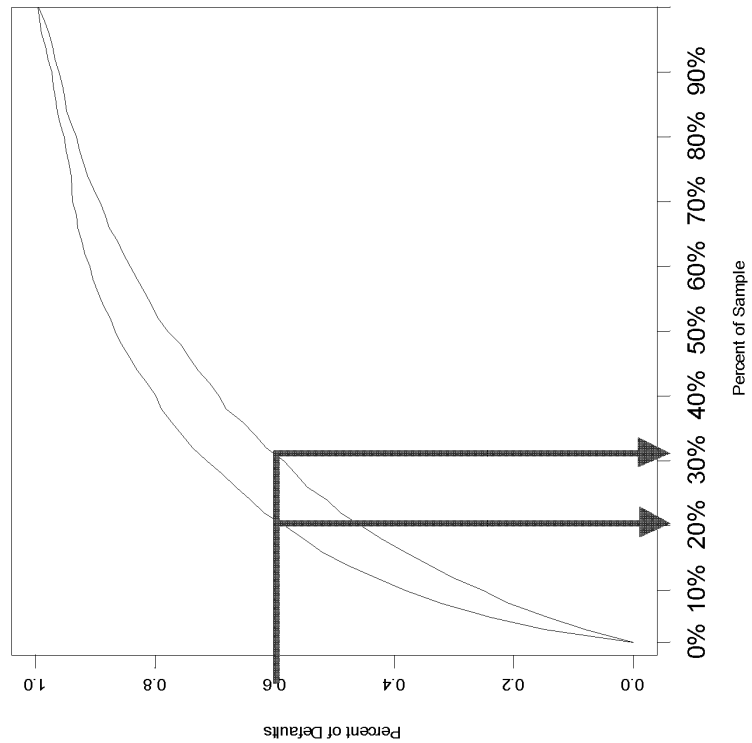


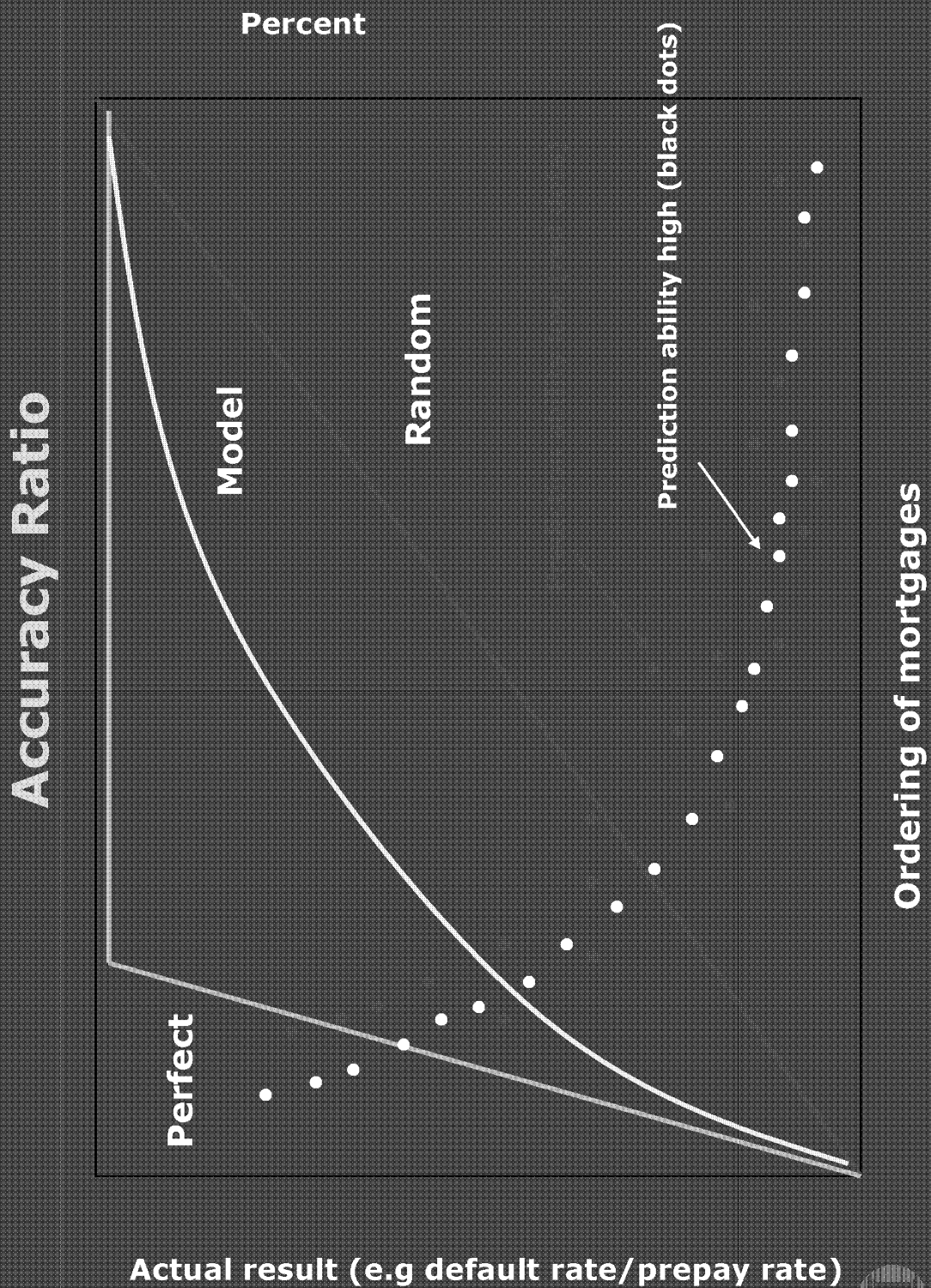
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Why more powerful models are better

If our goal is to avoid 60% of the defaults in a mortgage pool, the more powerful model requires us to exclude fewer good loans.

If our goal is to include 80% of a portfolio in a pool, the more powerful model avoids more defaults.



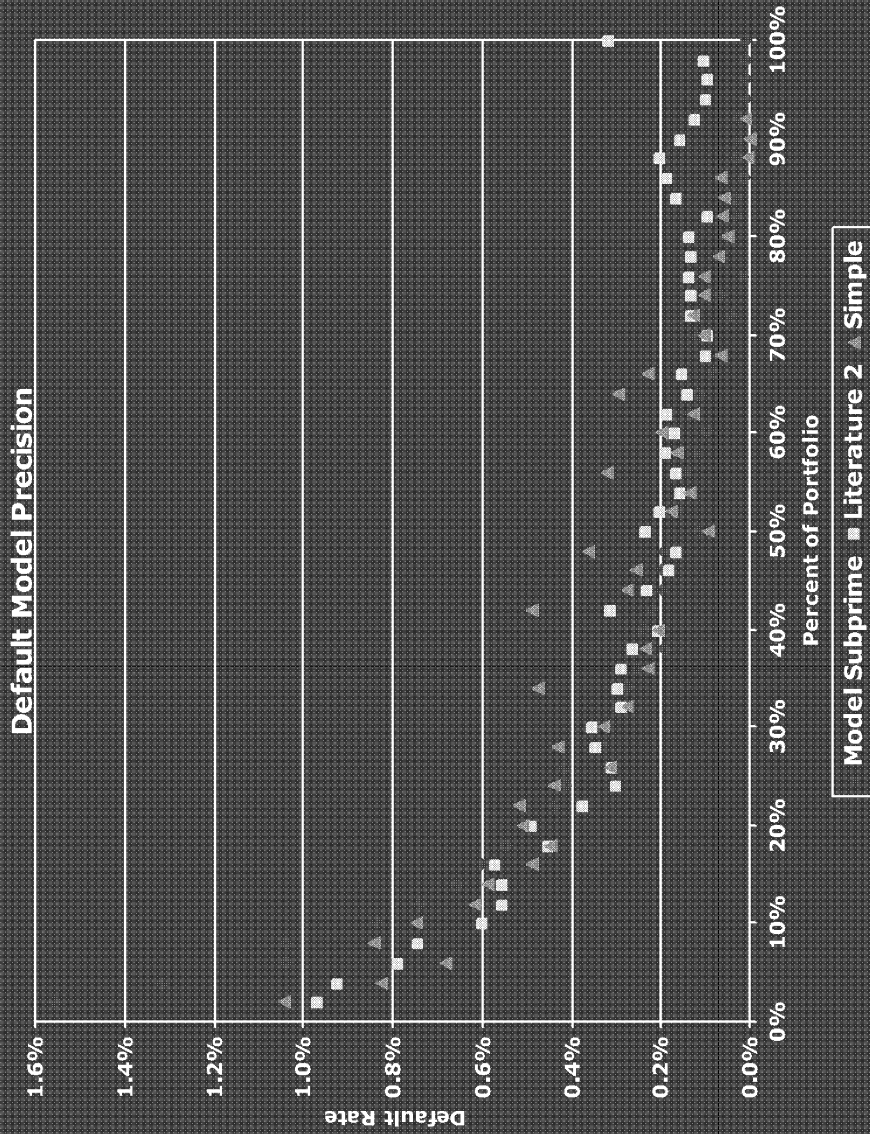


Ordering of mortgages

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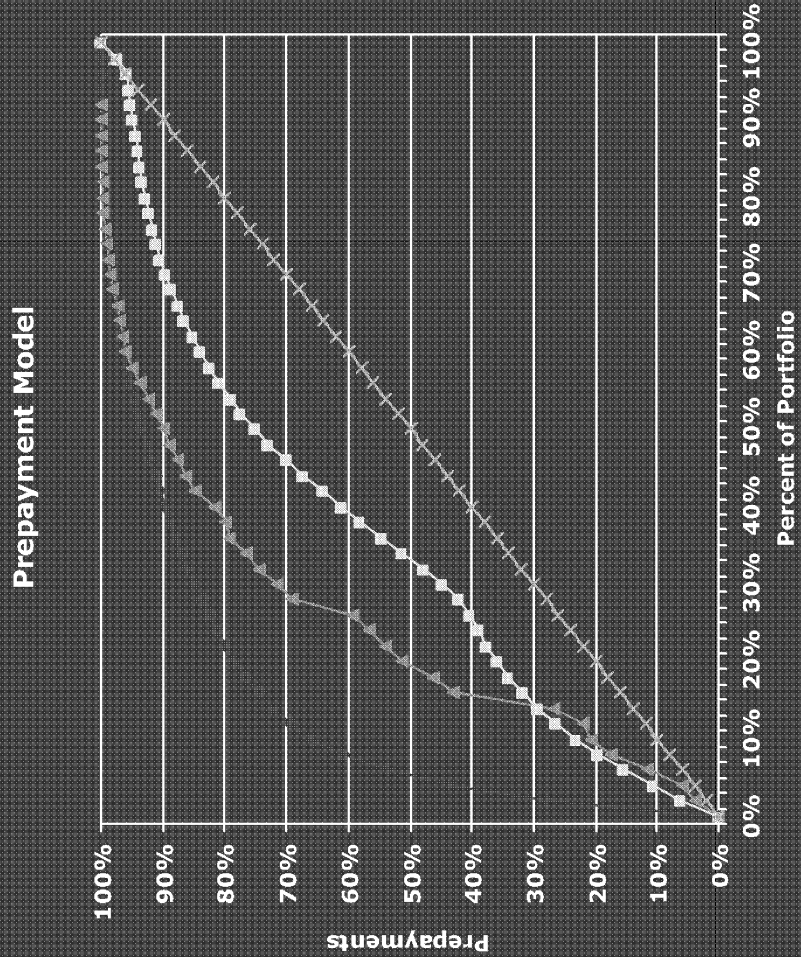


Default Model Precision



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Prepayment Model Out of Sample Power Curve



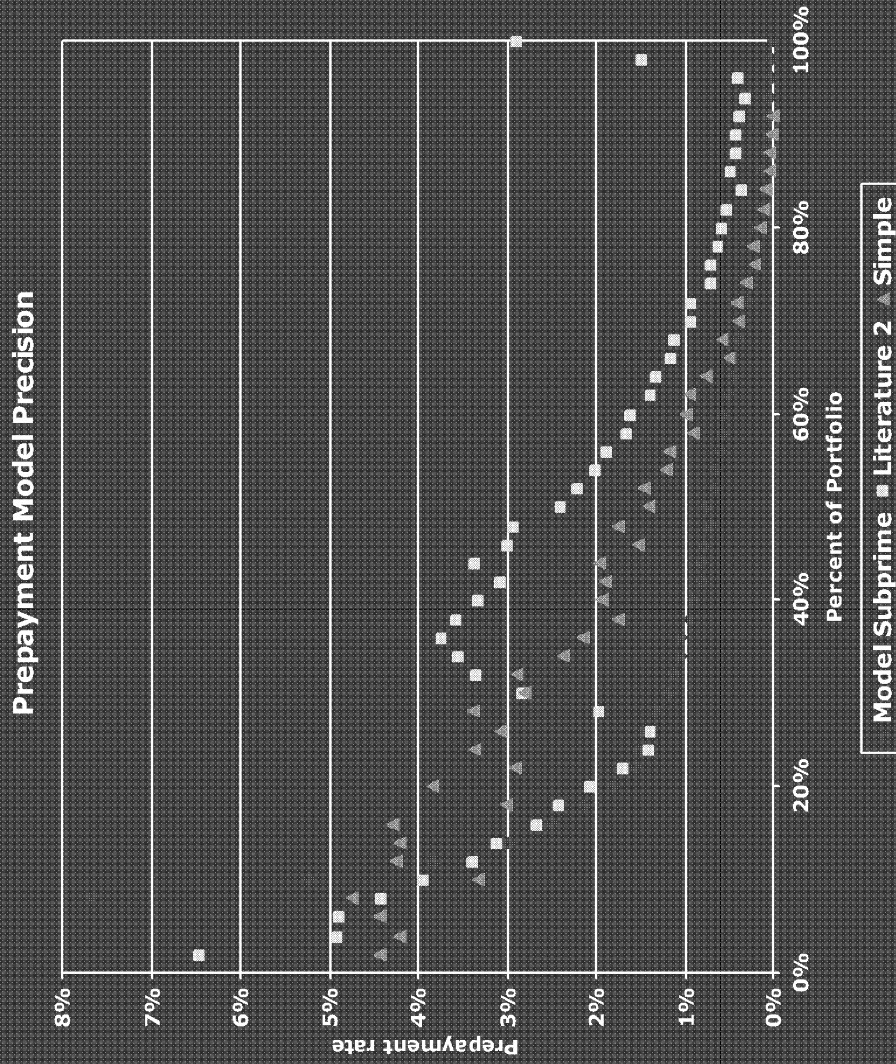
Prepayment Model
 Model Subprime —■— Literature 2 —▲— Simple

AR

Model Subprime	Literature 2	Simple
0.31	0.31	0.42



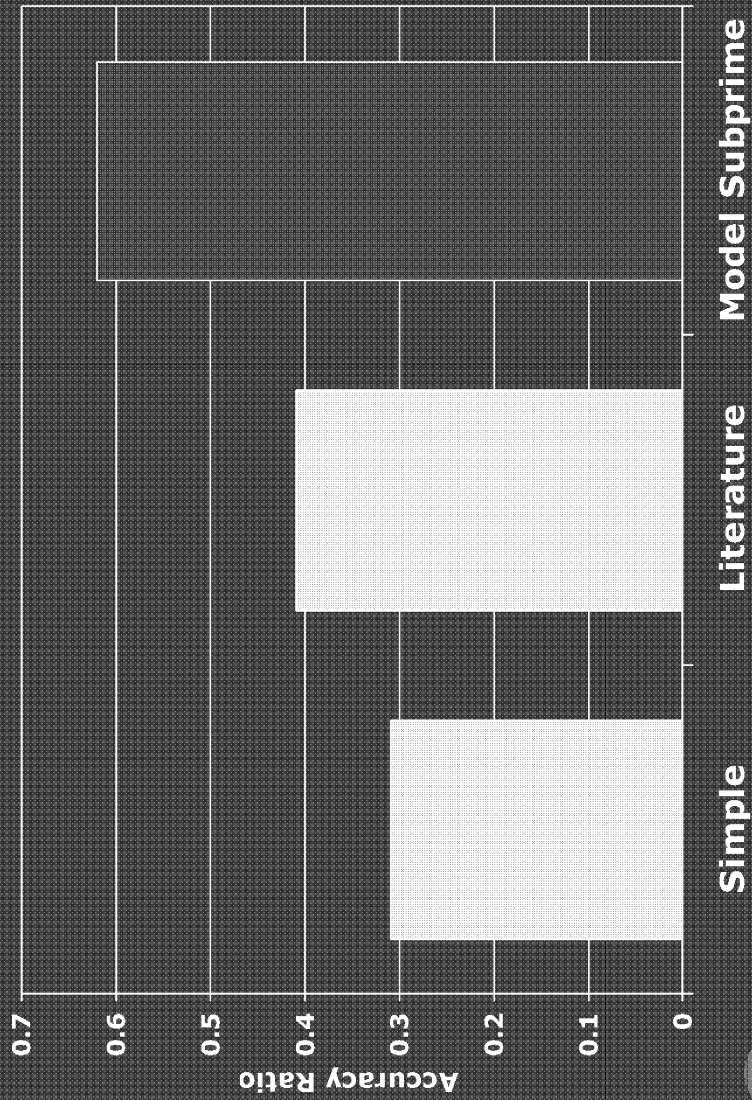
Prepayment Model Precision



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Severity Model – Accuracy Ratio

Accuracy Ratio - Severity



Out of Sample AR

Simple

0.31

Literature

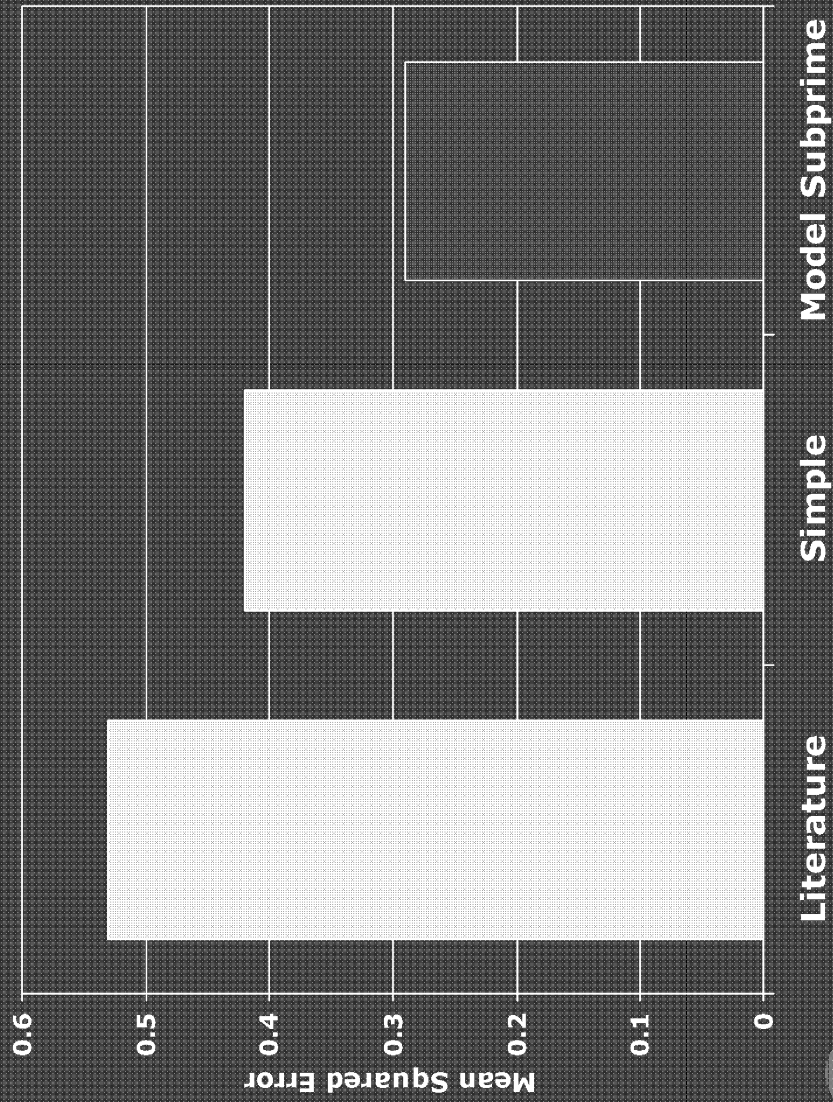
0.41

Model Subprime



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Severity Model – Mean Square Error



Out of Sample MSE

(Low values are better)

Literature 0.53

Simple 0.42

Model Subprime



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Moody's Mortgage Metrics for Subprime is a Combination of Models

- **Econometric models of loan behavior**
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- **Supporting validation results suggest good predictive power and intuitive relationships between inputs**



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Some of Moody's research on model validation

Benchmarking Default Prediction Models: Pitfalls and Remedies in Model Validation,
Stein, R. M., **Technical Report #030124 (2002)**.

http://www.moodyskmv.com/research/files/wp/BenchmarkingDefaultPredictionModels_TR030124.pdf

The Relationship Between Default Prediction and Lending Profits: Integrating ROC Analysis and Loan Pricing Roger M. Stein, May, *Journal of Banking and Finance*, Vol. 29, No. 5. (2003, 2005).

http://www.moodyskmv.com/research/files/wp/JBF_2026.pdf

Inferring the Default Rate in a Population by Comparing Two Incomplete Default Databases, Dwyer, D. W. and Stein, *Journal of Banking and Finance*, Vol. 30 (2003, 2005)

http://www.moodyskmv.com/research/files/wp/InferringDefaultRate_JBF.pdf

Are the probabilities right?: Dependent Defaults and the Number of Observations Required to Test for Default Rate Accuracy, Stein, R. M., *Journal of Investment Management*, 2, 4, 2006.

<http://joim.com>

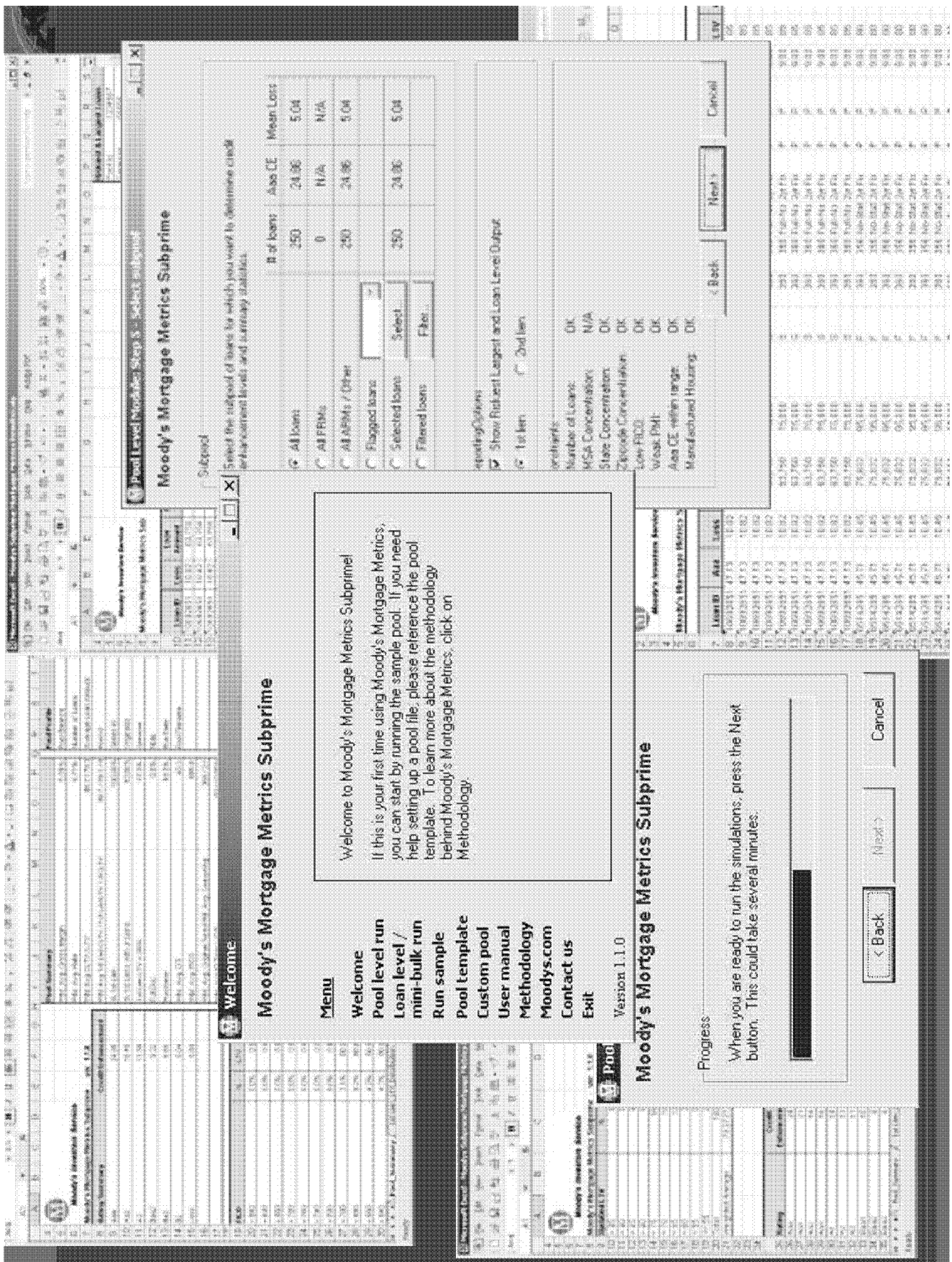
http://www.defaultrisk.com/pp_test_23.htm (draft version)

What is a more powerful model worth?, Stein, R. M. and Felipe Jordão, **Technical Report #030422 (2003)**

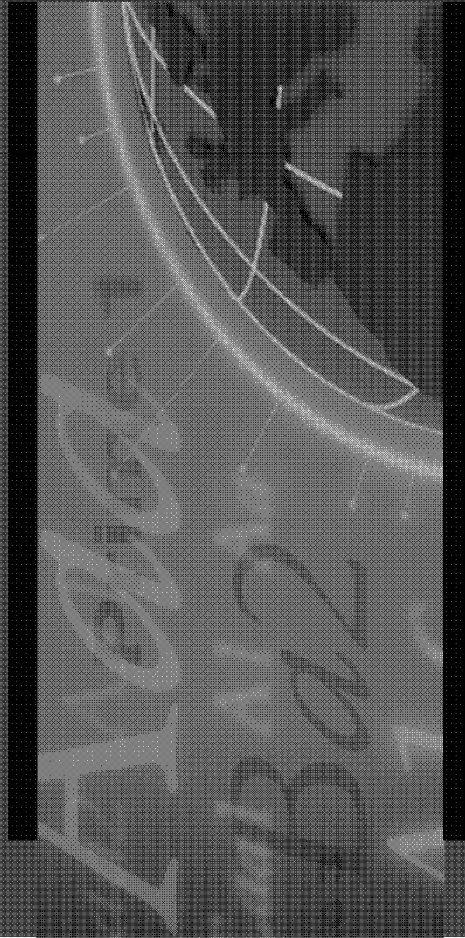
http://www.moodyskmv.com/research/files/wp/MorePowerfulModel_TR030124.pdf



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Moody's Mortgage Metrics Subprime User's Perspective



Chris Schiavone
Principal and Head of Home
Equity and Asset Backed
Securities
Bank of America Securities



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Moody's Mortgage Metrics Subprime



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Mortgage Credit Research Database

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A Large, High-Quality Data Set of Sub-Prime Loans

- **The Moody's Mortgage Credit Research Database (MCRD) contains highly scrubbed data on about 2 million sub prime loans**
- **Collection efforts continue, currently have 9 data providers, primarily originators**
- **The data goes back to 1995**



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Data Cleaning Process



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Overview

- **Mapping – least common denominator**
- **Outliers – simple and statistical techniques**
 - Developed over 100 rules for cleaning
 - Used Cook's Distance measure for outliers
- **Provided clean research database**



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Data Mapping and Cleaning

- Different number of fields (doc type)
- Missing fields
- Use uniform standards for content and formats
 - Map data sets into our format
 - Same data scale
- Manual entry
 - Typos
 - Fields swap positions, etc.



Statistical anomaly detection and business rules

Example of Business Rules

- **Over 100 business rules put in place**
 - CLTV can't be less than LTV
 - Mortgage rate >0
 - Remaining term \leq Original term, etc.
 - Use constraints on all loan attributes that will be included in our model
- **Raw data contained a significant amount of common sense errors**



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Statistical Techniques to Detect Outliers



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Statistical Data Cleaning Techniques

- **Outlier with respect to the predictors - Data is Outside a Range**
- **Outlier with respect to response variable - Result is Outside a Range**
- **Cook's Distance - Impact on the Model Result**
- **Etc.**



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Data Cleaning – One Provider

Margin_Freq	Frequency	Percent	Cumulative Frequency	Cumulative Percent
(20, inf)	2	0	2	0
(10, 20]	174	0.02	176	0.02
(9, 10]	1019	0.13	1195	0.15
(8, 9]	4703	0.6	5898	0.75
(7,8]	40396	5.13	46294	5.88
(6,7]	132574	16.84	178868	22.72
(5,6]	236022	29.98	414890	52.7
(0,5]	118088	15	532978	67.7
null or 0	254269	32.3	787247	100

There are two loans with Margin larger than 20 (These outliers are often detected by the COOK'S DISTANCE test). We find the margins for these two loans are 545 and 710. We also find that the other loan attributes are quite normal. So we correct these two loans' margins from 545 to 5.45, and 710 to 7.10.

Data Eliminated

LTV_Freq	Frequency	Percent	Cumulative Frequency	Cumulative Percent
(140,inf)	11	0	11	0
(120, 140]	10	0	21	0
(100, 120]	122	0.02	143	0.02
(80, 100]	253414	32.19	253557	32.21
(70, 80]	452201	57.44	705758	89.65
(60, 70]	59243	7.53	765001	97.17
(40, 60]	13839	1.76	778840	98.93
(0, 40]	8407	1.07	787247	100

There are 11 loans with LTV larger than 140. Most of these are 3-digit values, like 280, 230, etc. It's really hard to correct them. We just delete 8 loans from our data set with LTV greater than 150.



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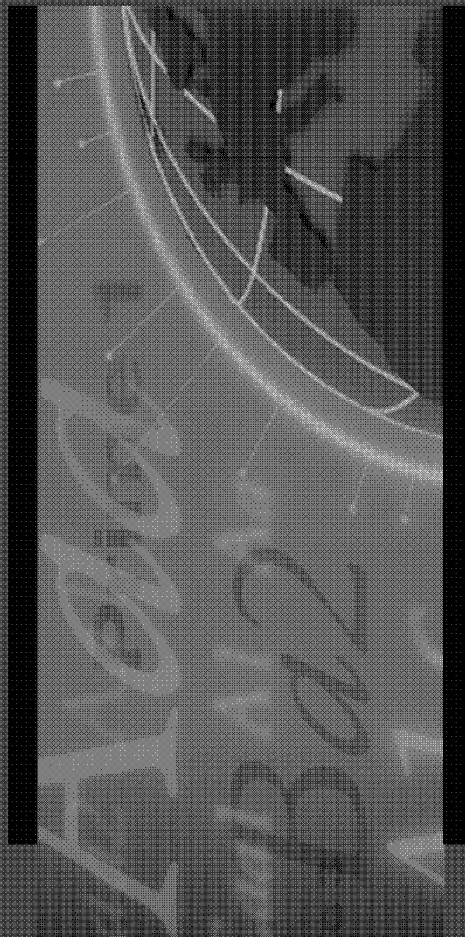
Data Substituted

FICO_Freq	Frequency	Percent	Cumulative Frequency	Cumulative Percent
(1000, inf)	1148	0.15	1148	0.15
(800, 1000]	2905	0.37	4503	0.51
(600, 800]	356844	45.33	360897	45.84
(400, 600]	362910	46.1	723807	91.94
(200, 400]	1018	0.13	724826	92.07
(0, 200]	388	0.05	725214	92.12
null or 0	62033	7.88	787247	100

Here we have 1,148 loans with unreasonable FICO values. Since there are 62033 loans with 0 or missing FICO in our data set, we set missing values for all these 1,148 loans.



**For a demonstration of
Moody's Mortgage Metrics Subprime
please contact Kelly Slicklein**



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Introducing
**Moody's Mortgage Metrics
Subprime**

just became more transparent.

The tool used by Moody's investors to reveal the extent of risk in
subprime mortgage products now available to our clients.



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