ANDREW KALOTAY ASSOCIATES, INC.

Where is the Option?
Prepayment Modeling of MBS

Toronto, 4 April 2007

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The Size of the U.S. Mortgage Market

Home mortgages

- $10 trillion outstanding
- $2.5 trillion originated in 2006

Mortgage-backed Securities (MBS)

- $6 trillion total outstanding
- Of which $4 trillion are Fannie Mae, Freddie Mac, and Ginnie Mae ("Agency" MBS)

$4.5 trillion Treasury securities outstanding

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Conventional Mortgages

Offered in standardized structures

- We'll focus on 30-year fixed rate mortgages
- Borrower can reduce rate by paying points
- Or avoid transaction costs by paying a higher rate

Prepayable at any time

- Rate reflects an implicit charge for this option
- Refinancing entails transaction cost

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What Is an Agency MBS?

- Originator wants to convert a pool of similar "conforming" mortgages into a security
  - Say 6% FRMs into a 5 ½% MBS
- Agency puts its stamp of approval on pool: creates MBS and guarantees payments
  - All of the principal and most of the interest passed through to MBS investors
- Residual interest retained by originator covers servicing cost and guarantee fee

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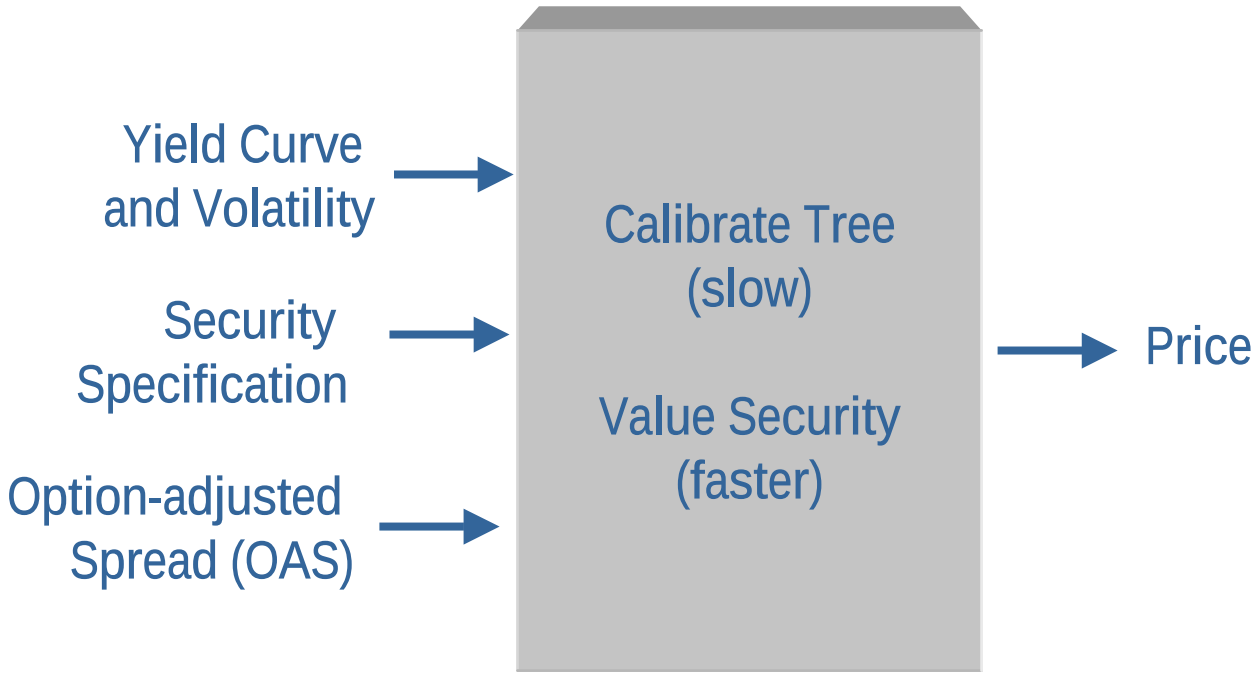
OAS-Based Valuation of Bonds and MBS Since1986



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Bond Valuation Speed Has Improved Dramatically

	1990	2007
Processor	386	3.0 GHz Pentium
Calibrate tree	Up to 4 hours	500 per minute
Compute fair value recursively	Several seconds	80,000 per minute

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What About MBS Analysis? Relative to Bonds, It Lags By a Mile

Slow and imprecise

- At most a few 100 of valuations per minute
- Because of the limitations of Monte Carlo simulation

Prepayment models are ad hoc formulas, based on statistical analysis of historical data

- Lack underlying financial principles
- Treatment of “burnout” is an afterthought
- Ongoing release of “new and improved” models is a predictable consequence

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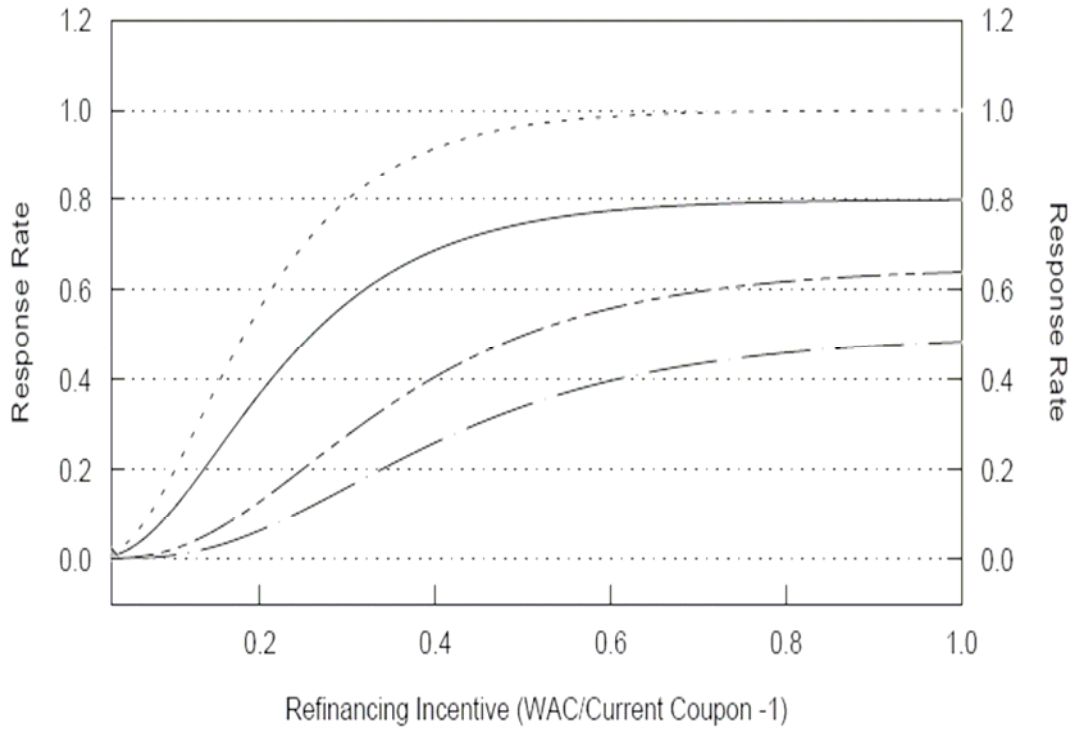
Typical S-shaped Prepayment Model: Rate Depends on Refinancing Incentive

Figure 14. Refinancing Curves for Different Borrower Types



WAC Weighted-Average Coupon
Source: Salomon Brothers Inc.

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A Good MBS Pricing Model …

Accurately estimates market value and price response to interest rate changes

- For trading and risk management

Requires a good prepayment model

- Interest-rate driven refinancings feed into pricing

Should produce a realistic response to all relevant variables

- Because conventional models are not based on financial principles, they have no hope of doing so
- Hence their short half-life

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Conventional MBS Models Can't Answer Pertinent "What if" Questions

How much would MBS yields increase if refis were optimal?

How sensitive are refis to transaction costs? To interest rate volatility?

What would happen to MBS yields if borrowers gave up the right to refi?

Can prepayments be sensibly modeled without a command of refis?

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The right approach to MBS valuation:
Understand mortgages; the rest will follow

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Analytical Framework for Optimum Mortgage Refinancing

Mortgage: a callable amortizing bond

Represent call prices as remaining principal plus anticipated transaction cost

e.g. 1% of remaining principal

Mortgage rates: OAS to a benchmark curve

Use a volatility consistent with swaption vols

Optimum: act only if value received is adequate

Provides a benchmark for sub-optimal behavior

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The Right Decision Tool Is Generalized Refunding Efficiency

$$Efficiency_{gen} = \frac{PV\ Savings}{\Delta\ Option\ Value}$$

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Refinance or Wait? Decide Like a Professional!

Should I Refinance?

CURRENT MORTGAGE

Years left:	26
Interest rate (%):	6.000
Remaining principal ($):	100,000

Refinance Now?

patent pending

NEW MORTGAGE

Term (in years):	30
Interest rate (%):	5.600
Discount points (%):	1.000
Upfront costs (legal fees, etc.) ($):	1,500
New principal ($):	102,525

Use Custom Inputs

And The Answer Is...

CASH FLOWS

Current monthly payment ($):	634
New monthly payment ($):	588
Savings per month ($):	46
Principal remaining after 26 years ($):	25,259

Analysis as of 09/07/2005 11:02:14 10-Yr Treasury at 4.131%

RECOMMENDATION

Total savings (in today's $):	1,498
÷	
Loss of option value (in today's $):	2,029
=	
Kalotay Refi Score 100% best. Refinancing not recommended below 90%.	72.3%

Not Yet!

See www.kalotay.com/calculators

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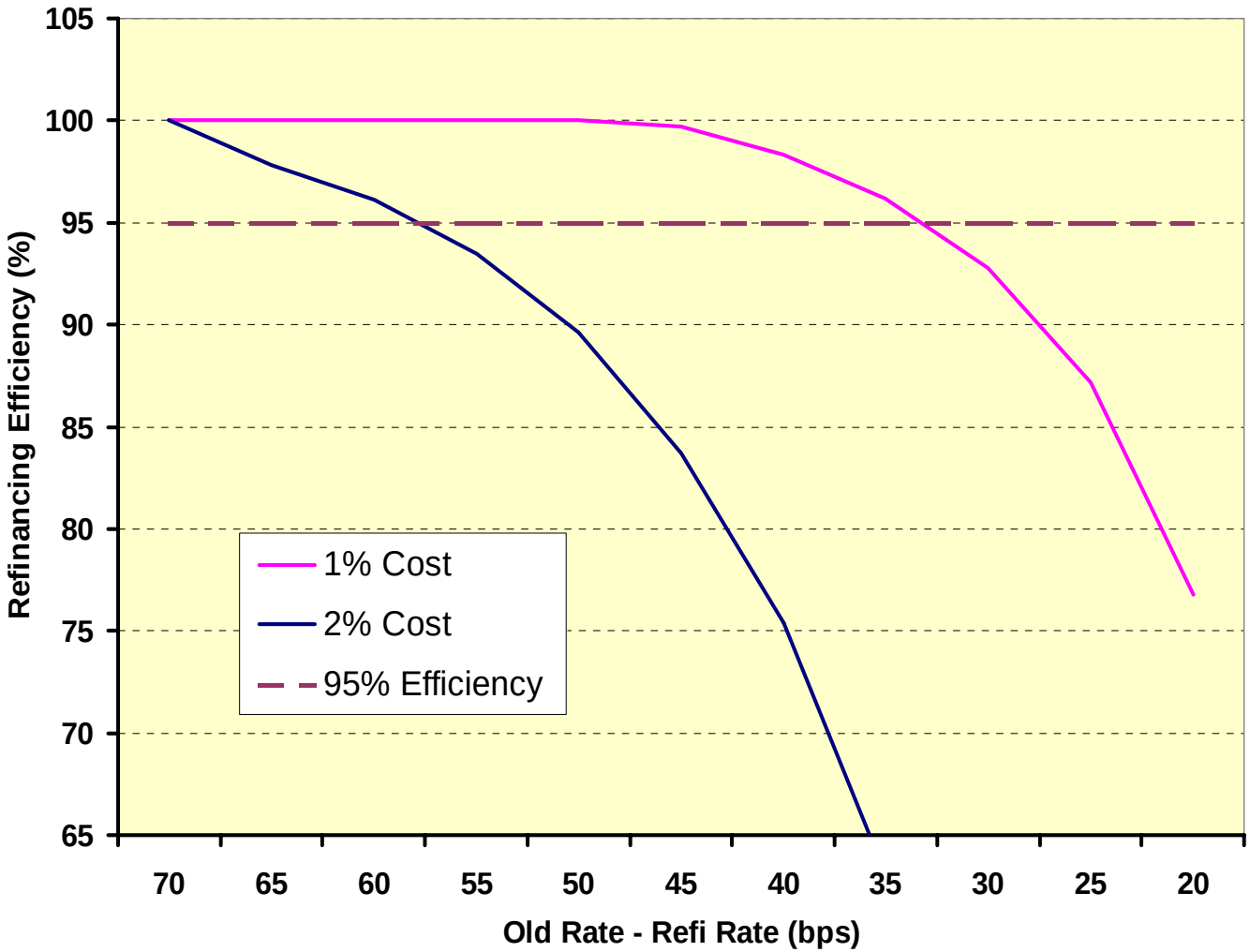
Transaction Costs Impede Refinancing…



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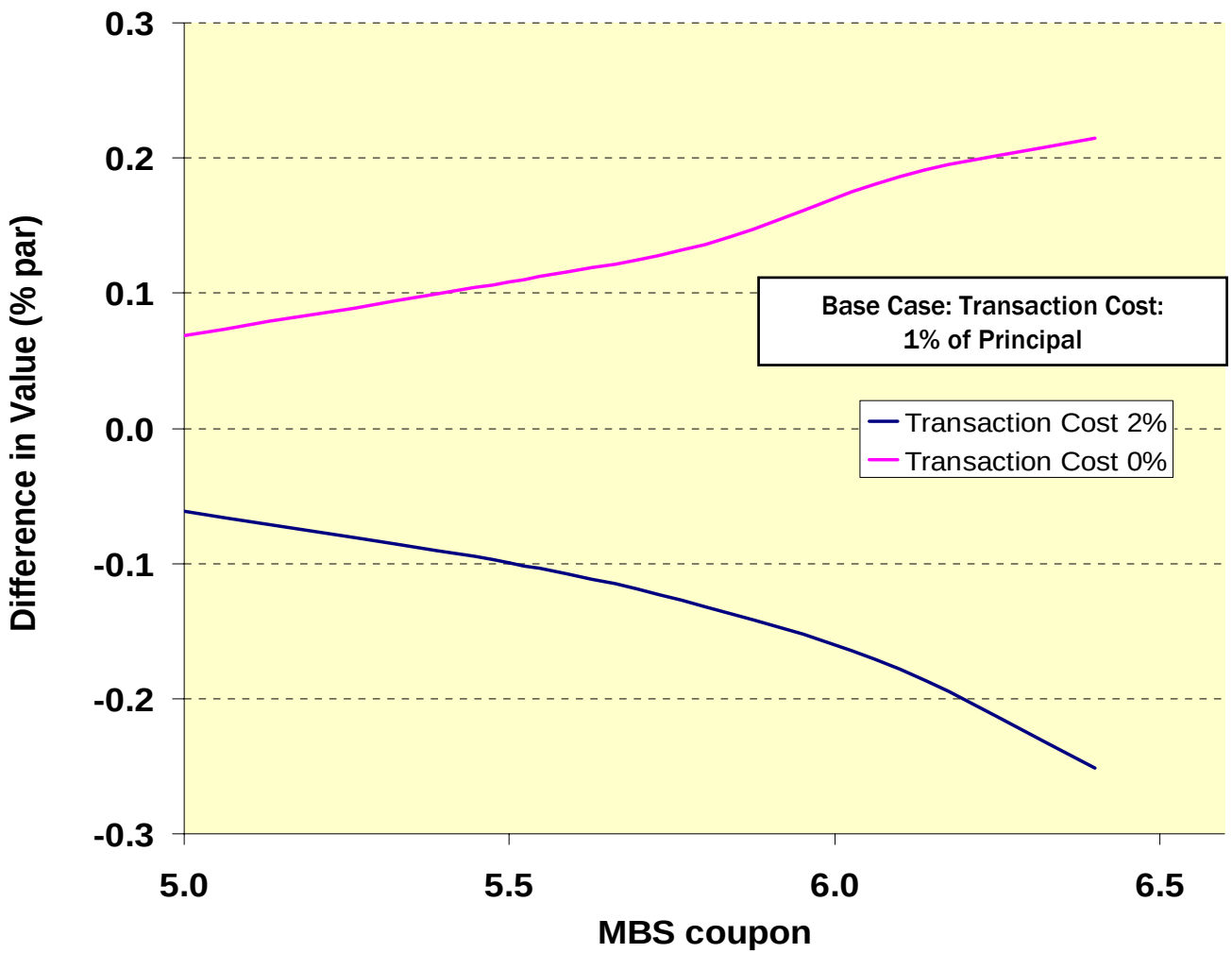
And Increase MBS Value (Explained Below)



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CLEAN™
*C*oupled *L*attice *E*fficiency *AN*alysis

- Mortgage rates and MBS rates are modeled as a coupled lattice
  - Each lattice has its own OAS spread relative to benchmark term structure
- Mortgage rates determine refis
  - Using notion of refunding efficiency
- MBS cashflows (coupon and principal) discounted on MBS lattice

See "An Option-Theoretic Prepayment Model for Mortgages and Mortgage-Backed Securities" in References

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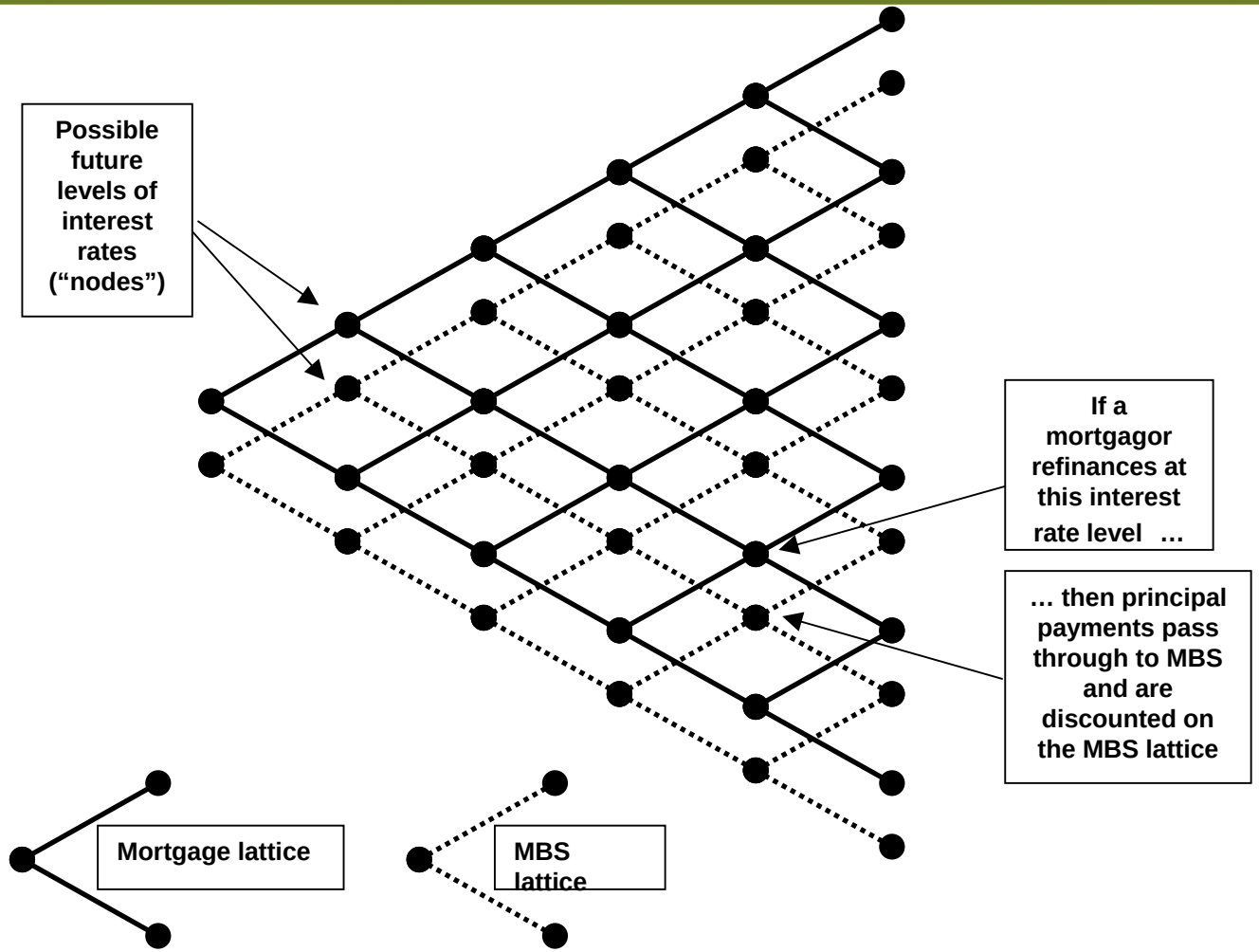
Mortgage-MBS Coupled Lattice



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CLEAN™ Framework for Prepayments

A deterministic model of turnover

- Say a specified annual rate

A simple but complete parametrization of interest rate driven refinancings

- A wide spectrum of refinancing behavior
- Pool is divided into several buckets
  - Financial engineers, leapers, and laggards
- For a given behavior, prediction is straightforward

Burnout is a natural consequence of the model

- As “leapers” refinance, pool becomes weighted towards “laggards”

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Modeling Laggards

Each mortgagor is assigned an "imputed" coupon representing refinancing behavior

- Refinancing is triggered when a Financial Engineer would refinance a mortgage with the imputed coupon
- A 7% mortgagor whose imputed coupon is 6% is a 1% Laggard

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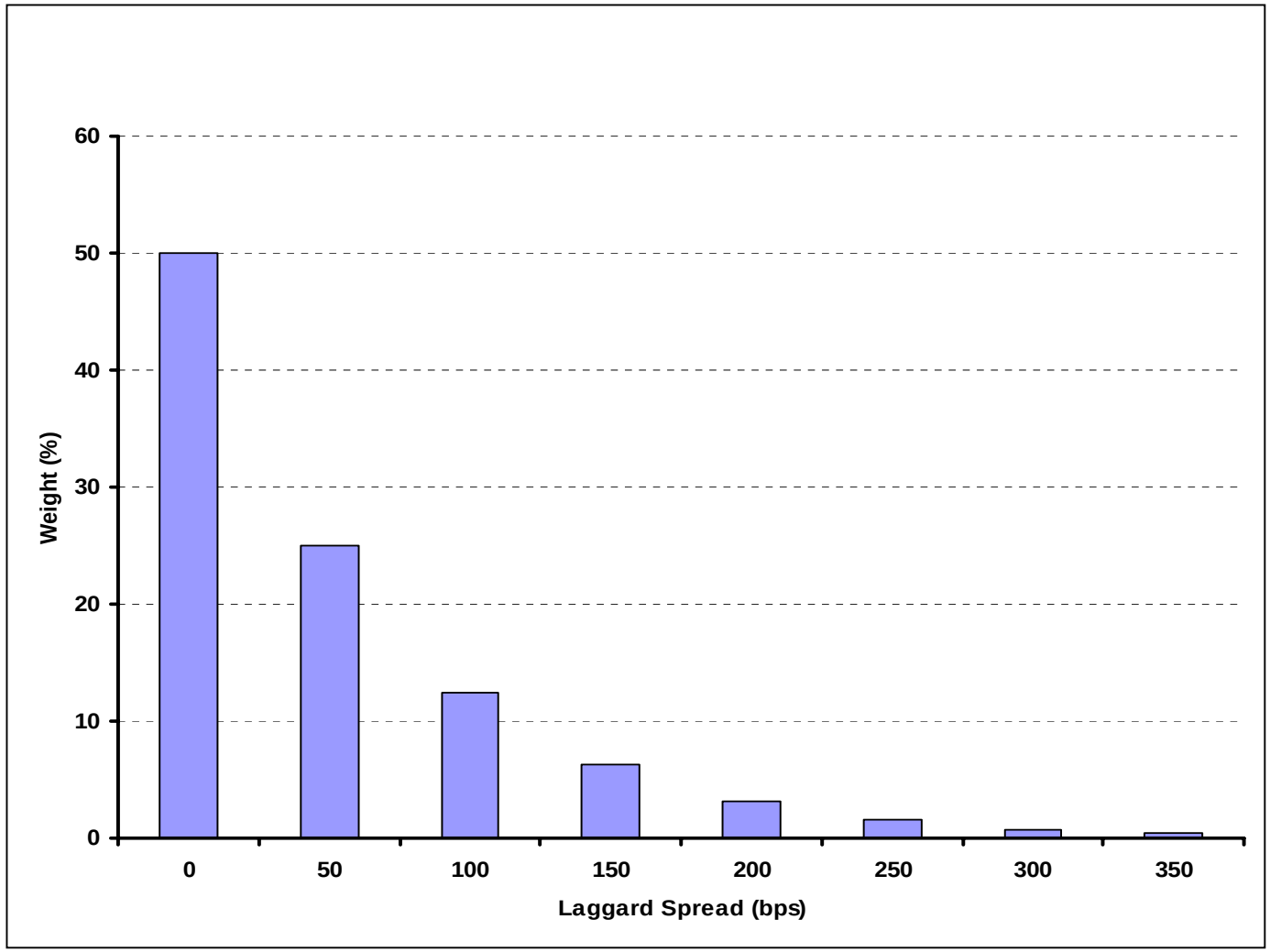
Laggard Distribution Used In Analysis Below (Same as in Paper)



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CLEAN™ Inputs

Environment:

- Reference yield curve
- Interest rate volatility

Mortgagors:

- Turnover rate
- Mortgagor OAS
- Refinancing cost (% principal)
- Laggard distribution

MBS:

- MBS OAS

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Baseline Inputs for Market Testing
September 5, 2006

Environment:		
	Reference yield curve	Swap curve
	Interest rate volatility	14%
Mortgagors:		
	Turnover rate	8%/year
	Mortgagor OAS	70 bps
	Refinancing cost (% principal)	1%
	Laggard distribution	Original*
MBS:	OAS	5 bps

**As in paper*

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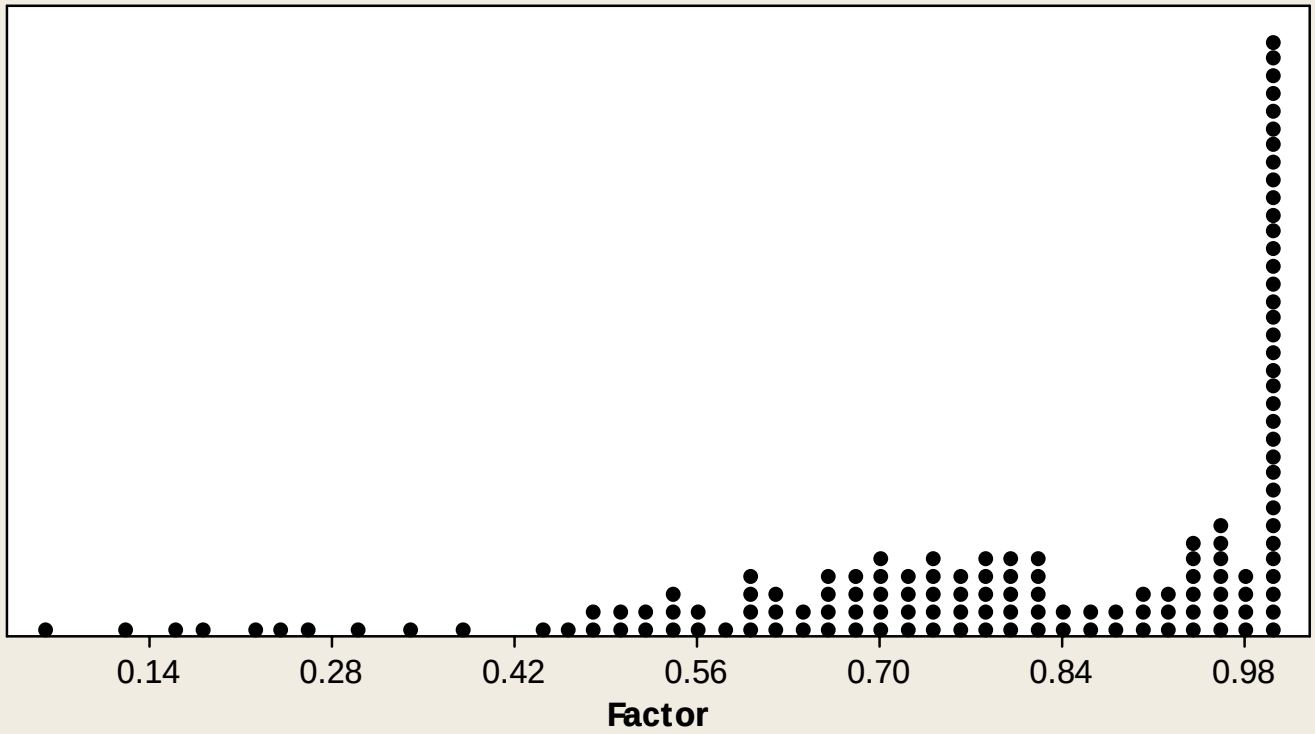
Distribution of Factors in Sample (363 Fannie and Freddie MBS)



Each symbol represents up to 3 observations.

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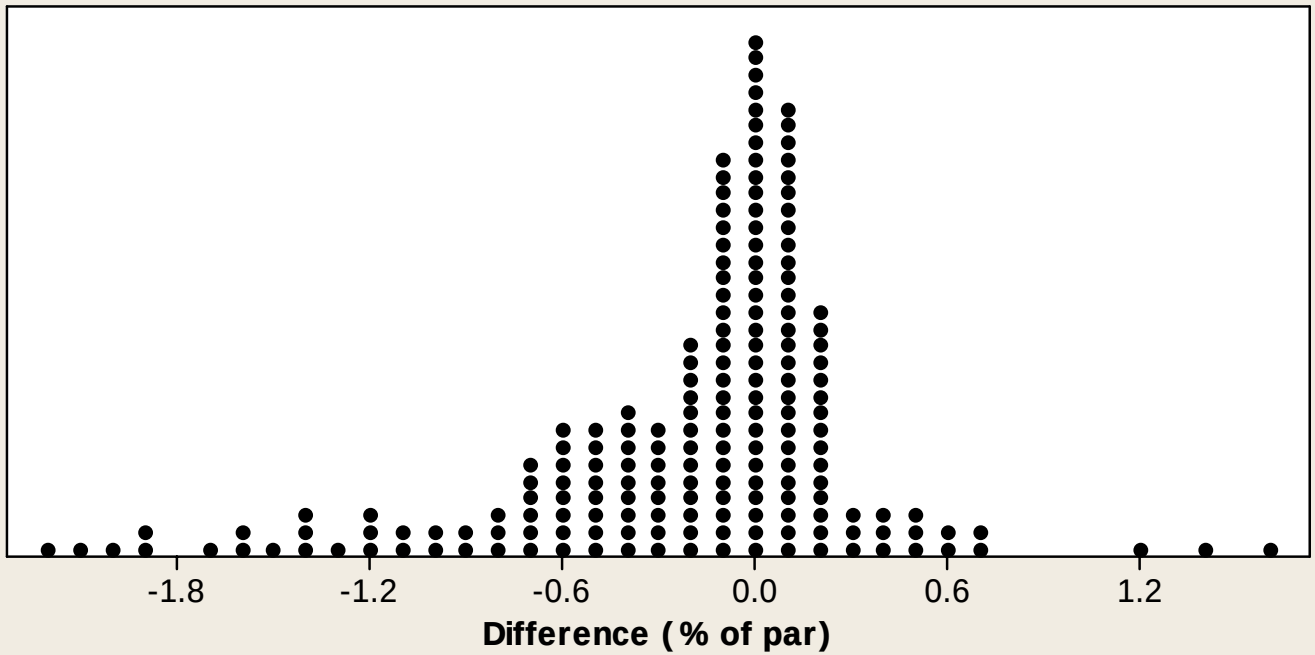
Distribution of "Model – Quote"



Each symbol represents up to 2 observations.

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Where Baseline Inputs Fall Short

New high-coupon MBS undervalued

- *Above-market* WAC reflects weaker credit, which impedes refis
- Flat 70 bps OAS overestimates mortgagor's ability to refi and thus undervalues MBS

Low-factor MBS mispriced

- Pool down to last holdouts
- Prepayment behavior unpredictable

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The Cause Suggests a Cure

New MBS with above market coupons undervalued

- Increase mortgagor OAS to reflect weaker credit
- Slows down refis and increases MBS value

Low-factor MBS mispriced

- Loan-level data could provide insight
- Requires further research

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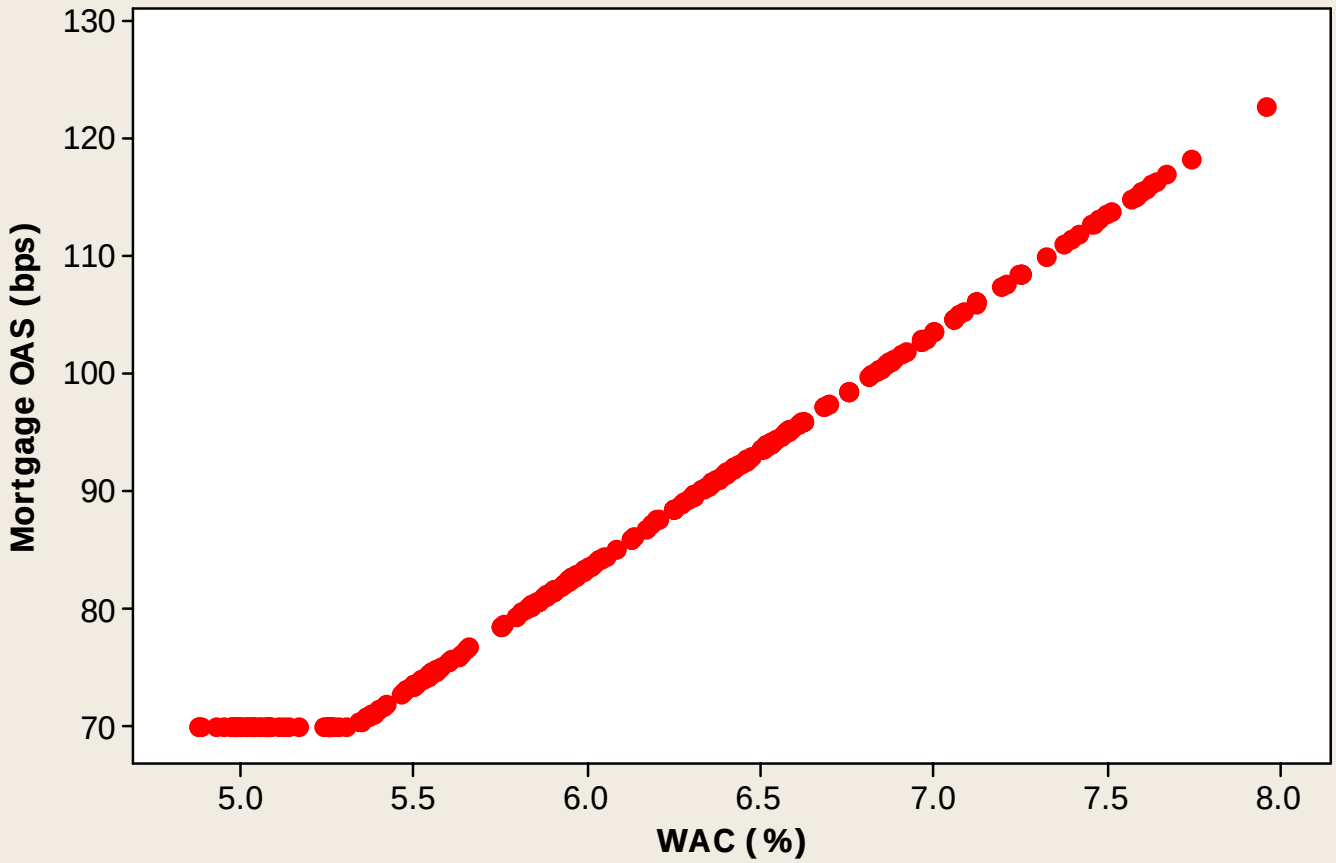
"Hockey-stick" Adjustment to Mortgagor OAS



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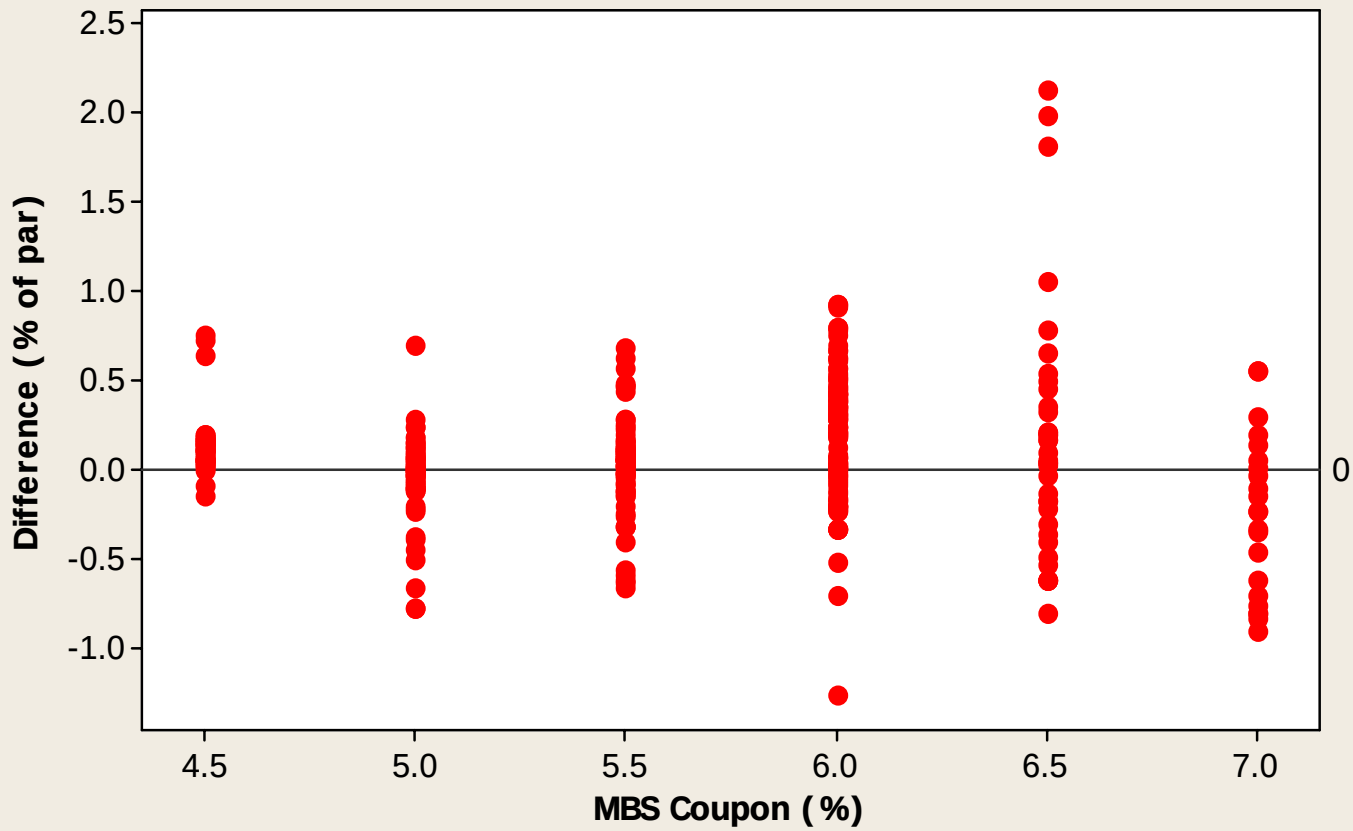
Model Values of High-Coupon MBS Improve



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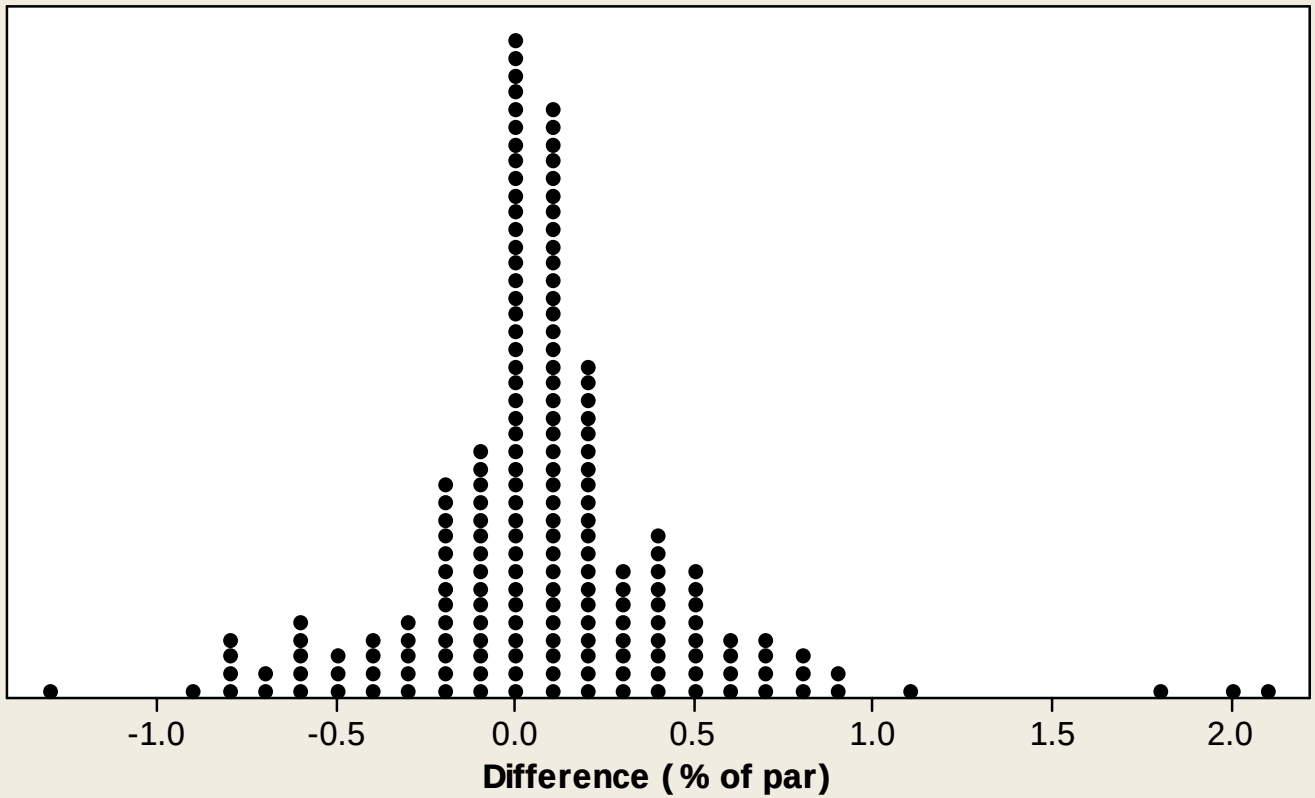
Resulting in a Much Better Fit



Each symbol represents up to 2 observations.

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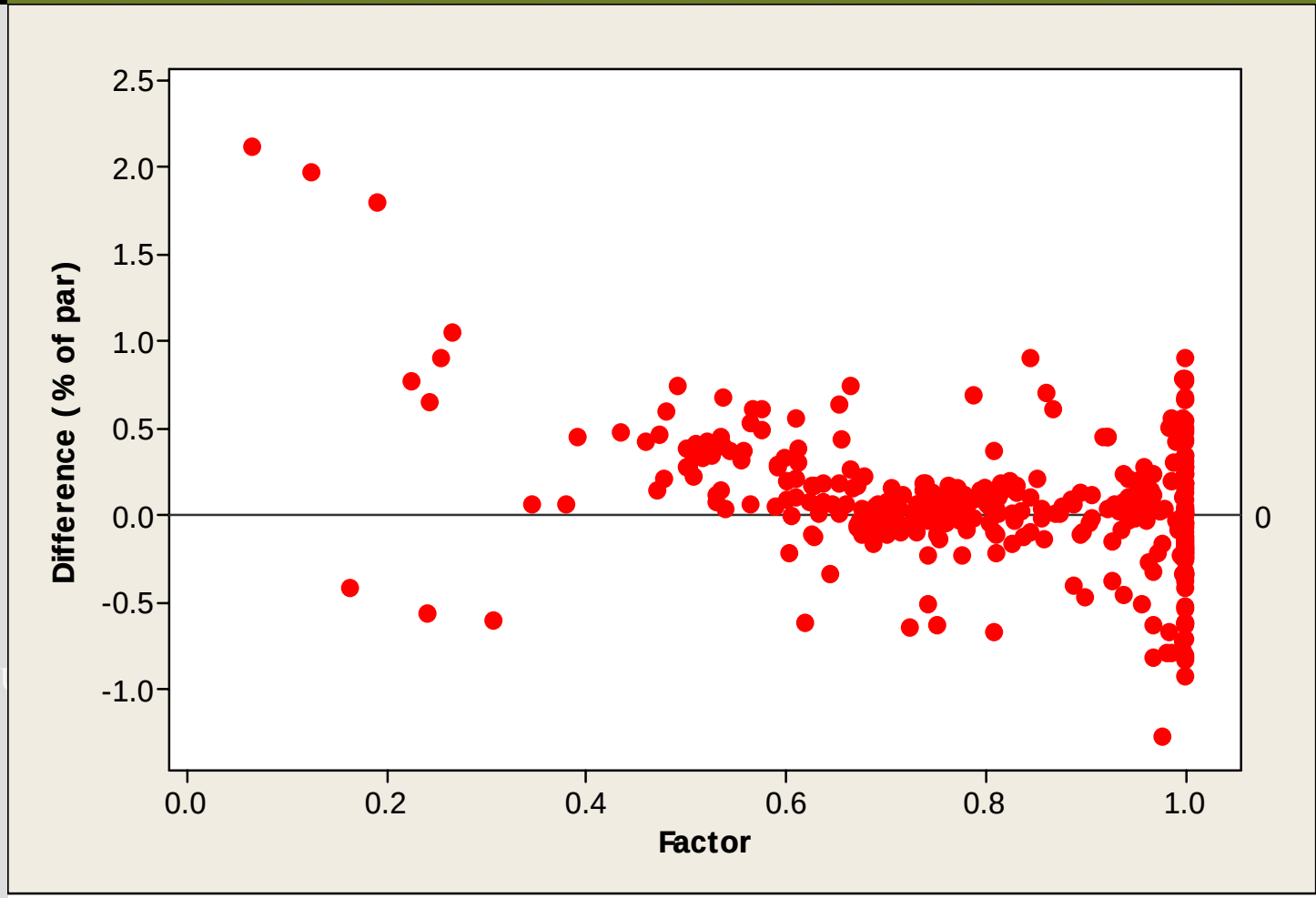
But Low-Factor Pools Remain Problematic



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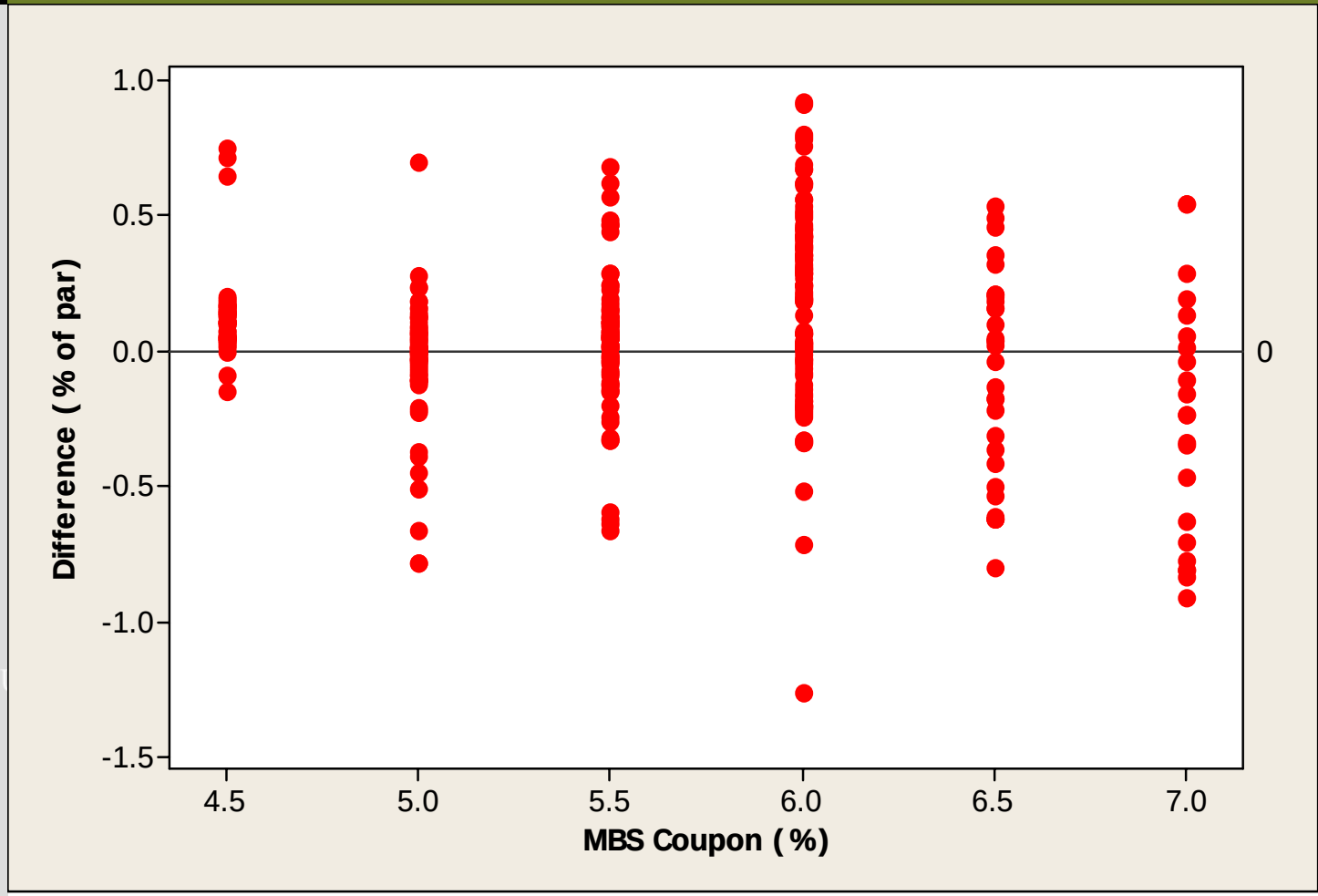
After Removing 9 Low-Factor 6.5% MBS



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Summary Statistics of "Model-Quote" (363 MBS)

Model Inputs	Mean	Median	Std Dev	1st Quartile	3rd Quartile
Baseline	0.21	-0.07	0.53	-0.40	0.10
Hockey-stick adjustment	0.07	0.06	0.37	-0.09	0.21
Hockey-stick, without 9 low-factor MBS	0.05	0.05	0.32	-0.09	0.19

All units % par

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Calibration of CLEAN™

Mortgagor OAS should reflect borrower's credit

- For Fannie and Freddie pools, 70 bps over swap curve (strong BBB credit)
- For Ginnie pools, 100bps (weak BBB credit)

Keep other inputs as in example above

- Including laggard distribution and hockey stick adjustment

Estimate MBS OAS from TBA prices

- OAS of whole loans should be roughly 30 bps higher

Refine inputs, depending on precision required

- Low factor pools require special handling
- Turnover can be customized

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Why is CLEAN™ a Good Model?

Fully consistent with analysis of swaps and bonds

- Including volatility-dependent option exercise and interpretation of OAS

Expected prepayment behavior is inferred from the market, rather than history

- Just as options trade on implied volatility

User has full control of model

- Including parameterization of refinancing behavior

Recursive valuation allows quick and accurate calculation of prices and sensitivities

- 10,000 valuations per minute

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Applications of CLEAN™

End-of-day pricing

- 850,000 fixed-rate Agency MBS
- Joint venture of Sector/NYSE, Gmarkets and AKA

Electronic trading

- Beacon Capital, buy-side platform

Risk management

- IFS

Real-time portfolio analysis

- MuniWorks

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For Calculators, see www.kalotay.com/calculators

CLEAN™ available at www.kalotay.com/downloads/clean