Mortgage Prepayment Models and Risk Perception

September 15, 2009

PACE UNIVERSITY
Applications of Fixed Income Analytics

Pricing: determine fair value
Given prevailing environment
Yield curve, interest rate volatility, etc.

Repricing: determine change in value
Given price and change in environment

Need to ensure that models are consistent across asset classes
1. Create a lattice based on specified interest rate process
   Black-Karasinski, BDT, HJM, etc.

2. Apply rules to determine cashflows on lattice and discount appropriately
   Rules may be standard or arbitrary

When there is a standard option exercise rule, results from different systems will agree
   E.g. call bond when exercise price is less than cost of leaving the bond outstanding (100% efficiency)

But this is not the case for MBS!
   Cashflow (and therefore value) depend on prepayment model
Prepayment Models Are Only a Means to An End

MBS analytics got off on the wrong track in 1979
  Statistical approach to identify trends and seasonal patterns of prepayments
  Effect of interest rates on refis an afterthought

Focus on cashflows, rather than on value
  Similar in spirit to today’s “econometric” models

Remember that the ultimate goal is to quantify risk
  Rather than to explain history

...prepayment models have strayed away from economics and have increasingly relied on the fitting of data with complicated *ad hoc* parameterizations...

...prepayment behavior of large pools can be explained ... through economic incentive ...
Where Conventional Approach Falls Short

Fitting to history is high maintenance
  Require frequent revisions by quants
  Complexity leads to lack of transparency and unexpected behavior

MBS valuation is painfully slow
  Uses Monte Carlo simulation

Absence of option-based refinancing results in a disconnect from the rest of fixed income
  Callable bonds and interest rate derivatives
Prepayment Models in a Perfect World

Founded on accepted theory
Consistent with valuation of bonds and IR derivatives
Including option-exercise and the meaning of OAS

Transparent and intuitive
Parameters based on economic incentives
User has control

Fast execution
Comparable to bond and derivative valuation
Real time portfolio management
Understand Mortgages; MBS Valuation Will Follow Naturally
Outline

Option exercise – for modeling refis
  Call efficiency

Agency bonds – analytics are standard
  Sensitivity to interest rates and volatility

Mortgages – can be managed like callable bonds
  But not everybody is a “financial engineer”

Agency MBS
  How risk sensitivity depends on the prepayment model
Bond Professionals Use Call Efficiency to Make Refunding Decisions

Compare savings to loss of option value

Applicable to mortgages

Exercise is optimal when efficiency reaches 100%

95% may be justifiable

Not exercising at 100% is wasteful and speculative

\[ Efficiency = \frac{PV \ Savings}{\Delta Option Value} \]
1. Calculate OAS (option-adjusted spread) under current environment
2. Freeze OAS
3. Determine $\Delta P$ for specified change of the environment

Note to Risk Managers: Be aware of $\Delta P$’s sensitivity to choice of model
How Does the Expected Life of a Callable Bond Change When Rates Rise?

Lengthens

Because bond is less likely to be called
How Does the Expected Life of a Callable Bond Change When Volatility Increases?

Depends on the coupon

- Low coupon: more opportunities to refund economically shortens life
- High coupon: greater time value of option reduces refunding efficiency and therefore lengthens life!
Volatility Extends Expected Life of High Coupon 30-Year Callable Bonds
Even Bond Experts Are Confused

Survey Results

“How does increasing volatility affect the expected life of high-coupon callable bonds?”

- Shortens 40%
- Lengthens 40%
- Need more info 20%
Fortunately $\Delta P$ for Callable Bonds is Not Model-Dependent

*All using lognormal interest rate process; zero mean reversion

5.7% 20 NC-1 FHLMC Debenture
Price at 30% Volatility: 99 3/8

- Kalotay’s BondOAS
- Bloomberg
- Third Party

Change in Price (% of par)

Volatility (%)
Call Efficiency Is Applicable to Mortgages: Refi When Rates Decline by 40 to 70 bps

Refinancing Efficiency (%)

Old Rate - Refi Rate (bps)

- 1% Cost
- 2% Cost
- 95% Efficiency
Understanding Mortgages: What Determines the Market Rate?

**Interest rate environment:**
Mortgagors’ *optionless* yield curve (unobservable)
Represented as an OAS to LIBOR swap curve
- Strong credit: single-A 10-year spread, say 150 bps
- Weaker credit: wider spread

**Volatility:** consistent with callable agencies

**Prepayments:**
- Expected turnover rate
  - Say 8% per year
- Refinancing risk
  - Expected call efficiency (discussed below)
  - Transaction cost, say 1% of principal
Fixed Coupon Agency MBS

Issued by Fannie Mae or Freddie Mac

The vast majority

Collateral consists of conforming prime fixed coupon mortgages

30-year and 15-year maturities

Excludes jumbos

Default risk, even now, is small

Dominant risk is refinancing
Use a deterministic assumption on turnover rate

As in other models

Recognize that many mortgagors are not ‘financial engineers’

‘Laggard’ factor assigned to mortgagors who wait too long (roughly 10 ‘buckets’)

Mortgagors refinance in inverse order of laggardness, automatically accounting for ‘burnout’

Assign weights to the buckets

Calibrate weights to market prices

Check sensitivity of results to weight distribution
A 100 bps laggard refis when a “financial engineer” refis a mortgage with a 100 bps lower coupon.

**Generic Laggard Distribution**
MBS Valuation Using an Option-based Prepayment Model

Mortgage and MBS rates are modeled as a coupled lattice

- Each lattice has its own option-adjusted spread relative to LIBOR swap curve

Mortgage rates determine refis

- Using notion of refunding efficiency

MBS cashflows (coupon and principal) discounted on MBS lattice
Mortgage-MBS Coupled Lattice

Possible future levels of interest rates ("nodes")

If a mortgagor refines at this interest rate level …

… then principal payments pass through to MBS and are discounted on the MBS lattice.
Calibration of Option-based MBS Model

Live market data available via prices of newly created pools (TBA’s)

- OAS of TBA to benchmark curve should be comparable to that of like Agency bond
- Currently about 20 to 40 bps

All other inputs covered in slide18 “Understanding Mortgages: What Determines the Market Rate?”

Reminder: Understand sensitivity to model parameters
Sensitivity of $\Delta P$ to Laggard Spacing

Yield Curve Increases 100 bps

![Graph showing the sensitivity of ∆P to Laggard Spacing for a 30-yr 5% MBS. The current price is 101.8. The graph depicts the decrease in price as a percentage of par with respect to different laggard spacings.]
Sensitivity of $\Delta P$ to Mortgagor OAS Yield Curve Increases 100 bps

![Graph showing the sensitivity of 30-yr 5% MBS to Mortgagor OAS Yield Curve Increases 100 bps]
Sensitivity of $\Delta P$ to Turnover Speed
Yield Curve Increases 100 bps

30-yr 5% MBS
Current Price: 101.8

Decrease in price (% of par) vs. Turnover speed (%)
Volatility Dependent Prepayment Model Reduces Sensitivity of $\Delta P$

30-yr 5% MBS
Price at 30% Volatility: 101.8

Change in Price (% of par) vs Volatility (%)

- Option-based model
- Bloomberg
How to Increase Refinancing Speed Via Economic Incentives

Reduce mortgagor’s OAS
   Lowers current borrowing rate
   Say from 200 bps to 150 bps

Reduce transaction cost
   Lowers all-in borrowing cost

Reduce laggard spacing
   Increases refinancing efficiency
Advantages of Using a True Option-Based Prepayment Model

Sensible results with fewer knobs to turn
  Reasonable prices under different market conditions
  Realistic response to “risk-management” scenarios

Calibration is straightforward and intuitive
  Parameters correspond to economic incentives

Recursive valuation enables unprecedented speed: 14,000 securities per min. on low-end PC
  Orders of magnitude faster than Monte Carlo
Private Label MBS and Whole Loans

Need to specify default rates and recovery value

Analytically straightforward

Effect of potential defaults becomes the dominant consideration in valuation and risk analysis
Applications

Enterprise and desk-level risk management
Say goodbye to overnight runs

Hedging of mortgage products, including mortgage servicing rights
Duration of current-coupon products increases with interest rate volatility
Consistent with behavior of callable bonds (conventional models get the sign wrong)

End-of-day pricing
900,000 agency MBS priced in minutes, without taking shortcuts
Option-based Refinancing Technology
Is Available to All Mortgage Participants

“A Financial Analysis of Consumer Mortgage
Decisions”

*Mortgage Bankers Association* (June 2009)


Mortgage refinancing calculator available at
[www.kalotay.com/calculators](http://www.kalotay.com/calculators)
Recommendations for Risk Managers Regarding Model Selection

Understand theoretical underpinnings and limitations of models

Strive for consistency across asset classes

Demand transparency and hands-on control

Make an informed choice!
“Mortgage servicing rights and interest rate volatility,” Andrew Kalotay & Qi Fu, *Mortgage Risk* (May 2008)


Questions re: CLEAN™ implementation of option-based refi model?
Contact Deane Yang (212 482 0900 ext. 4, deane@kalotay.com)