Module 5:
Mortgage-Backed Securities

Roadmap…

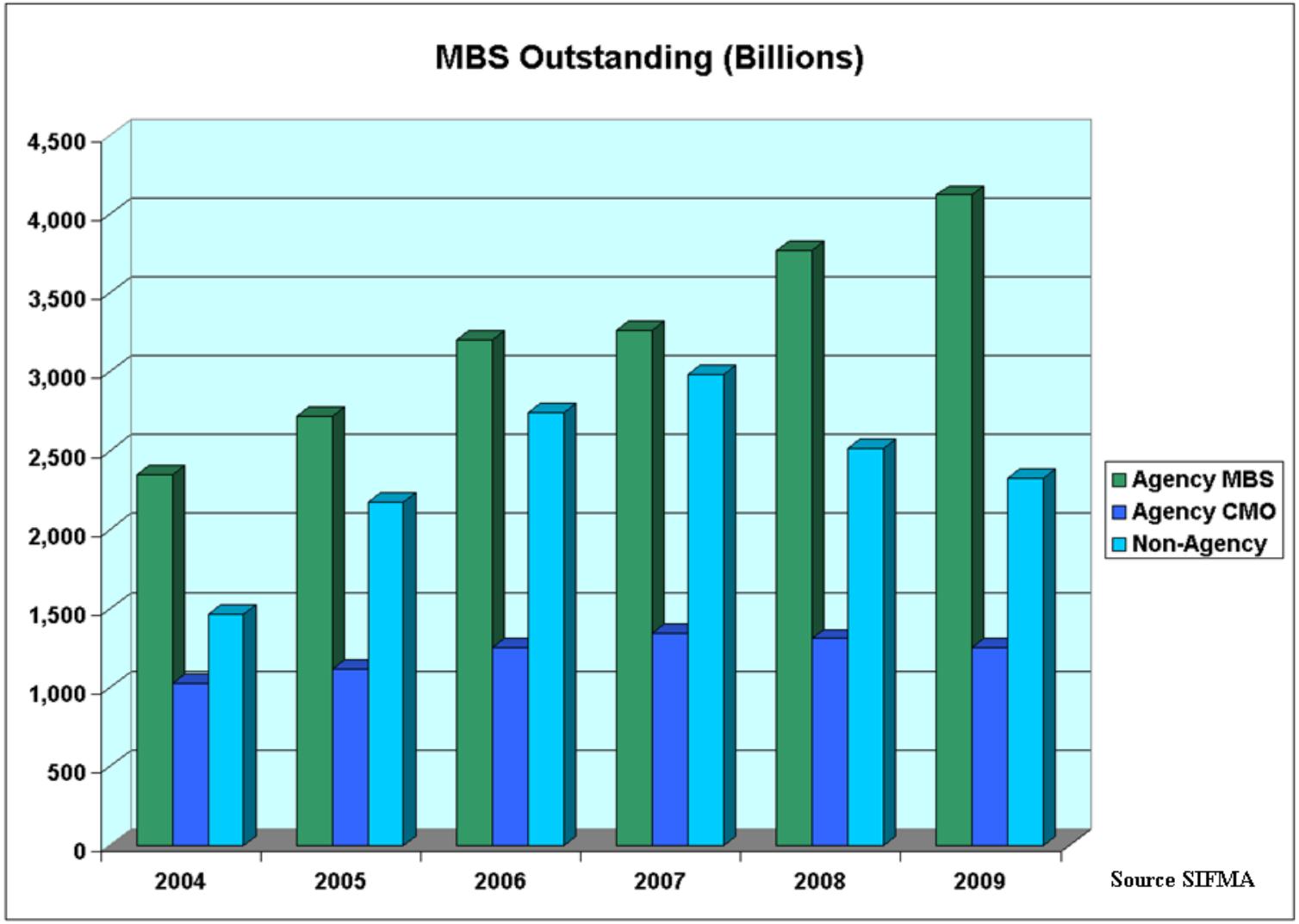
- Introduction to Mortgage and Mortgage Backed Security
- Pass-Throughs
- Collateralized Mortgage Obligations (CMOs)

Introduction to Mortgage and MBS

Definitions

- Mortgage = loan secured by a property.
- Mortgage-backed securities:
  - Example of *securitization* (innovation of the 1970's)
  - *Pass-throughs*: payments from pools of mortgages are "passed through" to investors and *mortgage derivatives*
  - About ½ of mortgages securitized.
  - Largest type of bond: about 6 trillion dollars (more than US Treasury bonds and notes).

Size of Mortgage Market



Mortgage Mathematics

Most typical mortgage type:

- monthly *level* (= constant) payment X
- Constant rate (compounded monthly) y
- X and y related by present value formula, where L is the loan amount, and T is the number of payments (e.g. 360 for a 30 year mortgage with monthly payments):

$$\sum_{t=1}^{T} \frac{X}{\left(1+\frac{y}{12}\right)^{t}} = L \Rightarrow X = \frac{L\left(y/12\right)}{1-\frac{1}{\left(1+y/12\right)^{T}}}$$

Mortgage Mathematics

- Payment = interest + principal.
- If B(t-1) is the outstanding principal after the time (t-1) payment, then the interest component of the time t payment is B(t-1)*(y/12).
- The principal component of the time t payment is X – B(t-1) * (y/12).

Mortgage Example

- Let’s look at an example with fixed rate, level-payment, and full amortization.
  - The mortgage rate is fixed during mortgage period.
  - Monthly payment of mortgage is identical.
  - The remaining amount of mortgage is zero after the last payment.

Mortgage Example

- A mortgage (loan) with 30-year (360 months), principal of $100,000, and mortgage rate of 8.125%.
  - What is the (fixed) monthly payment?

    SUM(PV(C, 360, 8.125%) = $100,000 → C = $742.5
  - What is the interest payment for each period?
  - What is the principal payment for each period?

We can calculate them using Excel (e.g., Module_5_MBS.xls).

Mortgage Prepayments

- Borrower has the option to repay the outstanding balance and end the loan.
- Problem similar to callable bond, with call price = outstanding balance (B(t)) (“call price” changes over time).
- Difference: borrowers often fail to prepay when it is optimal, or prepay for reasons unrelated to level of interest rates (e.g. when moving).

Mortgage Prepayments

- There are three common ways to state prepayment rates:
  - SMM (Single Monthly Mortality)
  - CPR (Conditional Prepayment Rate)
  - PSA (Public Securities Association Model)
- SMM is a monthly value, the other two are stated in annual terms.
- We usually refer to the rate at which a MBS pays as the *prepayment speed* (or *prepayment rate*).

SMM

- The SMM is the ratio of mortgage prepayment to unpaid mortgage payment (excluding planned monthly payment). Following the above example,
  - The unpaid mortgage payment at the beginning of 11^{th} month is $99,325.57.
  - The planned mortgage payment of 11^{th} month is $742.5.
  - The prepayment of 11^{th} month is $500.

The SMM of 11^{th} month is

$$SMM = 500/(99,325.57- 742.5) = 0.5072\%$$

CPR

- The CPR is an annualized rate.
- It can be determined from the SMM as:

$$CPR = 1 - (1 - SMM)^{12}$$
$$= 1 - (1 - 0.5072\%)^{12}$$
$$= 0.59195\%$$

so

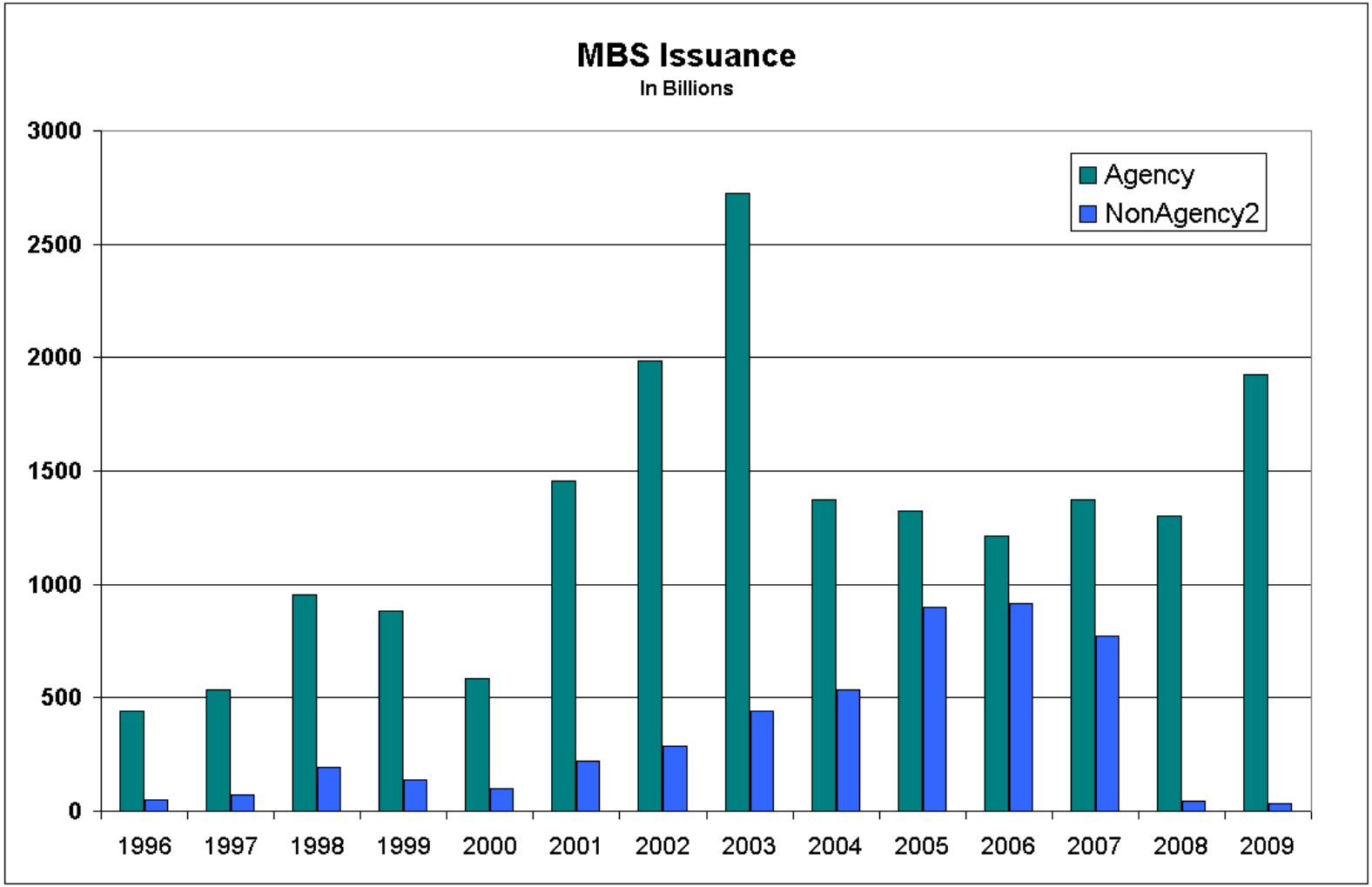
$$SMM = 1 - (1 - \text{CPR})^{\frac{1}{12}}$$

CPR

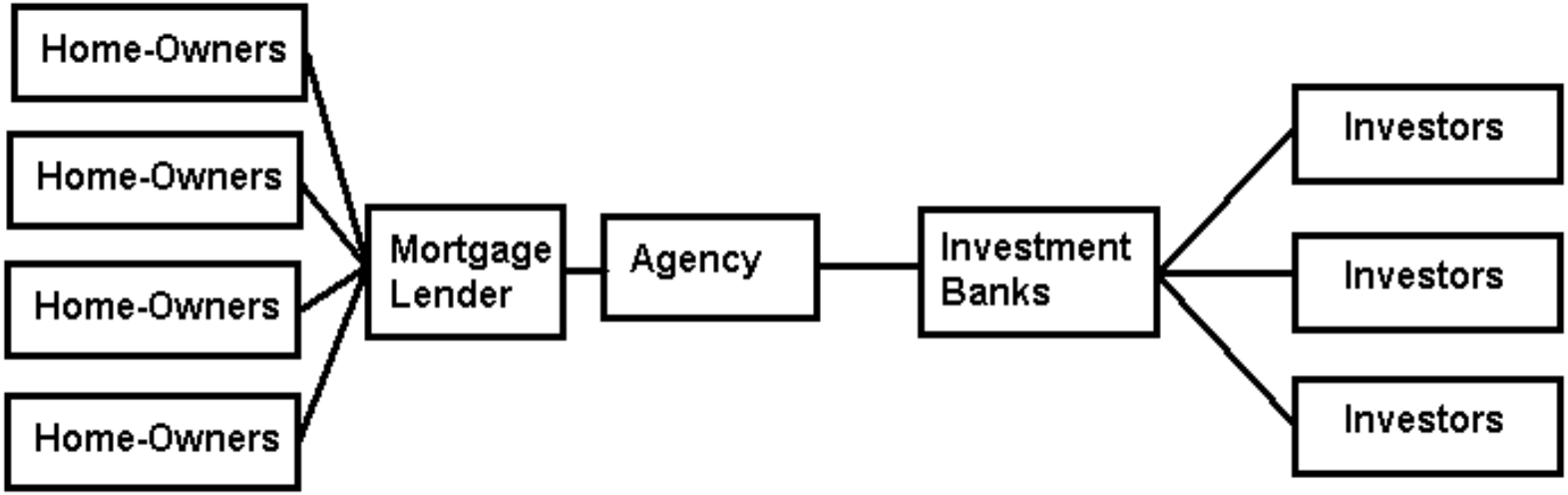
- The CPR gives rise to a single SMM that is used every month.
- CPR was the most common model used in the early days of MBS, but had problems, since MBS do not prepay at a steady rate.

PSA

- The PSA model modifies the CPR model by recognizing that new mortgages prepay at a slower pace.
- 100PSA is denoted by
  - CPR = 6% * (t/30) if t<30 (months);
  - CPR = 6% if t>=30 (months).


MBS Issuance
In Billions
3000
2500
2000
1500
1000
500
0
Agency
NonAgency2
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009

Economics of MBS Market



Agencies

- GNMA
  - Government agency
  - Uniform pools
  - Explicit US guarantee
- FNMA/FHLMC
  - Regulated corporations
  - Less uniform pools
  - Implicit US guarantee
- Buy mortgages, sell as pools

Risks for Investors

- Interest Rate Risk
  - Fixed: the “usual” Risk
  - Floating: reinvestment risk
  - Floating: caps and floors
- Prepayment Risk
  - Homeowners can refinance, so the timing of flows is uncertain.
- Default Risk
  - Agency MBS are guaranteed, so default shows up as prepayment. Non-agency MBS can default.

Pass-Through MBS

Pass-Through MBS

- The Mortgage Pass-Through Security is formed when the lender of one or more mortgage loans forms a mortgage portfolio and sells the whole or part of the portfolio.
- Typically, the pass-through rate is less than the mortgage rate.

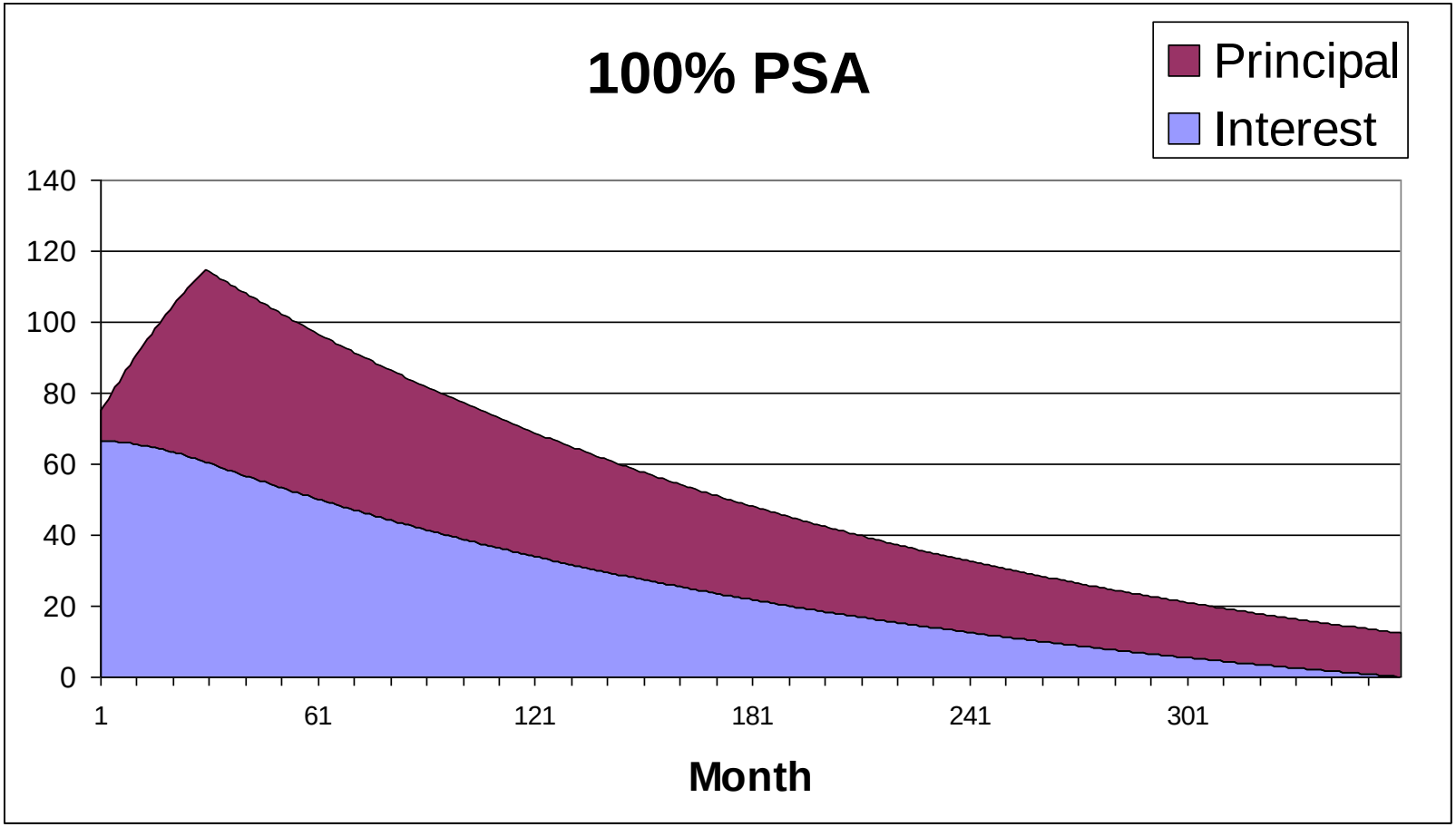
Components of Prepayment Risk

- Coupon rate
- Mortgage rates
- Short term interest rates
- Age
- Seasonality
- Burnout
- Ability to refinance
- Fees
- Relocations
- Home prices
- State of economy

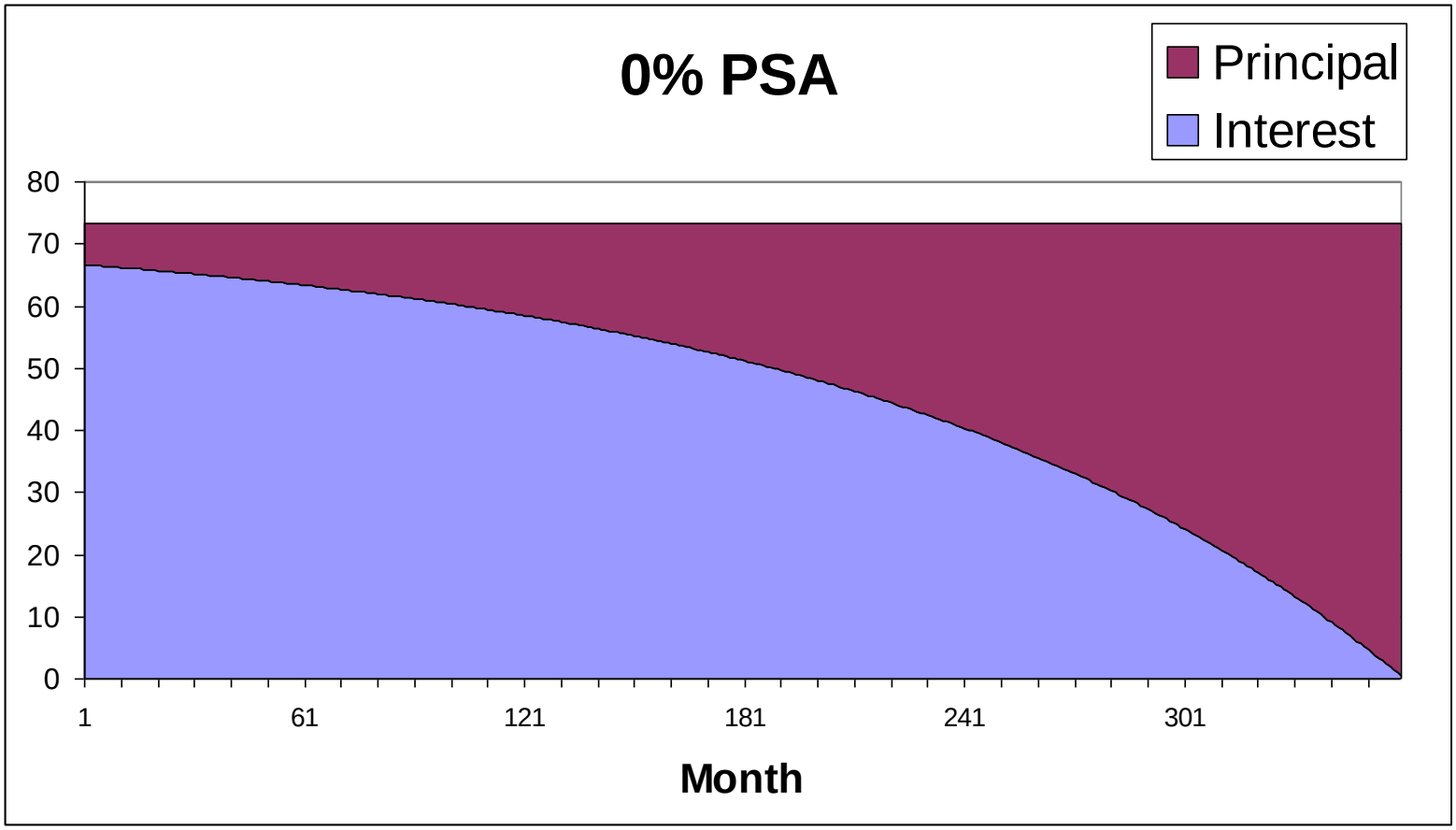
Cash Flows

- The next three graphs show the principal and interest payments assuming various PSA prepayment speeds.
- The CPR of 200PSA is twice of the CPR of 100PSA, where the CPR of 40PSA is 40% of the CPR of 100 PSA.

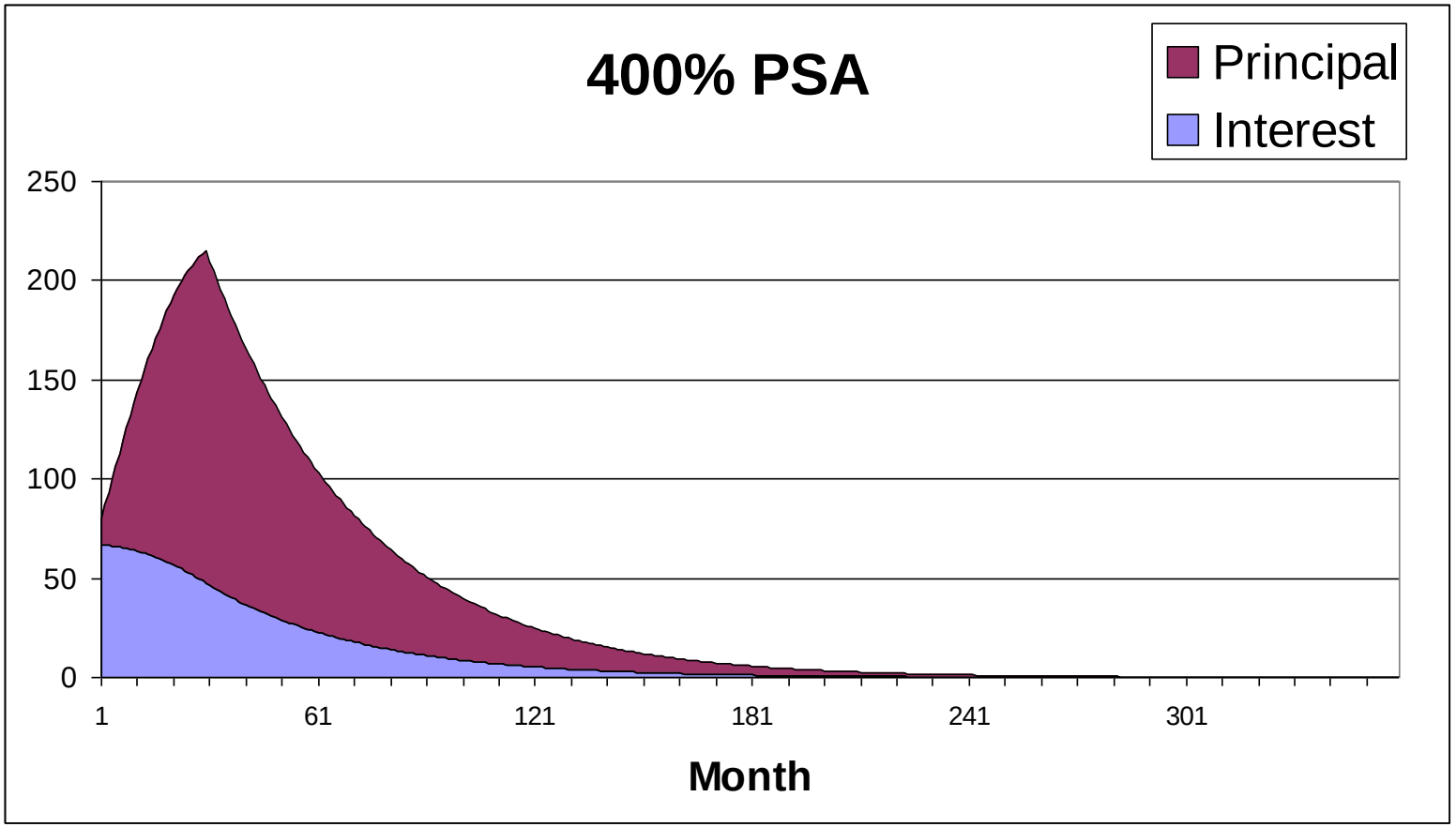
Cash Flows


100% PSA
Principal
Interest
140
120
100
80
60
40
20
0
1
61
121
181
241
301
Month

Cash Flows


0% PSA
Principal
Interest
80
70
60
50
40
30
20
10
0
1
61
121
181
241
301
Month

Cash Flows


400% PSA
Principal
Interest
250
200
150
100
50
0
1
61
121
181
241
301
Month

Goldman's Prepayment Model

- Richard & Roll discuss the *Goldman Sachs* Model in a paper where he makes several points.
- GS model tries to capture four primary effects:
  - Incentive to refinance.
  - Seasoning (age) of a mortgage.
  - Month of year (seasonality).
  - Premium burnout (path of previous prepayments).

Incentive to Refinance

- Early models measured the incentive by (*C*-*R*) – the spread between coupon rate and current mortgage rates.
- Richard & Roll suggest using the ratio (*C*/*R*)
  - They actually look at

$$\frac{A}{P} = \frac{C}{R}\frac{\left(1-(1+R)^{-360+t}\right)}{\left(1-(1+C)^{-360+t}\right)}$$

  - But find that is approximately equal to (*C*/*R*).
- Theory suggests that if A/P exceeds some critical value, it makes sense to refinance, but the value is not the same for everyone in mortgage pool.

Seasoning

- Seasoning looks like a factor that is multiplied by other factors, and increases with age.
  - This reflects the fact that someone who just took out a new mortgage is unlikely to refinance under most conditions, but is more likely if the mortgage is older.
  - A fully seasoned mortgage would have a factor of one.
- The PSA model attempts to incorporate seasoning, by having prepayments ramp up during the first 30 months.

Seasoning

- Richard & Roll find that slight premium bonds are fully seasoned at 30 months, but discount mortgages may take up to nine years, indicating that seasoning is affected by path of interest rates.
- Prepayments are affected by the month of year.
  - Most people move in the summer
    - This is true even in warm climates, because of schools
  - Richard & Roll find that the period after summer has highest seasonal adjustment, since prepayments are delayed (45 days for GNMA, 75 day for FHLMC & FNMA).

Premium Burnout

- Burnout is meant to capture the fact that prepayment history must be taken into account.
- MBS that have had heavy prepayments in the past will have lower expected prepayments than pools that have not experienced high levels of prepayments.

Fitting the Model

- Goldman uses a multiplicative model:

$$CPR = REFI \cdot SEASON \cdot MONTH \cdot BURN$$

Linear regression can be used if we take logs :

$$\ln(CPR) = \beta_0 + \beta_1 \ln(REFI) + \beta_2 \ln(SEASON) + \beta_3 \ln(MONTH) + \beta_4 \ln(BURN) + \varepsilon$$

  - Note that the result is an array of CPRs through time.

Using the Model

- Recall

$$SMM = 1 - \left(1 - \text{CPR}\right)^{\frac{1}{12}}$$

- Consider the effect of the error term on SMM.
  - It is slightly concave.
  - But the error effect is not symmetric because of the log.
  - The overall effect is that ignoring the error term can lead to a slight bias.

Other Considerations

- Other values may have an impact
  - Volatility enters implicitly through the choice of mortgage rates.
  - Macroeconomic Variables
    - These may matter but
    - Including them doesn't help short-term projections since these variables change slowly.
    - Including them doesn't help long-term projections since they are harder to project than prepayment rates.
  - Short-term Rates
    - Newer models include short-term rates, because there is an incentive to refinance into floating rate MBS when rates are high and yield curve is steep.

Prepayment Facts

Morgan Stanley (1997)

- Prepayments went from extreme highs to extreme lows between 1993-1994
  - Why? Interest rates rose dramatically.
  - Is this happening now?
- Prepayments accelerate when coupon is above rates.
- Steeper yield curves make prepayments more sensitive to refinancing incentives.

Average Speeds

- Using a prepayment model is better than assigning a single PSA speed.
- But when asked how fast a mortgage is prepaying, a buyer doesn't want to hear an array of 360 speeds.
- Banks choose an average speed to report
  - For premiums & discounts, they choose the PSA that gives the same yield as the array of speeds.
  - For bonds near par, all speeds give the same yield, so they choose the speed that gives the same Macaulay duration or the same average life as the array of speeds.

Collateralized Mortgage Obligations (CMOs)

Introduction

- Instead of passing through cash-flows from pool of mortgages, create different categories (tranches) of securities: some receive principal right away, some later.
- Question? How can prepayment risk (associated with Pass-Through securities) be lessened?

CMOs An Historical Approach

- Attempt 1: Sequential-Pay CMOs
  - All Tranches get interest (proportional to principal).
  - Second tranche gets principal when (the principal of) first is paid off.
  - Later tranches look like callable bonds.
  - Early tranches had too much prepayment risk.

CMOs

- Attempt 2: Z-Tranches
  - To “stabilize” early tranches, “borrow” interest from last tranche. Z-tranche looks like an option on prepayments.
  - While early tranches were more stable, some investors wanted more protection.
  - The duration (of receiving the payments) will be reduced for early tranches.

CMOs

- Attempt 3: PACs
  - Split early tranches into PAC and companion.
  - PAC
    - fixed cash flows for “normal” prepayments.
    - Two-sided prepayment protection (e.g., contraction and extension risk).
  - Companion
    - Absorbs most prepayment risk.
    - Option-like payoff.
    - Hard to sell.

CMOs

- Attempt 4: Floaters & Inverse Floaters
  - Split companion into floating rate and inverse floating rate tranches -- rates are capped at a preset value.
  - Floating rate
    - Prepayment risk is reduced, since interest rate floats.
    - Risk due to capped rates when interest rates rise.
    - Short duration.
    - Duration extends when rates get near the cap.

CMOs

- Inverse Floaters
  - As interest rates fall:
    - Higher present value of a flow.
    - Principal come sooner (good, since priced at discount).
    - Higher interest payments.
  - As rates increase:
    - Lower present value.
    - Principal comes later (bad).
    - Lower interest payments.
  - Long duration.

IOs and POs

- Interest only (IO) strips receive all interest payments. Unusual negative duration (since low interest rates => many prepayments => interest payments reduced) makes them useful for hedging.
- Principal only (PO) strips receive all principal payments (both scheduled ones and prepayments). Very high duration (low interest rates => prepayments => cash-flows received earlier).

POs – Principal Only CMOs

- Total payments fixed
  - Timing unknown.
- When interest rates decline:
  - Prepayments speed up (good, since money is received sooner).
  - PV of cash flow is higher (good).
- When interest rates rise
  - Prepayments slow down (bad, since money is received later)
  - PV of cash flow is lower (bad).
- Very long duration
  - This is a *very* bullish instrument.

IOs – Interest Only CMOs

- Interest payments decline as principal is paid down (here total payments are unknown).
- When interest rates decline:
  - Prepayments speed up (bad, since interest on that principal is no longer paid).
  - PV of fixed flow: higher (good).
  - Net effect is usually bad.

IOs – Interest Only CMOs

- When interest rates rise
  - Prepayments slow down (good, get interest payments for a longer period).
  - PV of fixed flow: lower (bad).
  - Net effect is usually good.
- Negative duration when Rates is near coupon rate -- bearish instrument (or useful for hedging).

Summary

- Prepayment of mortgage
- Pass-through: cash flows and prepayment models.
- CMOs: IOs and POs.