CHARTA LEARNING · LESSON NOTES

Mortgages and Mortgage-Backed Securities

FRM Part I

1 A story: a loan you can end early

- A home loan is a stream of monthly payments
- The borrower may repay early: a one-sided option
- Rates fall: money returns early, reinvested cheaply
- Rates rise: the loan stays, at a below-market rate

IN THE LESSON

- Imagine lending a friend money to buy a house.
- They promise to repay in small equal amounts every month for thirty years, with interest.
- You like the steady income.
- Then one day interest rates fall, and your friend borrows more cheaply from someone else and repays you in full.
- You get your money back early, exactly when you can only reinvest it at lower rates.
- If rates rise instead, your friend keeps the cheap loan for the full thirty years.
- Heads they win, tails you lose.
- That one-sided right to repay is the heart of this whole topic.
- Now picture an investor holding thousands of such loans bundled together.

2 Residential mortgage products

Each product has its own cash-flow risk

Product	Cash-flow risk
Fixed-rate, fully amortizing	Steady payment; prepayment
ARM and 5/1 hybrid	Index + margin, with caps
Interest-only	Payment jumps at recast
Option ARM	Negative amortization
Balloon	Large balance due at maturity

IN THE LESSON

- A residential mortgage is a loan secured by a home, and the products differ in how the rate and the balance behave over time.
- A fixed rate, fully amortizing loan has a constant payment and the balance falls to zero.
- An adjustable rate mortgage resets to an index plus a margin, limited by caps on the first reset, on later resets, and over the life of the loan.
- An interest only loan pays no principal for a period, then recasts over the remaining term, so the payment jumps.
- An option A R M lets the borrower pay less than the interest due, so the balance grows, which is negative amortization.
- A balloon loan leaves a large balance due at maturity.

3 Hybrids, credit tiers and who backs the loan

- 5/1 hybrid: fixed for 5 years, then adjusts yearly
- Credit tiers: prime, Alt-A (limited docs), subprime
- FHA and VA loans back Ginnie Mae pools
- Conforming loans back Fannie Mae and Freddie Mac pools
- Jumbo loans go to the non-agency market

IN THE LESSON

- Two more distinctions.
- A five one hybrid is fixed for five years and then adjusts every year.
- Next, loans are sorted by borrower quality.
- Prime borrowers have strong credit.
- Alt A loans rely on limited documentation.
- Subprime loans go to weaker borrowers.
- Finally, the loan type decides who stands behind the securities.
- Loans insured by the Federal Housing Administration, or guaranteed by the Department of Veterans Affairs, back Ginnie Mae pools.
- Conforming loans, those within the agency size and quality rules, back Fannie Mae and Freddie Mac pools.
- Jumbo loans, which are too large, go to the non agency market.
- The key habit is to link each product to its cash flow risk.

4 The level payment on a fixed-rate loan

Payment = L × r ÷ (1 − (1 + r)^{−n})
r = annual rate ÷ 12, n = years × 12

Loan, L	Amount borrowed
Monthly rate, r	Annual rate ÷ 12
Months, n	Number of monthly payments
Level payment	Same every month

IN THE LESSON

- A level payment mortgage pays the same amount every month.
- Let the loan be the amount borrowed, the monthly rate be the annual rate divided by twelve, and the number of payments be the months in the term.
- The payment equals the loan times the monthly rate, divided by one minus one plus the monthly rate raised to the power of minus the number of payments.
- Behind it is simple present value: the payment is the amount whose discounted stream exactly equals the loan.
- The classic slip is to use an annual rate with annual periods and then divide by twelve.
- Use the monthly rate and the number of months, always together.

5 Example 1: the monthly payment

Illustration: $300,000 at 6% for 30 years

Monthly rate	6% ÷ 12	**0.5%**
Number of payments	30 × 12	**360**
Discount term	1 − 1.005^−360	**0.8340**
Level payment	300,000 × 0.005 ÷ 0.8340	**$1,798.65**

IN THE LESSON

- Example one, with made up round numbers.
- Borrow three hundred thousand dollars at six percent for thirty years.
- The monthly rate is six percent divided by twelve, which is half a percent, point zero zero five.
- The number of payments is thirty times twelve, three hundred and sixty.
- Now the discount term: one plus point zero zero five, raised to the power of minus three hundred and sixty, is about point one six six.
- One minus that is point eight three four.
- The payment is three hundred thousand times point zero zero five, which is fifteen hundred, divided by point eight three four.
- That gives one thousand seven hundred and ninety eight dollars and sixty five cents every month.

6 Example 2: interest and principal

Payment $1,798.65; balance at start of month 1 is $300,000

Month 1 interest	300,000.00 × 0.5%	**$1,500.00**
Month 1 principal	1,798.65 − 1,500.00	**$298.65**
Month 2 interest	299,701.35 × 0.5%	**$1,498.51**
Month 2 principal	1,798.65 − 1,498.51	**$300.14**

IN THE LESSON

- Now split the first two payments.
- Interest each month is the monthly rate times the balance at the start of that month.
- In month one the balance is the full three hundred thousand, so interest is fifteen hundred dollars.
- The rest of the payment, two hundred and ninety eight dollars and sixty five cents, is principal, and the balance falls to two hundred and ninety nine thousand, seven hundred and one dollars and thirty five cents.
- In month two, interest is charged on that smaller balance: one thousand, four hundred and ninety eight dollars and fifty one cents.
- So principal is three hundred dollars and fourteen cents.
- Interest falls and principal rises every month, because the balance is highest at the start.

7 Example 3: the balance after 12 payments

Illustration: same loan, 348 payments still to come

Payments remaining	360 − 12	**348**
Discount term	1 − 1.005^−348	**0.8237**
Balance after 12 payments	1,798.65 × 0.8237 ÷ 0.005	**$296,316**
Principal repaid so far	300,000 − 296,316	**$3,684**

IN THE LESSON

- The balance after a number of payments is the present value of the payments still to come, discounted at the monthly rate.
- After twelve payments, three hundred and forty eight remain.
- The discount term is one minus one point zero zero five to the power of minus three hundred and forty eight, which is about point eight two three seven.
- Multiply the payment by that and divide by point zero zero five: one thousand seven hundred and ninety eight dollars and sixty five cents times point eight two three seven, over point zero zero five, gives two hundred and ninety six thousand, three hundred and sixteen dollars.
- After a whole year of payments, only about three thousand seven hundred dollars of the loan has been repaid.
- Early payments are mostly interest.

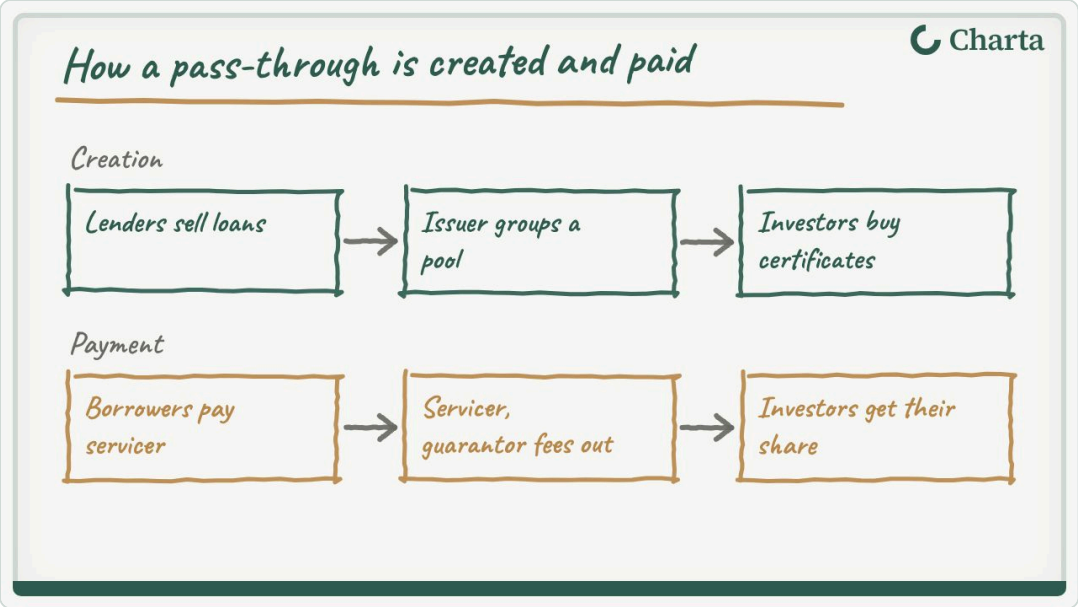
8 Securitization: from loans to securities

- Lenders sell loans; the issuer forms a pool
- Pass-throughs pay a pro rata share of pool cash flows
- Interest + scheduled principal + prepayments
- Coupon = WAC − servicing and guarantee fees
- Ginnie: explicit U.S. guarantee. Fannie, Freddie: GSEs

IN THE LESSON

- Securitization turns pools of mortgage loans into tradable securities.
- Lenders sell loans to an agency or another issuer, which groups similar loans into a pool and issues pass through certificates.
- Each certificate gives its holder a pro rata share of the pool's interest, its scheduled principal, and its prepayments.
- The investor does not receive the borrowers' full rate.
- The coupon on the security equals the weighted average coupon of the loans, less servicing and guarantee fees.
- Ginnie Mae securities carry the explicit guarantee of the U S government.
- Fannie Mae and Freddie Mac are government sponsored enterprises, so their guarantee is not explicit in the same way.

9 How a pass-through is created and paid



IN THE LESSON

- Follow the top row from left to right.
- Lenders originate loans and sell them to an agency or issuer.
- The issuer groups similar loans into a pool.
- It then issues pass through certificates, and investors buy them.
- The bottom row follows the money once the pool exists.
- Borrowers make their monthly payments to the servicer.
- The servicer and the guarantor keep their fees.
- What is left passes through to the investors, each receiving a pro rata share of interest, scheduled principal and any prepayments.
- When a borrower repays early, the investor receives that principal at once, which is why the timing of the cash flows is uncertain even though the guarantee protects against default loss.

10 Example 4: pass-through coupon and share

Illustration: pool of $500M; investor holds 2% ($10M)

Weighted average coupon	from the loans	**4.50%**
Servicing + guarantee fees	0.25% + 0.25%	**0.50%**
Principal collected	1M scheduled + 3M prepaid	**$4M**
Pass-through coupon	4.50% − 0.50%	**4.00%**
Investor's principal	2% × $4M	**$80,000**

IN THE LESSON

- A pool of loans has a weighted average coupon of four and a half percent.
- The servicer keeps a quarter of one percent, and the guarantor keeps another quarter of one percent.
- The pass through coupon is four and a half minus point two five minus point two five, which is four percent.
- Now suppose the pool balance is five hundred million dollars and an investor owns two percent of it, ten million dollars.
- In a month when the pool collects scheduled principal of one million dollars and prepayments of three million, the investor's pro rata share is two percent of four million, which is eighty thousand dollars of principal.
- The investor gets a proportional share of everything, nothing more and nothing less.

11 Specified pools and TBA trades

- Specified pool: a particular, identified pool
- Pay-up over generic price when prepayment is favorable
- TBA: forward on a generic pool (agency, term, coupon)
- Actual pools announced shortly before settlement
- The seller delivers the least valuable eligible pools

IN THE LESSON

- Two ways to buy a pass through.
- A specified pool is a particular identified pool, and it can trade at a pay up, meaning a premium over the generic price, when its loans prepay favourably for the holder.
- Small loan balances are an example, because those borrowers are slower to refinance.
- A to be announced trade, a T B A, is a forward contract for a generic pool defined only by agency, maturity and coupon.
- The actual pools are announced shortly before settlement.
- The key point for the course is that the T B A seller chooses what to deliver, and will deliver the least valuable pools that meet the rules.

12 SMM and CPR: measuring prepayment

SMM = prepayment ÷ (balance − scheduled principal)
CPR = 1 − (1 − SMM)^12, SMM = 1 − (1 − CPR)^{1/12}

Prepayment in month	Principal repaid early this month
Balance after scheduled principal	Opening balance less scheduled
SMM, monthly	Share of the pool prepaying
CPR, annual	Annual rate, compounded

IN THE LESSON

- To measure prepayment we use two rates.
- The single monthly mortality rate, S M M, is the share of the pool's balance that prepays in a month.
- It is measured after scheduled principal: the prepayment divided by the beginning balance less scheduled principal.
- The conditional prepayment rate, C P R, is the annual version, with monthly compounding.
- C P R equals one minus the quantity one minus S M M, raised to the twelfth power.
- Going the other way, S M M equals one minus the quantity one minus C P R, raised to the power of one twelfth.
- The common error is to multiply the monthly rate by twelve.
- That ignores compounding and overstates the annual rate.

13 Example 5: from SMM to CPR

Illustration: pool of $100M; scheduled principal $0.5M; prepaid $0.995M

Balance after scheduled	100 − 0.5	**$99.5M**
SMM	0.995 ÷ 99.5	**1.00%**
Survival over 12 months	0.99^12	**0.8864**
CPR	1 − 0.8864	**11.36%**
Shortcut (wrong)	12 × 1%	**12.00%**

IN THE LESSON

- A pool starts the month with one hundred million dollars.
- Scheduled principal is half a million, leaving ninety nine and a half million.
- Borrowers prepay nine hundred and ninety five thousand dollars, in other words point nine nine five million.
- The single monthly mortality rate is point nine nine five over ninety nine point five, exactly one percent.
- Now annualize.
- One minus point zero one is point nine nine.
- Raised to the twelfth power, that is about point eight eight six four.
- One minus it gives eleven point three six percent.
- The shortcut of twelve times one percent would say twelve percent, which overstates the true annual rate.
- Always compound.

14 Example 6: from CPR to SMM

Illustration: pool prepaying at CPR = 6% per year

Annual survival	1 − 0.06	**0.94**
Monthly survival	0.94^(1/12)	**0.99486**
SMM	1 − 0.99486	**0.514%**
Shortcut (wrong)	6% ÷ 12	**0.500%**

IN THE LESSON

- Now go the other way.
- A pool is prepaying at six percent per year, a C P R of six percent.
- What is the monthly rate?
- One minus point zero six is point nine four.
- Take the twelfth root, that is, raise to the power of one twelfth, and you get about point nine nine four eight six.
- One minus that is point five one four percent.
- The shortcut, six percent divided by twelve, would say half a percent, point five zero zero.
- The gap looks small here, but it grows at faster speeds.
- As a check, compound the monthly figure back: one minus point zero zero five one four three, raised to the twelfth power, returns point nine four, so the cycle closes.

15 Example 7: WAC and WAM of a pool

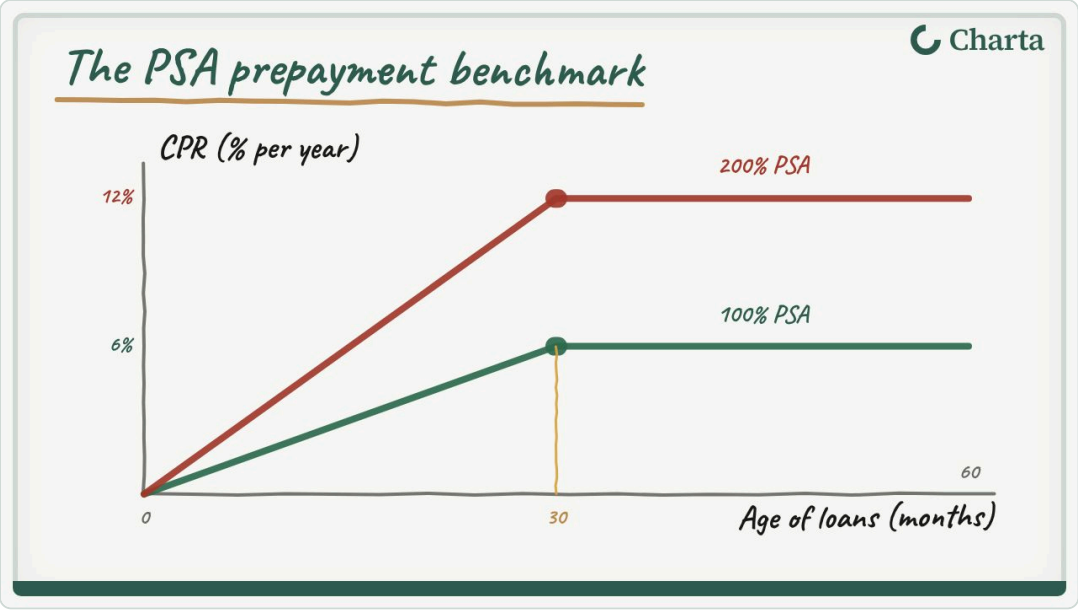
Illustration: $50M at 4% (340 mo), $30M at 5% (300), $20M at 6% (240)

Weights by balance	50%, 30%, 20%	**100%**
WAC (weighted)	2.0 + 1.5 + 1.2	**4.70%**
WAM (weighted)	170 + 90 + 48	**308 mo**
Simple average (wrong)	(4 + 5 + 6) ÷ 3	**5.00%**

IN THE LESSON

- The weighted average coupon and weighted average maturity describe a pool.
- Both weight each loan by its current balance.
- Take three loans, with made up figures.
- Fifty million dollars at four percent with three hundred and forty months left.
- Thirty million at five percent with three hundred months left.
- Twenty million at six percent with two hundred and forty months left.
- Weights are fifty, thirty and twenty percent.
- The coupon is point five times four, plus point three times five, plus point two times six: two, plus one point five, plus one point two, giving four point seven percent.
- The maturity is point five times three hundred and forty, plus point three times three hundred, plus point two times two hundred and forty: one seventy, ninety, forty eight, which is three hundred and eight months.
- A simple average would say five percent, which is wrong.

16 The PSA prepayment benchmark



IN THE LESSON

- The P S A benchmark gives a standard path of prepayment speeds.
- At one hundred percent P S A, the annual prepayment rate starts at zero and rises by two tenths of a percentage point for each month of age.
- That reaches six percent at month thirty, and then the rate stays flat.
- Other speeds are multiples of this path.
- At two hundred percent P S A, the rate climbs twice as fast, reaching twelve percent at month thirty, and stays there.
- A faster path means the pool is repaying sooner, so its average life is shorter.
- The ramp reflects seasoning: new loans rarely prepay, and activity builds as borrowers settle in, then levels off.

17 Example 8: reading the PSA path

Base path: 0.2% per month of age, capped at 6% from month 30

100% PSA, month 20	0.2% × 20	**4.0%**
100% PSA, month 40	capped at month 30	**6.0%**
150% PSA, month 12	2.4% × 1.5	**3.6%**
200% PSA, month 40	6.0% × 2	**12.0%**

IN THE LESSON

- Let's read the path.
- At one hundred percent P S A and an age of twenty months, the rate is two tenths of a point times twenty, which is four percent.
- At the same speed and an age of forty months, we are past month thirty, so the rate is capped at six percent.
- Now change speed.
- At one hundred and fifty percent P S A and an age of twelve months, first find the base rate, two tenths times twelve, two point four percent, then multiply by one point five to get three point six percent.
- At two hundred percent P S A and an age of forty months, the base is six percent and doubling gives twelve percent.
- Notice the cap applies to the base path before the multiple.

18 How agency pass-throughs trade

- TBA fixes program, term, coupon, price, par, date
- Pools announced about 2 business days before settlement
- Fungible contracts make the market liquid
- Price in 32nds; "+" adds half a 32nd
- Pay = price × current face + accrued interest

IN THE LESSON

- Most agency pass throughs trade in the to be announced market, a forward market for generic securities.
- A trade fixes the agency program, maturity, coupon, price, par amount and settlement date, but not the pools, which the seller announces about two business days before settlement.
- Because any pool that meets the good delivery rules can be delivered, contracts are fungible, and that makes the market liquid.
- Prices are quoted in thirty-seconds of a point, and a plus sign adds half of one thirty-second.
- The buyer pays the price times the current face, plus accrued interest.
- Current face is the original face times the pool factor.
- Pools with special features trade as specified pools, at a pay up.

19 Example 9: paying for a TBA trade

Illustration: $10M original face, price 101-16+, 4% coupon, 12 days

Current face	10,000,000 × 0.80	**$8,000,000**
Price	101 + 16.5/32	**101.515625**
Principal paid	8,000,000 × 1.01515625	**$8,121,250**
Accrued interest	8M × 4% × 12/360	**$10,667**
Total paid	principal + accrued	**$8,131,917**

IN THE LESSON

- Suppose a buyer takes ten million dollars of original face at a price of one hundred and one, sixteen and a half thirty-seconds.
- The plus adds half, so the price is one hundred and one plus sixteen and a half over thirty two, which is one hundred and one point five one five six two five.
- The pool factor on delivery is point eight, so current face is eight million dollars.
- The principal payment is price times current face: eight million times one point zero one five six two five, or eight million, one hundred and twenty one thousand, two hundred and fifty dollars.
- Accrued interest runs at the four percent coupon, on a thirty over three sixty day count, for twelve days from the start of the month to settlement: eight million times point zero four times twelve over three hundred and sixty is ten thousand, six hundred and sixty seven dollars.
- The buyer pays the total.

20 Strips: interest-only and principal-only

- IO gets the interest; PO gets the principal
- Pass-through price = IO price + PO price
- PO bought at a discount: faster prepayment helps it
- Rates fall: PO price up. IO price down (flows lost)
- Rates rise: IO price can rise (negative duration)

IN THE LESSON

- Agency products reallocate pool cash flows.
- A strip splits a pool into an interest only security, an I O, which receives the interest, and a principal only security, a P O, which receives the principal.
- Together they replicate the pass through, so the pass through price equals the I O price plus the P O price.
- A P O is bought at a discount and repaid at par over time, so faster prepayment brings the money sooner and raises its value.
- Its price rises when rates fall.
- An I O is the opposite.
- Faster prepayment shrinks the balance on which interest is paid, so cash flows are lost.
- An I O can rise in price when rates rise, which is negative duration.

21 Strip prices and the rate response

Illustration: prices per 100 of face

Security	Price / response
Pass-through	102
P O (principal-only)	70; rises when rates fall
I O (interest-only)	32; falls when rates fall
Check: PO + IO	70 + 32 = 102

IN THE LESSON

- Here are made up prices for a strip.
- The pass through is worth one hundred and two.
- The P O is worth seventy and the I O is worth thirty two.
- Add them and you recover one hundred and two, as the rule demands.
- Now ask what happens when rates fall and prepayments speed up.
- The pass through gains a little, because the prepayment option caps its upside.
- The P O gains a lot, since its money arrives sooner.
- The I O falls, because interest stops flowing as balances shrink.
- When rates rise, the signs reverse: the P O falls and the I O can rise.
- The two pieces are the extremes, and together they give back the ordinary pass through.

22 CMOs: dividing the collateral into tranches

- Tranches split the collateral by payment priority
- Sequential: principal in order; first is shortest
- PAC: protected inside a band of prepayment speeds
- Support tranches absorb the prepayment swings
- Floater rises, inverse floater falls as the rate rises

IN THE LESSON

- A collateralized mortgage obligation, a C M O, divides the collateral into tranches.
- In a sequential structure, tranches receive principal in order, so the first tranche is repaid first and has the shortest average life, while the last has the longest.
- Other designs follow.
- A P A C tranche is protected inside a band of prepayment speeds, because support tranches absorb the surprises.
- Floaters and inverse floaters share the collateral coupon, one rising and the other falling when the reference rate moves.
- The key point: a C M O redistributes prepayment risk among investors.
- It does not remove it.
- Someone always holds it.

23 The dollar roll

- Sell TBA now, buy it back next month at a lower price
- Drop = front price − back price
- Roll: gives up coupon; buys back lower, earns income
- Implied rate = (coupon accrual − drop) ÷ price × 12
- Below repo: the roll is special (cheaper financing)

IN THE LESSON

- A dollar roll is a pair of T B A trades.
- The holder sells a given agency and coupon for this month's settlement, and buys the same type back for next month's settlement at a lower price.
- The price difference is called the drop.
- During the month between, the holder gives up the coupon and the principal paydown, but benefits from the drop, because it buys back at a lower price, and earns income from investing the sale proceeds.
- Viewed as a collateralized loan, the roll has an implied financing rate.
- It equals the monthly coupon accrual less the drop, divided by the price, times twelve.
- If that rate is below the repo rate, the roll is special, and cheaper financing than repo.
- Remember the pools returned are only substantially similar, so a pay up is lost.

24 Example 10: valuing a dollar roll

Illustration: sell 101.00, buy back 100.75; 4% coupon; repo 4.5%

Drop	101.00 − 100.75	**0.250**
Coupon forgone (one month)	4% ÷ 12 × 100	**0.333**
Implied financing rate	(0.333 − 0.25) ÷ 101 × 12	**0.99%**
Reinvestment income	101 × 4.5% ÷ 12	**0.379**
Value of the roll	0.25 + 0.379 − 0.333	**0.295**

IN THE LESSON

- Illustration.
- The holder sells at one hundred and one this month and buys back at one hundred point seven five next month.
- The drop is a quarter of a point.
- The coupon is four percent, so one month of coupon is four over twelve, point three three three per hundred.
- The implied financing rate is the coupon less the drop, point zero eight three, divided by the price, one hundred and one, times twelve.
- That is point nine nine percent.
- If repo costs four and a half percent, the roll is special.
- Value it directly.
- Investing one hundred and one at four and a half percent for a month earns point three seven nine.
- Add the drop, subtract the forgone coupon: point two five plus point three seven nine minus point three three three gives about point two nine five per hundred.

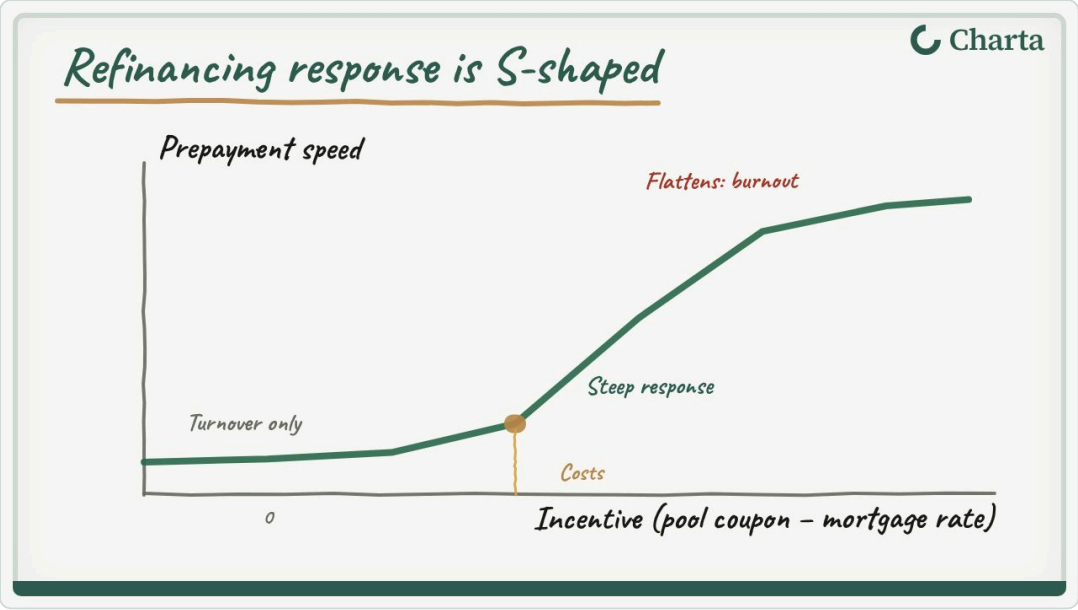
25 Prepayment modeling: four components

- Curtailments: partial extra principal payments
- Defaults: guarantor repays at par (involuntary)
- Turnover: home sold; depends on mobility and season
- Refinancing: driven by the rate incentive; S-shaped
- Investor short a call: negative convexity; burnout

IN THE LESSON

- Prepayment models split prepayments into four parts.
- Curtailments are partial extra principal payments.
- Defaults, for agency pass throughs, are repaid to investors by the guarantor, so they act as involuntary prepayments at par.
- Turnover is full repayment when a home is sold.
- It depends on mobility and the season, not on rates.
- Refinancing is driven by the incentive, usually the pool coupon relative to the current mortgage rate.
- The prepayment option is the borrower's right to repay at par, so the investor is effectively short a call, which produces negative convexity.
- Seasoning, home prices, loan size and burnout shift behavior.
- Burnout is the weaker response of a pool that has already been through a refinancing wave.

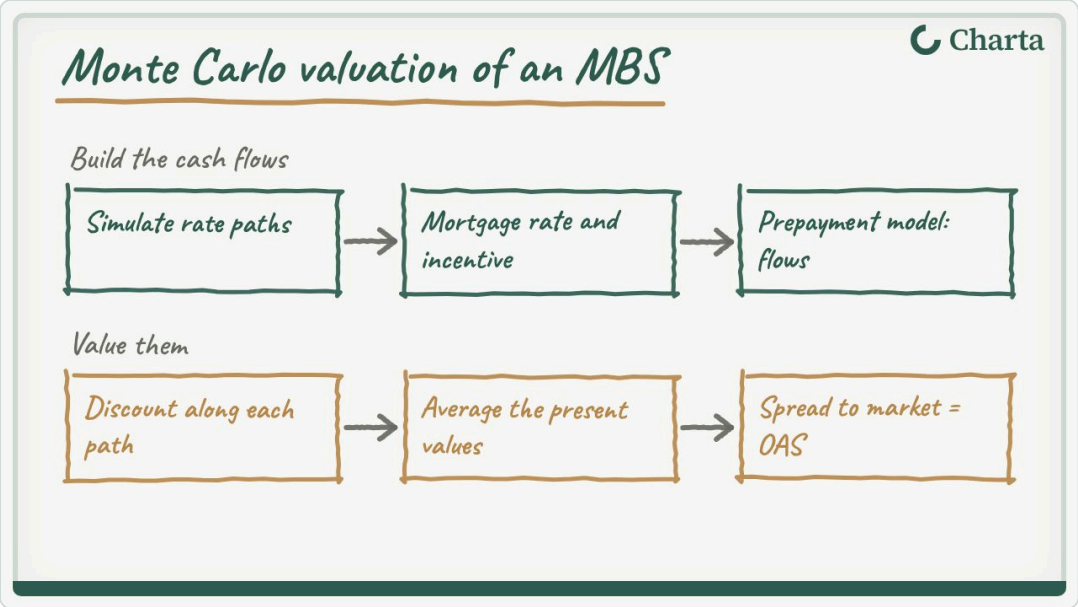
26 Refinancing response is S-shaped



IN THE LESSON

- This diagram shows how refinancing responds to the incentive.
- Along the bottom is the incentive, how far the pool coupon sits above the current mortgage rate.
- Up the side is the prepayment speed.
- At the left, even when the incentive is zero or negative, prepayments continue because of turnover and curtailments, so the line is low but not zero.
- Until the incentive exceeds the transaction costs of refinancing, the line barely moves.
- Once it does, the curve climbs steeply.
- At the top it flattens as the borrowers who will refinance have already done so, and burnout means a pool that has been through a wave responds less next time.
- Borrowers exercise their option imperfectly.

27 Monte Carlo valuation of an MBS



IN THE LESSON

- Monte Carlo valuation handles the fact that mortgage cash flows depend on the path of rates, not just today's rate, because of burnout.
- The top row builds the cash flows.
- Simulate many interest rate paths from an arbitrage free model calibrated to the current curve and volatilities.
- On each path derive the mortgage rate and refinancing incentive month by month.
- Then run the prepayment model to project interest, scheduled principal and prepayments.
- The bottom row values them.
- Discount each path's cash flows at that path's own simulated short rates, plus any spread.
- Average the present values across paths.
- Solving for the spread that makes the average equal the market price gives the O A S.

28 Example 11: averaging over paths

Illustration: four paths, zero spread; market price 100

Average present value	(101+103+99+105) ÷ 4	**102**
Versus market price 100	102 − 100	**+2: cheap**
Standard error, 1,000 paths	6 ÷ √1,000	**0.19**
Standard error, 4,000 paths	6 ÷ √4,000	**0.095**

IN THE LESSON

- A tiny illustration with four paths, far fewer than real life.
- Present values of the projected cash flows, each discounted along its own path, are one hundred and one, one hundred and three, ninety nine and one hundred and five.
- They add to four hundred and eight, and the average is one hundred and two.
- If the market price is one hundred, the model value is above the market, so the security looks cheap.
- Raise the discount spread until the average falls to one hundred; that spread is the O A S.
- Now sampling error.
- If one path's value has a standard deviation of six, one thousand paths give a standard error of six over the square root of one thousand, point one nine.
- Four times as many paths halves it, to point zero nine five.

29 OAS: definition and the option cost

OAS = Z-spread − option cost
average PV across paths (with OAS) = market price

OAS	Spread after the option cost
Z-spread	Spread on one static curve
Option cost	Value of the prepayment option

IN THE LESSON

- The option adjusted spread is the constant spread added to the short rates on every simulated path so that the average present value of projected cash flows equals the market price.
- The Z spread is the same idea on one static curve, with no option effect.
- The two are linked: the O A S equals the Z spread less the option cost, where the option cost is the value of the borrower's prepayment option in spread terms.
- The reasoning is that part of the Z spread is only compensation for being short the option, so we take it out.
- What remains is the spread for credit, liquidity and other risks.
- Use it to compare mortgage securities with each other and with other bonds, and to judge whether one looks cheap or rich.

30 Example 12: OAS and its weakness

Illustration, in basis points (bp)

Z-spread	static curve	**90 bp**
Option cost	model value	**55 bp**
OAS	90 − 55	**35 bp**
Same Z, option cost 30	90 − 30	**60 bp**
Higher volatility: cost 65	90 − 65	**25 bp**

IN THE LESSON

- Take a premium pass through with a Z spread of ninety basis points.
- The model says the prepayment option costs fifty five basis points.
- So the O A S is ninety minus fifty five, thirty five basis points.
- Another pass through with the same Z spread but a smaller option cost of thirty basis points has an O A S of sixty.
- It looks cheaper, since it pays more after the option is accounted for.
- Now the weakness.
- If the analyst raises the assumed volatility, the option is worth more, the option cost rises to, say, sixty five, and the O A S falls to twenty five.
- Likewise, underestimating the prepayment speed of a premium pass through understates the option cost and overstates the O A S.
- It is only as reliable as the models.

31 Four mistakes to avoid

- Annual periods, then ÷ 12: use monthly rate and months
- CPR = 12 × SMM: compound, 1 − (1 − SMM)^12
- Simple average of loans: weight by balance
- One average curve: discount along each path

IN THE LESSON

- Mistake one: using annual periods and then dividing by twelve.
- Use the monthly rate and the number of months together.
- Mistake two: multiplying the single monthly mortality rate by twelve to get the annual rate.
- Compound it instead.
- Mistake three: taking a simple average of loans of different size.
- Weight the coupon and the maturity by current balance.
- Mistake four: discounting mortgage cash flows on one average curve.
- Because prepayments depend on the path of rates, discount along each simulated path.
- A related reminder: the O A S is only as reliable as the interest rate model, the volatility input and the prepayment model behind it.

32 Recap: the main ideas

- Level payment: interest first, rest is principal
- TBAs: seller delivers the cheapest pools
- SMM, CPR, PSA, WAC, WAM describe the pool
- Strips, CMOs move risk; roll: compare with repo
- Monte Carlo path by path; OAS = Z-spread − option cost

IN THE LESSON

- Let's pull it together.
- Mortgage products differ in how the payment and balance behave, and each carries its own cash flow risk.
- A level payment splits into interest on the opening balance and principal.
- Pools of loans become pass throughs, traded mostly as T B As, where the seller delivers the cheapest pools.
- We measure prepayment with S M M and C P R, and describe a pool with the weighted average coupon and maturity.
- Strips and tranches redistribute prepayment risk.
- A dollar roll is compared with repo.
- Prepayment has four components, and the borrower's option makes the investor short a call.
- Monte Carlo values path by path, and the O A S strips out the option.

33 Try three quick questions

1. $200,000, 30 years, 6%. Monthly payment?
   Answer: $200,000 × 0.005 ÷ (1 − 1.005^−360) = $1,199.10.
2. SMM = 0.5%. What is the CPR?
   Answer: 1 − 0.995^12 = 5.84%, not 6%.
3. TBA: who picks the pools, and the effect?
   Answer: The seller; price reflects cheapest-to-deliver pools.

IN THE LESSON

- Now try three quick questions yourself.
- Pause after each one.
- Question one.
- What is the monthly payment on a two hundred thousand dollar, thirty year loan at six percent?
- Question two.
- A pool has a single monthly mortality rate of half a percent.
- What is the annual conditional prepayment rate?
- Question three.
- In a to be announced trade, who chooses the pools delivered, and what does that do to the price?
- The answers are on the board.
- Work each one out before you look, and notice which of the mistakes questions one and two test.