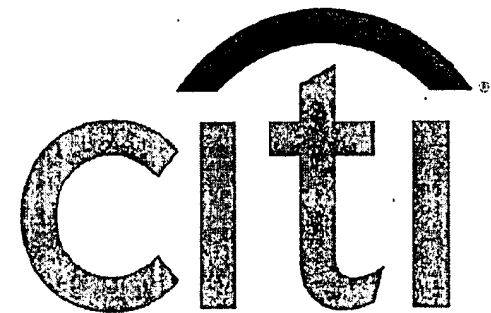


# *Risk View of CDOs on ABS*

*Confidential – not for distribution*

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Market Risk Analytics  
16 Nov 2007



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## *Executive Summary*

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- What happened:
  - Product Description: My understanding of what the products are, and what we are exposed to
  - Model Description: The ‘intrinsic value’ model used by the desk for ABS CDOs is very basic, limiting our risk management options. Cannot compute factor sensitivities, or even market value.
  - Model systematically underprices tail risk, which may have contributed to the ABS CDO losses.
  - Even if the model was adequate, there is no market price to calibrate a VaR model to

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## *Executive Summary*

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- What's next:
  - VaR: Not feasible to compute a VaR in the short term, due to limitations of desk model and lack of liquidity in the market
  - Risk Monitoring: We can track the 'spread' exposure of each CDO tranche in order to at least measure the magnitude of our exposure
  - Regulatory Capital: no chance of VaR-model approval, so have to stick with standard rules. Also presents a challenge for IDR modelling.
  - Risk Capital: Should be based on VaR for this Trading Book product, but we don't have VaR. Instead look at stress testing to 99.97<sup>th</sup> percentile equivalent
  - Going Forward: Help the desk to build a better model!

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## *Product Description*

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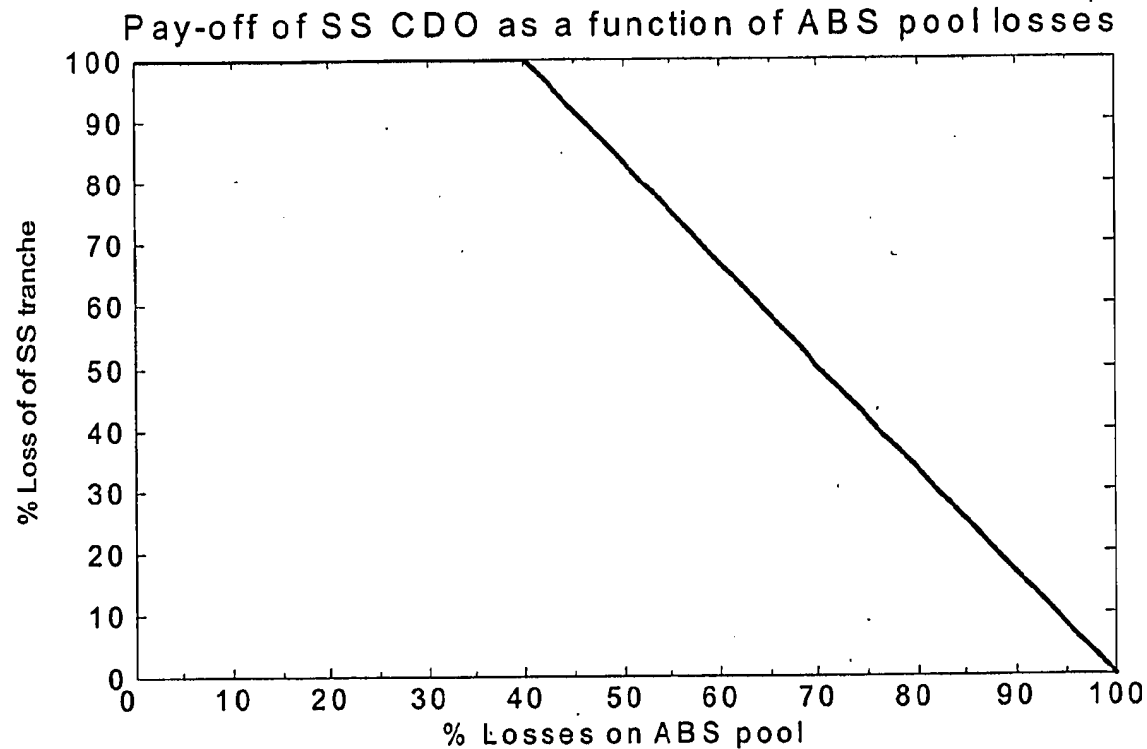
- Residential mortgages are pooled and placed in to tranced products: ABS
- ABS tranches rated by agencies by location in the capital structure and quality of underlyings. Most of the ABS underlying our ABS CDOs are A or BB rated.
- These are in turn pooled and placed into tranced products: ABS CDO. Again, tranches are given risk rating
- Sometimes this happens again: ABS (CDO)<sup>2</sup>
- Bank sells the tranches of the ABS CDO to investors, offers a low coupon on AAA-rated tranches since they have very low risk.
- Few investors purchase this tranche, so we are left with it on our books

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## Product Description

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- On the face of it, the super senior tranche is a safe product, since it is protected from (typically) the first 40% of losses on the ABS

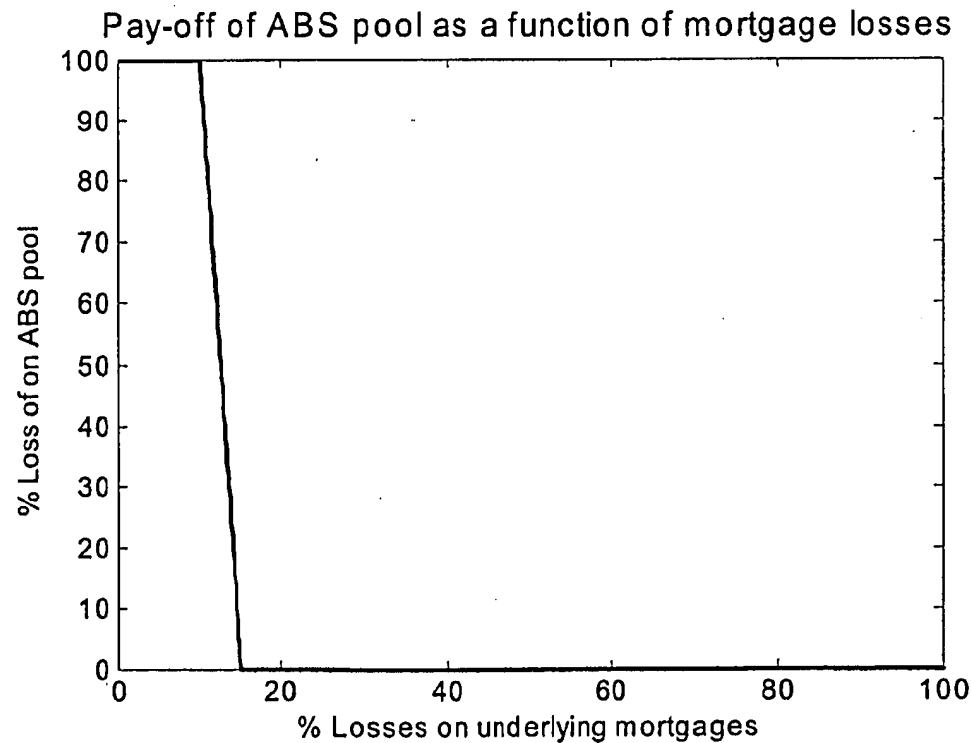


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# Product Description

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- But remember that the reference ABS are themselves only A or BBB. They are protected from roughly 10% of mortgages only, then take 100% of loss from next 5% of mortgage losses



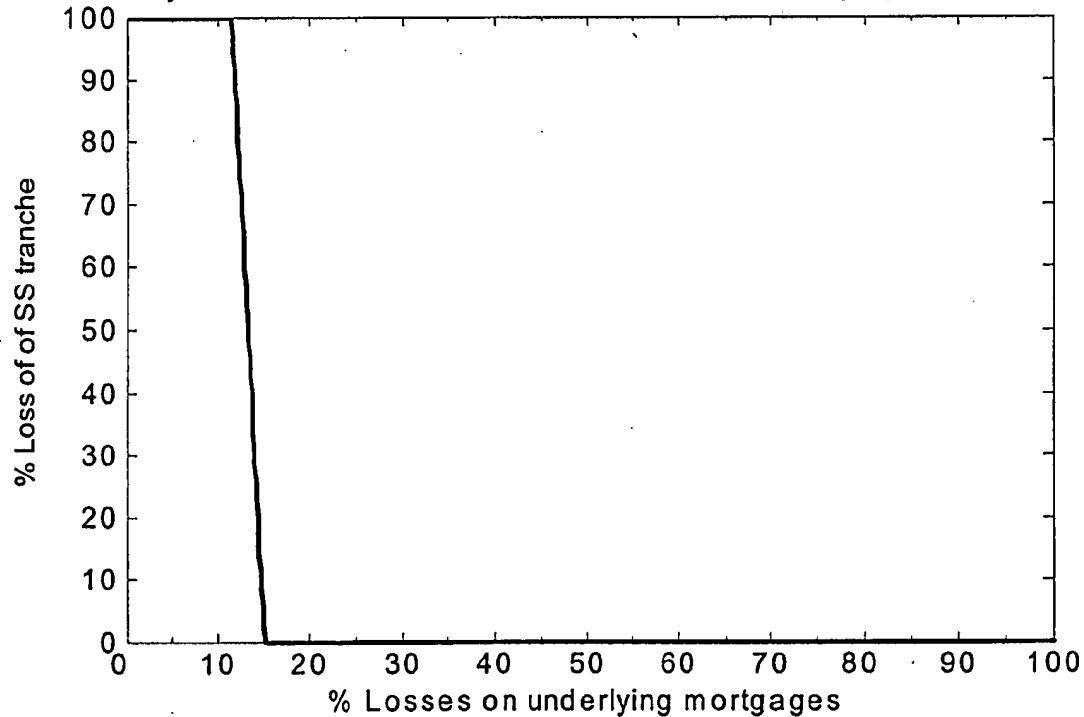
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# Product Description

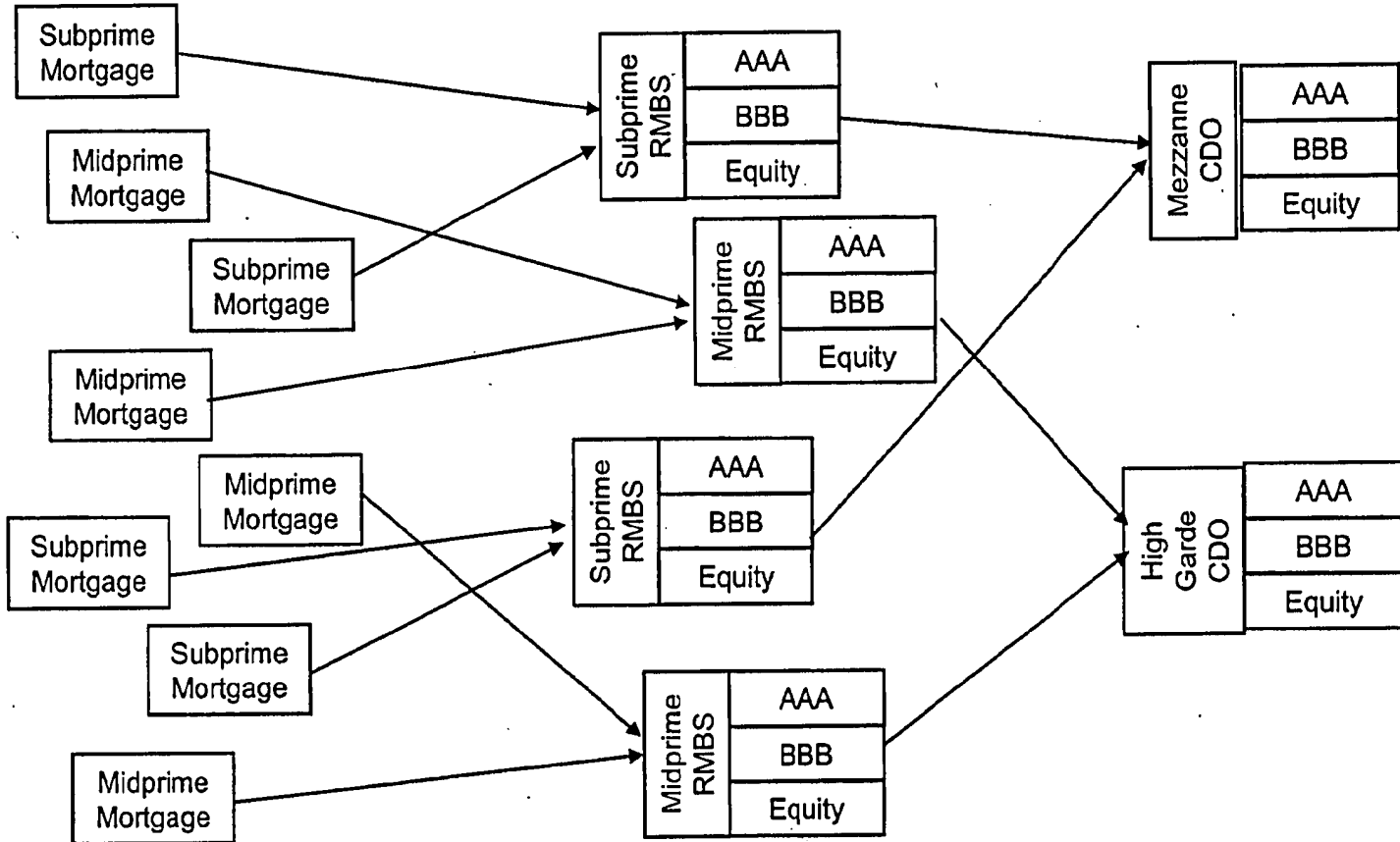
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- So the apparently 'super senior' CDO is actually protected from only 10% (from junior ABS tranches) + 40% \* 5% (from junior CDO tranches) = 12% of the underlying mortgages – more like a mezzanine product!

MV is banked Caveat: defaults take time to occur, over this time SS balance is being repaid and some  
Pay-off of SS CDO as a function of mortgage losses

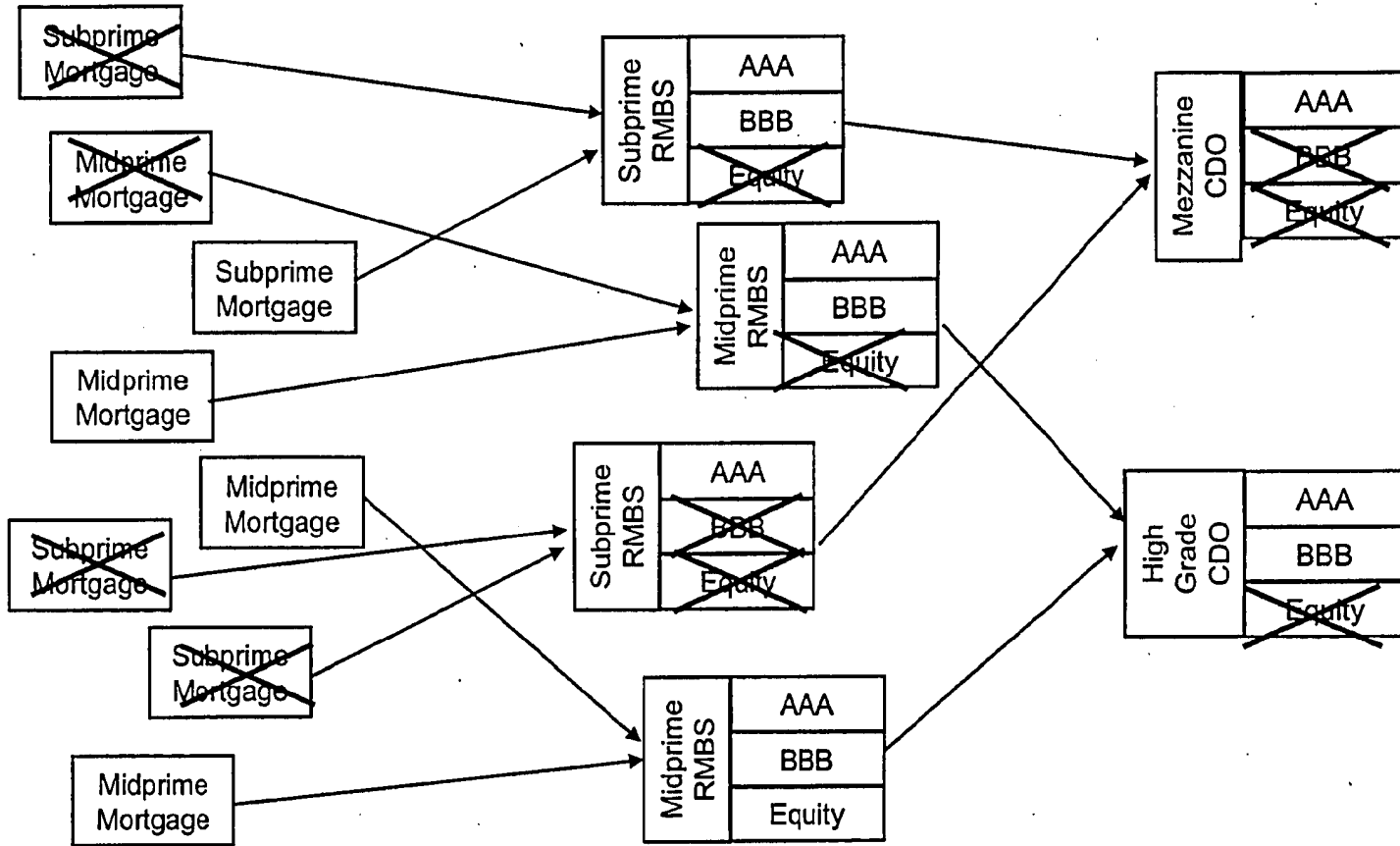


# Product Description – Before Credit Crunch

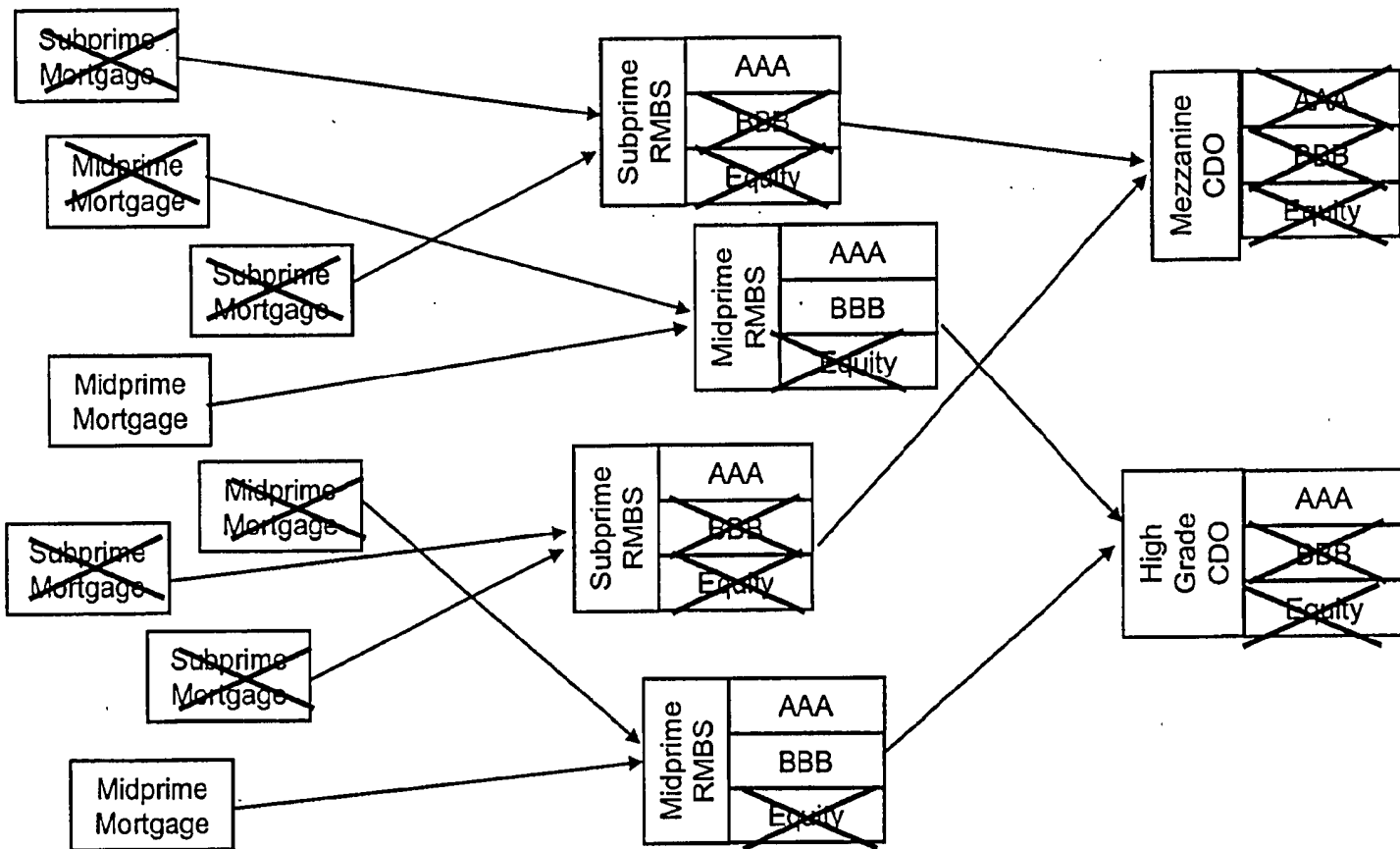




# Product Description – Where we are now



# *Product Description – Where the market thinks we are going*



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## *Model Description – Usual CDO model*

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- A standard synthetic CDO pricing model would price tranches by simulating the loss distribution of the underlyings, and taking risk neutral expectation of the pay-off (like any other derivative).
- Required Inputs:
  - Probability of Default: extracted from single-name CDS spreads
  - Recovery Rate: not traded, based on historical observation
  - Default Correlation: key ‘free parameter’ in CDO pricing. In the early days this was guesstimated by looking at historical data, now we can extract an implied correlation by tranche.
- Outputs:
  - Market Value
  - Sensitivity to spreads on the underlying, recovery rate and default correlation

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## *Model Description – ABS CDO model*

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- Three key risk factors affect cashflows from underlying mortgage pool:
  - Conditional Pre-payment Rate (CPR)
  - Conditional Default Rate (CDR)
  - Loss Severity (LS)
- Not priced by market, need a historical model.
- Desk assumes that all of the above are driven by fixed property of the issuer (credit score, LTV, etc) plus a single variable: House Price Appreciation (HPA)
- HPA is specified according to evolution over four years
  - Worst case scenario in model is [-2.5%, -2.5%, 0%, +3%]

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## *Model Description – ABS CDO model*

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- Mortgage Research group produces a look-up table mapping HPA scenario plus loan characteristics to CPR, CDR & LS
- Several limitations:
  - Calibration data are very limited, no large fall in nominal house prices in the US since 1930s.
  - Structural change in US housing market as mortgages are issued by brokers not banks, more floating rate mortgages, teaser rates etc.
  - CPR, CDR, LS are likely to be sensitivity to other variables that are not modelled e.g. interest rates, unemployment
- Can test model by implying net four year HPA from ABX
  - A-rated tranche (as of 8/14) implies net HPA  $\approx$  -30%
  - Recall that worst scenario run in the IV model: net HPA = -2%
  - -2% is too low, but -30% seems quite extreme, suggests that HPA-based model is incomplete

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## *Model Description – ABS CDO model*

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- Given evolution of HPA we get CPR, CDR & LS, and hence we can in principle compute probability distribution of cash flows through CDO, and hence get a price
- But, cash flows from Mortgage Pool to ABS are opaque
  - We send our CPR, CDR & LS assumptions to a third party (www.intex.com), who tell us the resulting cash flows (!)
  - These are then run through CDO spreadsheet to get cash flow to tranches
- Process is time consuming and expensive so only a few scenarios are run
  - No probability is assigned to HPA scenarios, so no expectation can be computed
  - Instead we compute the value of the cash flow given some discount factor = Libor + spread
  - This is called the “Intrinsic Value” of the product

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## *Model Description – Why this is a problem*

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- Imagine the Intrinsic Value approach were applied to pricing equity options. What would happen?
  - Value the options by specifying a few forward scenarios for the absolute value of the FTSE (spot = 6300), and discount
  - Say the worst forward scenario is [5700, 5300, 5000, 5400]
  - A written four year put with strike 4500 never expires out-of-the-money => option is priced very cheaply!
  - Even if the FTSE falls to 6000, we don't change the forward scenario, so no fall in intrinsic value => zero delta or gamma => zero risk!
- Correct approach is of course to specify *probability distribution of changes in* forward prices, and take discounted expectation
  - Non-zero price, non-zero FS, non-zero risk, even for deep out-of-the-money

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## *Model Description – Why this is a problem*

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- The Intrinsic Value approach was applied by the desk (and rating agencies?) What happened:
  - Owning a Super Senior tranche is a bit like writing a deep out-of-the-money put, where premium is paid at expiry
  - Specify a few forward CPR, CDR & LS scenarios, none of which are bad enough to generate losses on the SS tranche
  - “Intrinsic value” is then just the notional less discount rate, only factor sensitivity is to the choice of discount rate
  - Model prices these options very cheaply, so we sell lots (tens of billion USD) of them
  - US housing market falls, underlyings fall in value
    - Projected HPA scenario still generates no SS loss, so model still shows no change in intrinsic value
    - But the market value of the puts falls, Citi loses billions.



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## *Risk View – Measuring the Risk*

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- Risk Reporting
  - Existing Model cannot compute Factor Sensitivities to the underlyings, but does have sensitivity to the discount factor
  - This gives an indication of the magnitude, direction and tenor of exposure -> can be used to track the risk, maybe via GMR?
  - Does not capture the optionality in the tranches
- VaR
  - We have no pricing model, no factor sensitivities and no market price
  - Hard to see how we can build a VaR model in the short term

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## *Risk View – Regulatory Capital*

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- Regulatory Capital
  - ABS CDO are currently covered under standard rules. Will this RAP go up if (when) rating agencies downgrade them?
  - Will continue to use standard rules going forward, no chance of Fed granting model approval for these products
  - ABS CDO (and all structured credit) present a challenge for modelling Incremental Default Risk
    - Tempting to use ratings to calibrate PD and default correlation and hence compute loss distribution
    - But all of the credit risk models are calibrated to corporate credit
    - We have no justification for assuming that the credit rating on structured credit is in any way equivalent to the same rating on corporate credit
    - Better to simulate the defaults on the underlyings (under some asymptotic large portfolio approx)
    - However opacity of ABS and ABS CDO could be a problem

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## *Risk View – Going Forward*

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- Can only progress beyond the stress testing approach if we have some kind of pricing model, not an intrinsic value model
- What might this look like?
  - Start with HPA scenario based on house price forwards, as traded on the CME
  - Simulate changes in this using historical vols of HPA
  - Map the simulated HPA plus other factors like rates and macro-economy (?) to CDR, CPR & LS and value the deal
- Or, simulate CDR, CPR and LS directly? But how to calibrate these? And what about implied correlation?
- Need to work with the desk and with risk management to verify what I've said in this report, and work on a model that can estimate price and sensitivities

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## *Risk View – Economic Risk Capital*

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- Would normally be based on 99.97<sup>th</sup> percentile VaR for Trading Book products, but VaR is not feasible in the short term
- More realistic to use stress loss, under a severe (99.97% equivalent) shock to the housing market
  - Need to estimate CDR, CPR, LS due to interest rates, macro-economic factors and HPA falls.
  - Could base on Citi's Global Real Estate Stress Test, or try to get data on historical real estate shocks (e.g. UK 1989-1993, Japan 1991-1995)
  - Might need to make more severe to get good estimate of true potential losses on SS tranche