

A Multi-Agent Model of Financial Stability and Credit Risk Transfers of Banks

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MOTIVATION

- Systemic risk from securitization (MBS, ABS)
- CCFEA research started 5 years ago
recognized that ABS & MBS will have systemic risk implications
- Anticipated crisis of subprime defaults
- Multi-agent model needed for: fine grained data base for agents with spatial and dynamic features; non-linear feedbacks; multi period modelling

Origins of Crisis and Why We Are Mired in it ?

- **‘Weapons of mass destruction’(Warren Buffet): Residential Mortgage Backed Securities (RMBS) on Sub Prime Mortgages, Collateralized Mortgage/Debt Obligations (CM/DOs) and Credit Default Swaps (CDS)**
- **Little or no regulatory scrutiny**
- **Multiples of debt/leverage (‘shadow’ banking sector est. at \$62 tn vs. deposit based banking at \$39 tn and M0 at \$ 3.9 tn Source: Guardian 29Feb 09) with little contribution to returns from investment in the real economy (Global GDP \$55 tn). Systemic Ponzi scheme collapsed, (Aug 07 Bear Sterns – Northern Rock – Sept 08 Lehman etc) , then Freddie Mac and Fanny Mae in Sept 08, severe mark downs on the market value of retail banks**
- **Interbank and short term markets for liquidity seized up resulting in the credit crunch.**
- **‘Liquidity trap’ even at low interest rates of 1% or under, a loss of investor and consumer confidence**
- **Little traction in interest rate policy, reflation by printing money, euphemistically called ‘quantitative easing’.**
- **Limited success to date of tax payer bail-out of the banking system**
:Why ?
- **Radical options:A ‘toxic’/ Recovery bank or full nationalization of banks**
- **Massive public sector spending on capital projects to prevent a slide into another ‘Great Depression’**

Financial Contagion

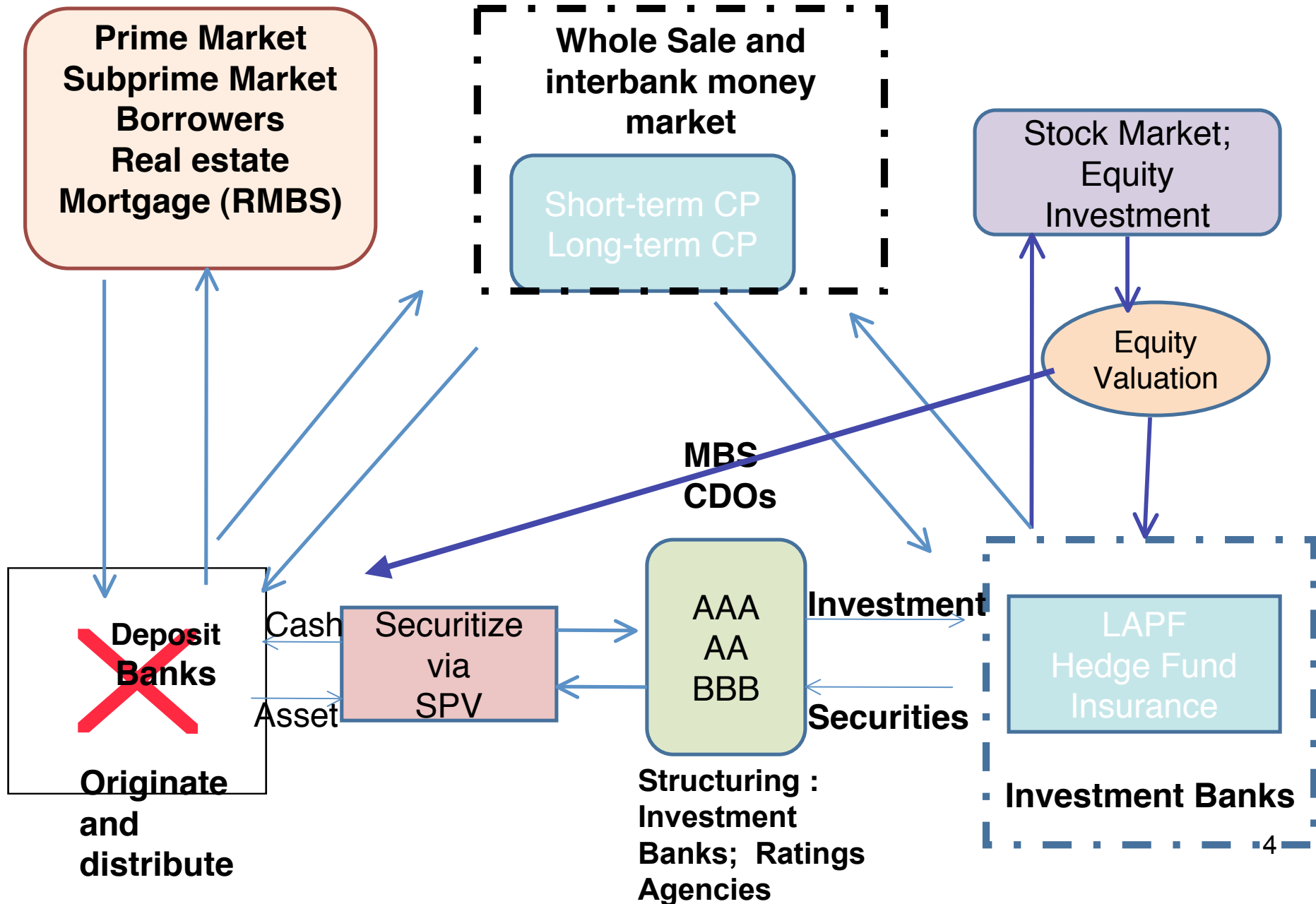
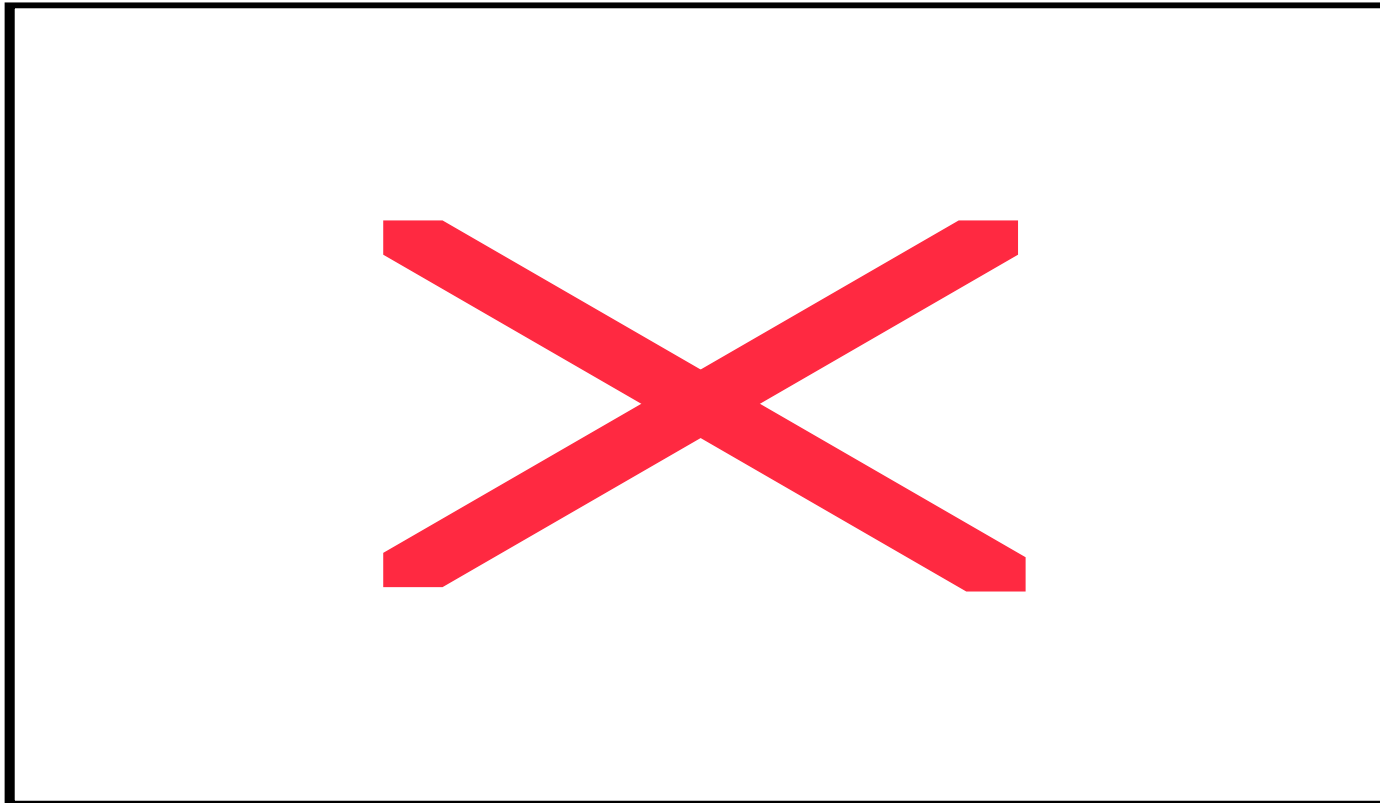


Figure 1.5: Increase in Subprime Delinquency 2005 to 2006 Map



Source: First American LoanPerformance; Census Bureau , and Wall Street Journal Online

Two Sector ABM for Credit Risk Transfer

- **A dynamic multi-period model of securitization with a A/L framework was missing (Simon Wolfe ABS model (2000) : lucid but static)**
- **Banks profit maximisation should be constrained by insolvency risk**
- **Regulations are set to mitigate the systemic risk implications: capital adequacy requirement**
- **What banks did? Securitization and credit risk transfer play a key role in enabling them to reduce their regulatory capital amount and increasing loan portfolio growth**

Where it Began : Securitization of Bank Loans

Regulatory Arbitrage

- Basel I required 8% of equity capital against bank assets ie. the loan side of the balance sheet
- Consider 1 bn Mortgage Loans
- Equity Capital needed 80 million
- If .5 bn securitized and **moved off balance sheet** ie.50% of securitization
- Bank now needs only 40 million of Equity Capital ; further 40 million can be lent out ; securitize again and again MONEY PUMP

Sub-prime Market

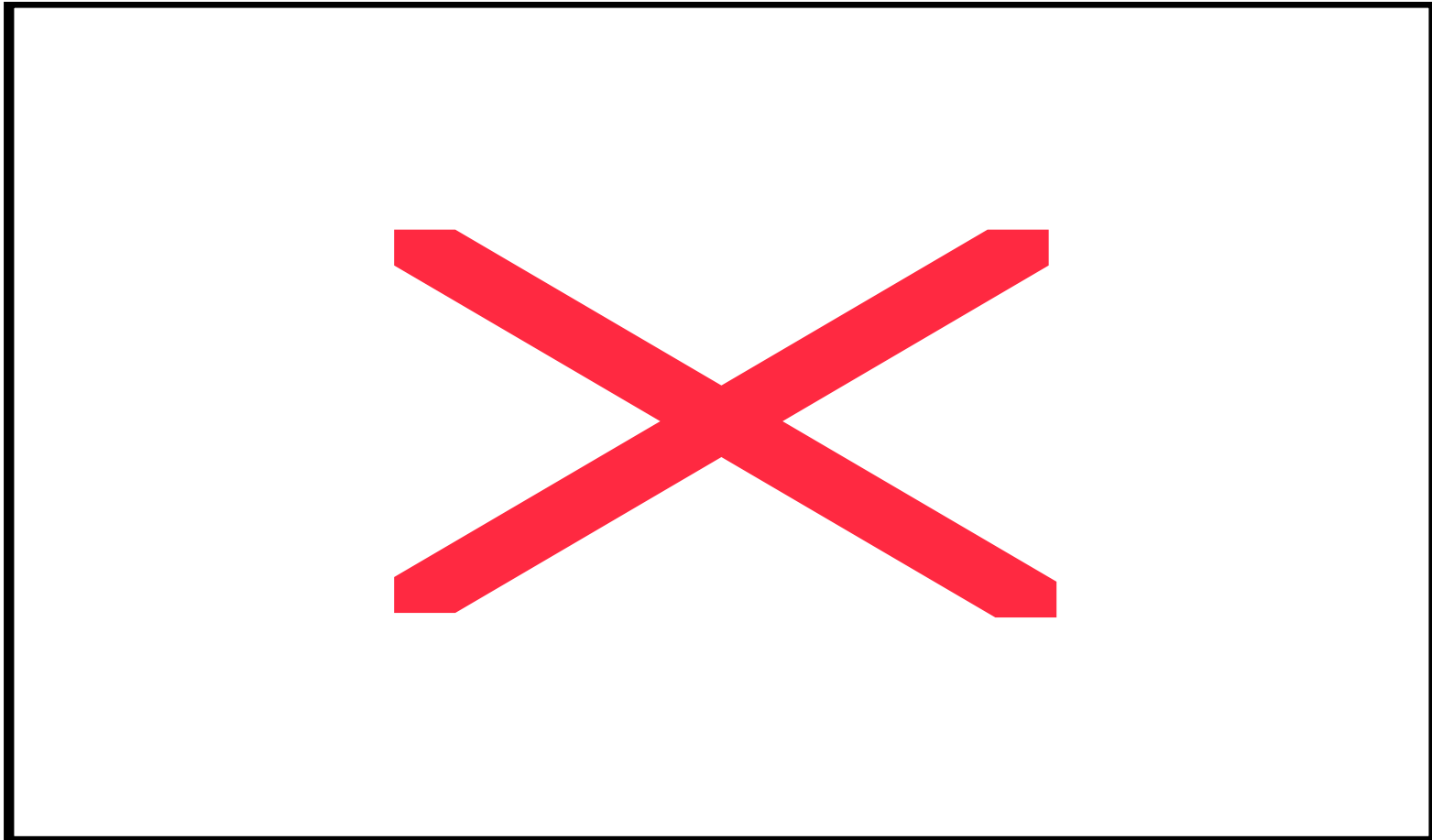
MBS on Loan on Real Estate:Source FDIC

| ∞ | WASHINGTON Mutual | NEW CENTURY |
|---------|-------------------|-------------|
| 2001.3 | 0.497971656 | 0.255255547 |
| 2001.6 | 0.427332242 | 0.236253407 |
| 2001.9 | 0.393723897 | 0.205321179 |
| 2001.12 | 0.302951192 | 0.180109436 |
| 2002.3 | 0.232911549 | 0.17544783 |
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| 2004.3 | 0.037408302 | 0.112385321 |
| 2004.6 | 0.038606 | 0.127830593 |
| 2004.9 | 0.035673732 | 0.134108553 |

Was there excessive securitization ?

The question is how were banks able to willy nilly pass on the subprime loans ? **In other words what needs explaining is how so much bad stuff got passed on.** The 'popular' answer: Default risk on these loans and hence costs to the bank for securitization in coupon payments and credit enhancement **were under estimated .**

Ratings companies helped pass off sub prime with high ratings. **Basel II in 2004 requiring equity against MBS came too late**



With linear costs note that as a higher and higher % of assets are securitized, a bank can keep improving its capital accumulation :

The Money Pump model of Securitization

Collateralized Debt Obligation, CDO Weapon of mass destruction (Warren Buffet)

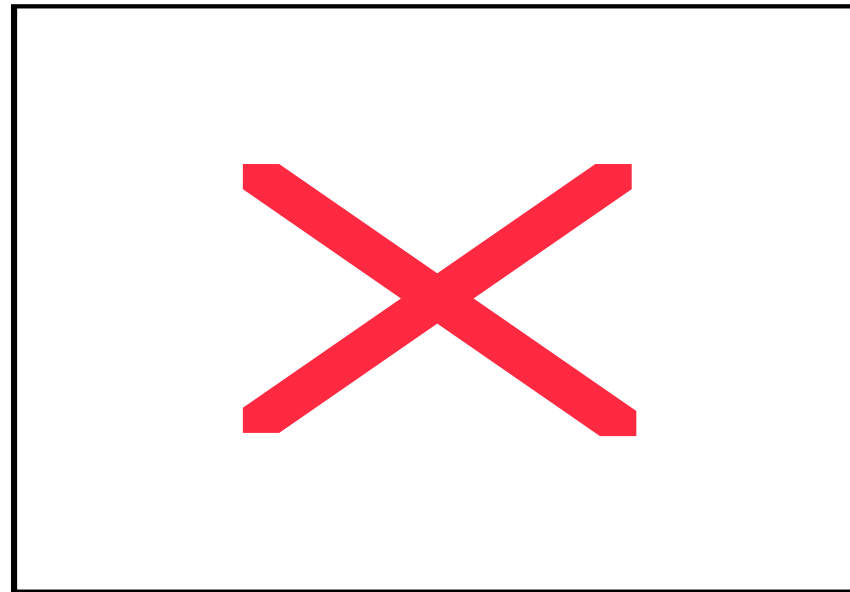
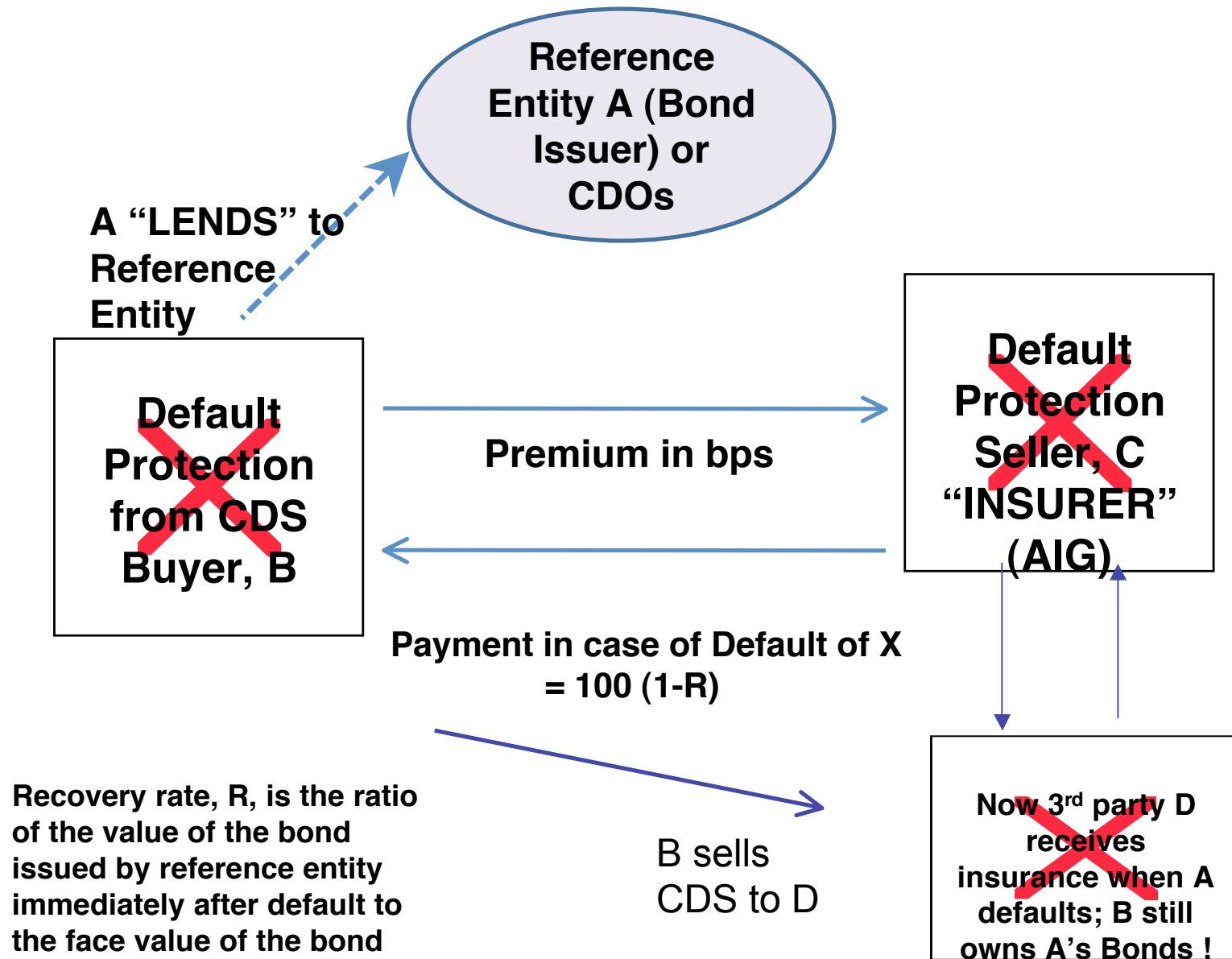
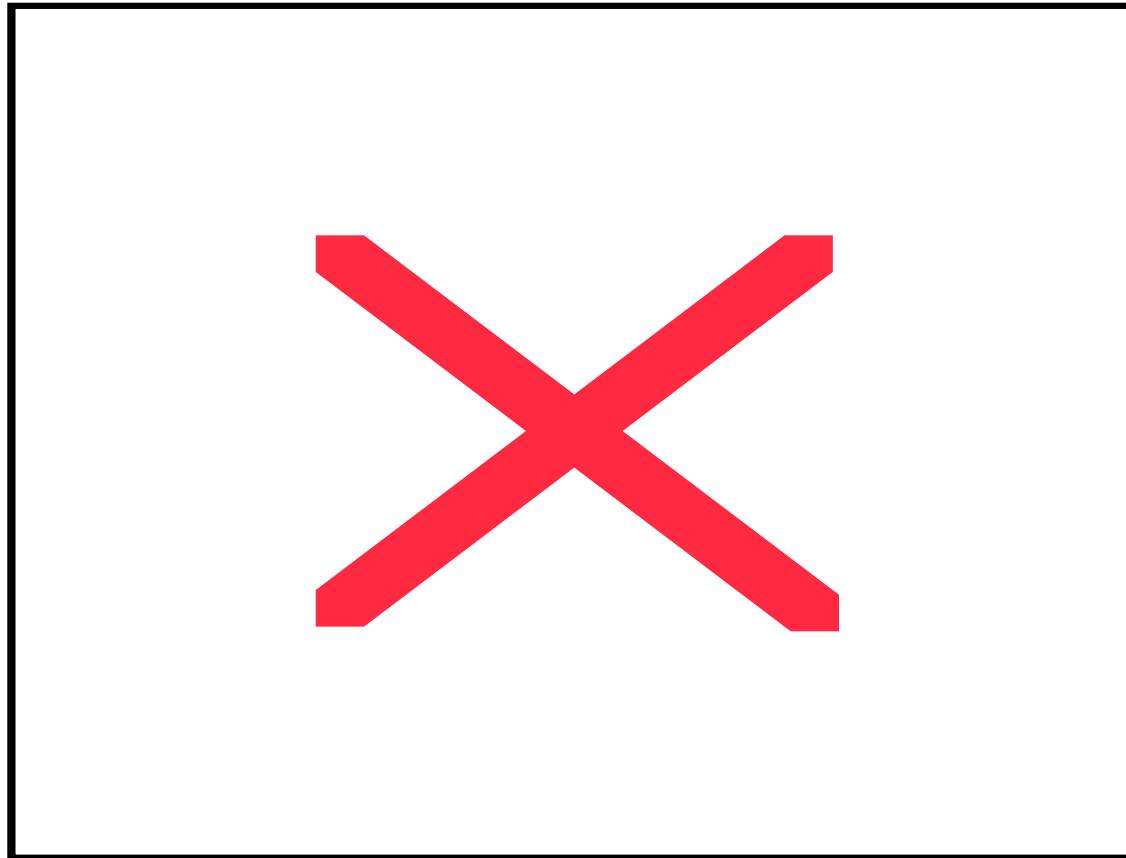


Fig. 1. Tranche structure at time t_0 ; at time t_1 , pool's losses (shaded in black) absorbed by Equity tranche; Mezzanine Jr., Mezzanine, Senior and Super-Senior tranches are not yet affected by pool losses.

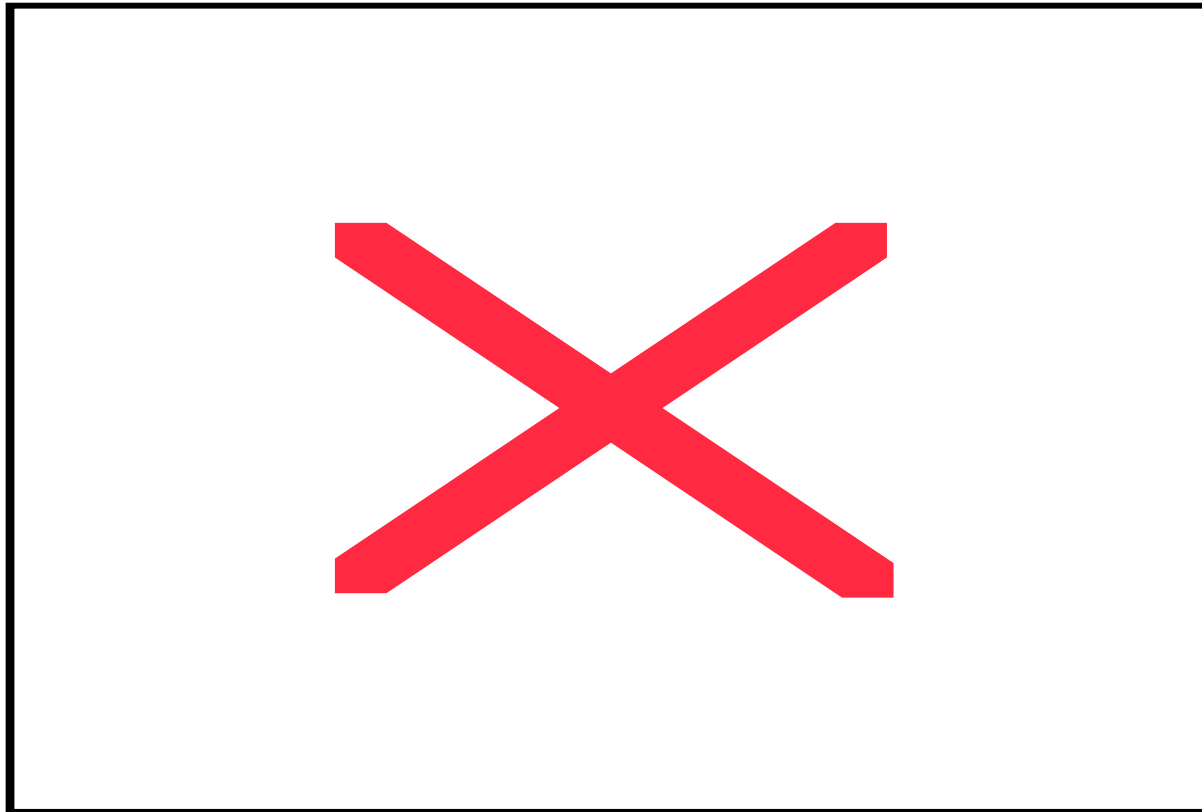
Credit Default Swap Structure(CDS) and Bear Raids



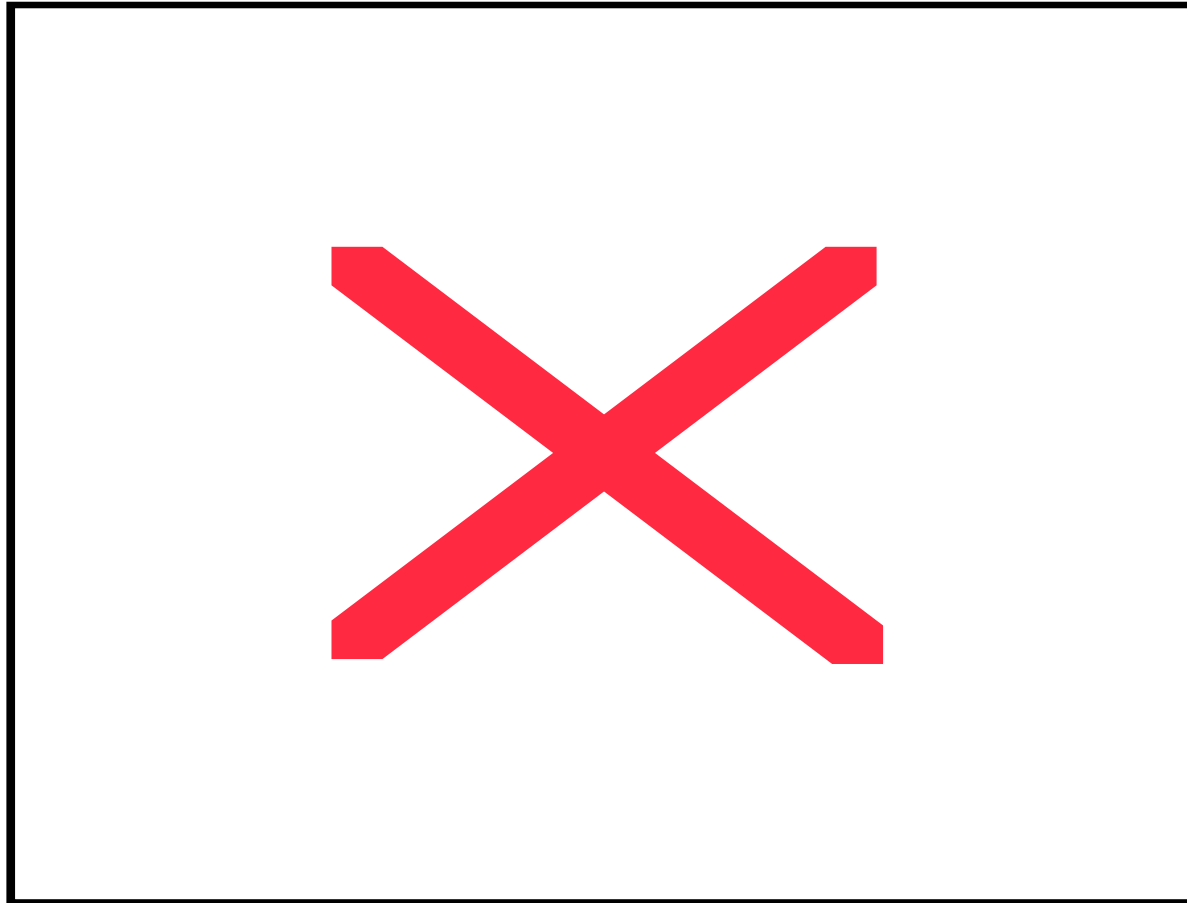
Credit Crunch Mainly From ZERO Growth in ABS vs Troubled Assets Relief Program (TARP)



2008 Value of SubPrime



ABX: Mark to Market Value of SubPrime Losses \$1.6 as ABX implies
20 cents to Dollar
First American Loan Performance estimated a default rate of 15%, this
would translate to \$300 billion of non-collectable principal and interest.



Section 1: Multi-period: Dynamic Model for Securitization in Banks

- **Definitions**

- N banks with initial liabilities given by L_0 , where r^L is the interest rate on liabilities
- Banks have a basic asset accumulation process such that $A_{t+1} = \alpha A_t + R_t$ is the survival rate on assets and r^A is the return on assets
- Bank equity capital is given by E_t
- α is the minimum capital required to be held on the balance sheet in the capital account, where α denotes the capital adequacy requirement ratio which is 8%

Insolvency analysis

Bank is

~~solvent~~



Bank is solvent, capital injection required



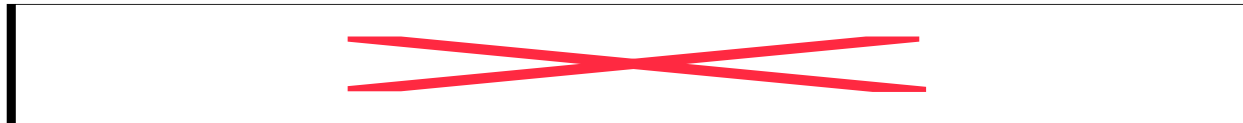
Bank is bankrupt



..Bank Model

- Securitizing (illiquid assets → tradable securities)

- Condition for capital injection/accumulation:

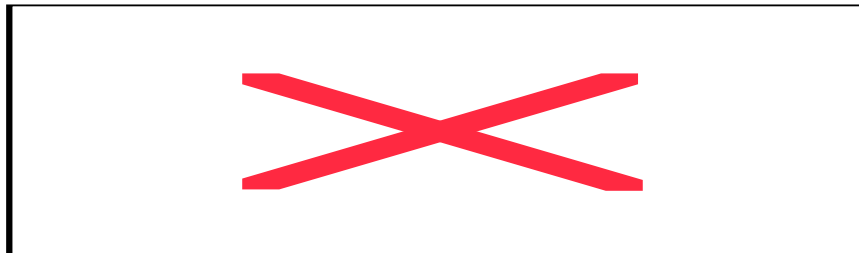


α : proportion of securitized assets

if $M > 0$ → capital injection is needed

if $M < 0$ → capital accumulation

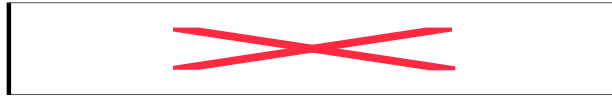
- Asset accumulation process with securitization:



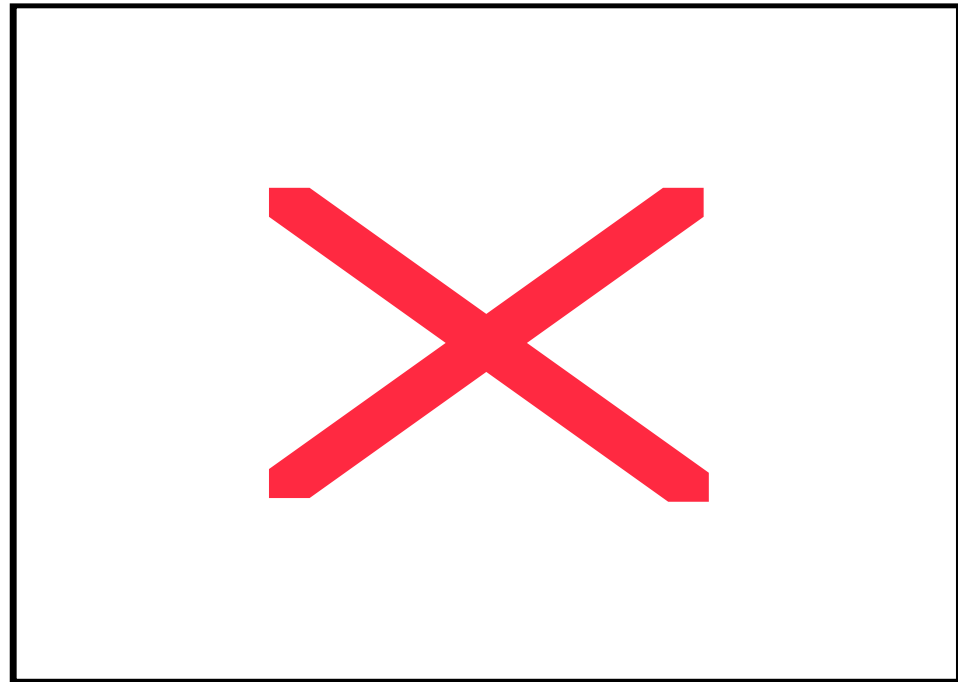
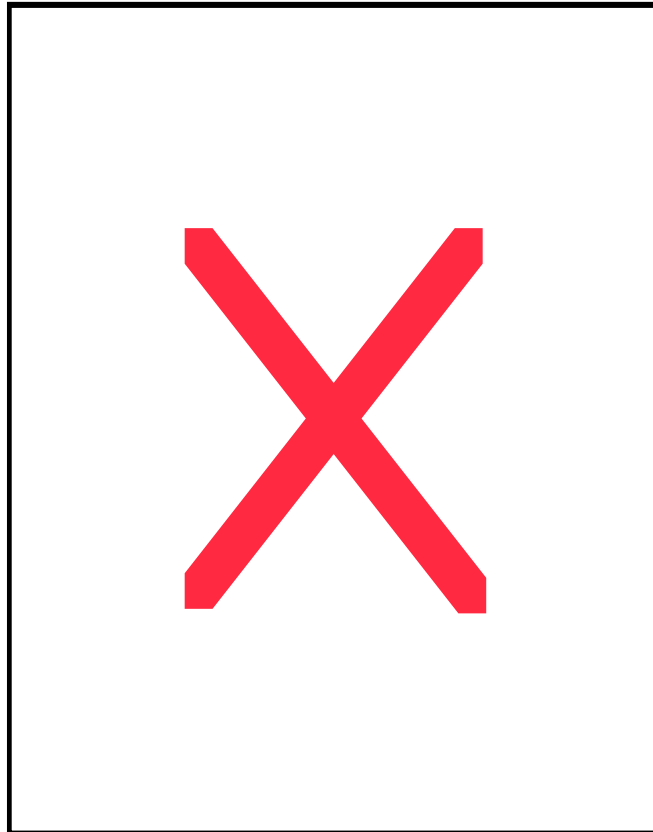
, where $C(\alpha)A_t$ denotes the

- **Optimal securitization ratio (minimising capital injections/ maximising capital accumulation):**

Costs of MBS



is Coupon Rate on MBS.

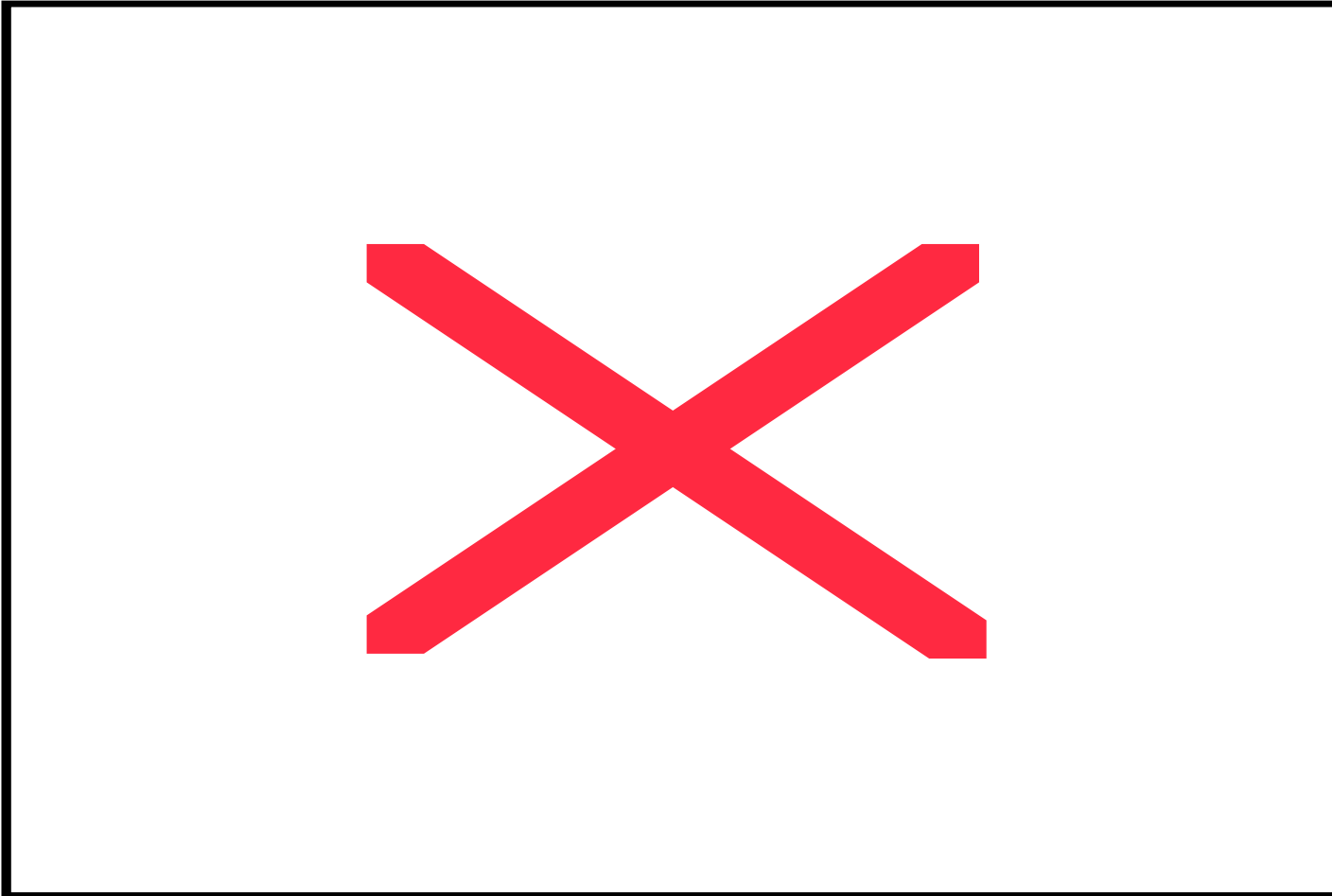


Sub-prime Market

MBS over Loan on Real Estate

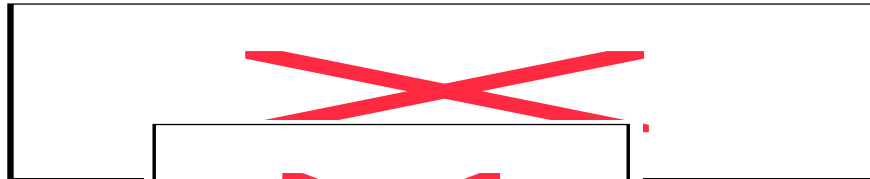
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Sub-prime: Exploding ARM

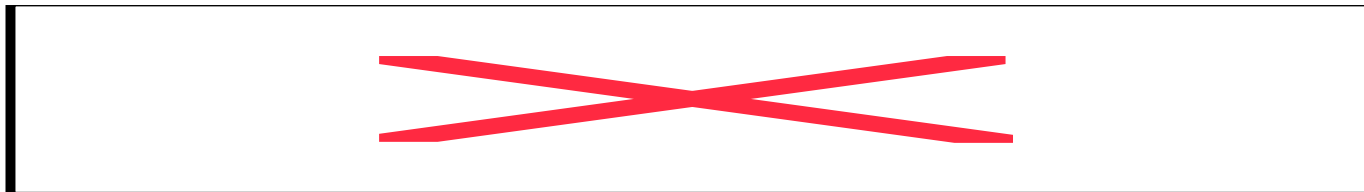
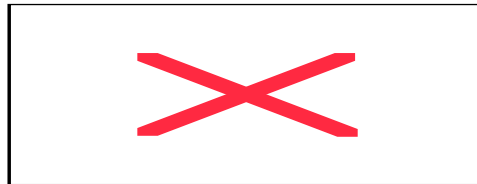


Dynamic Model Applied to Sub-prime

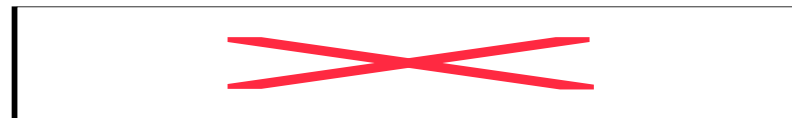
The Asset accumulation process:



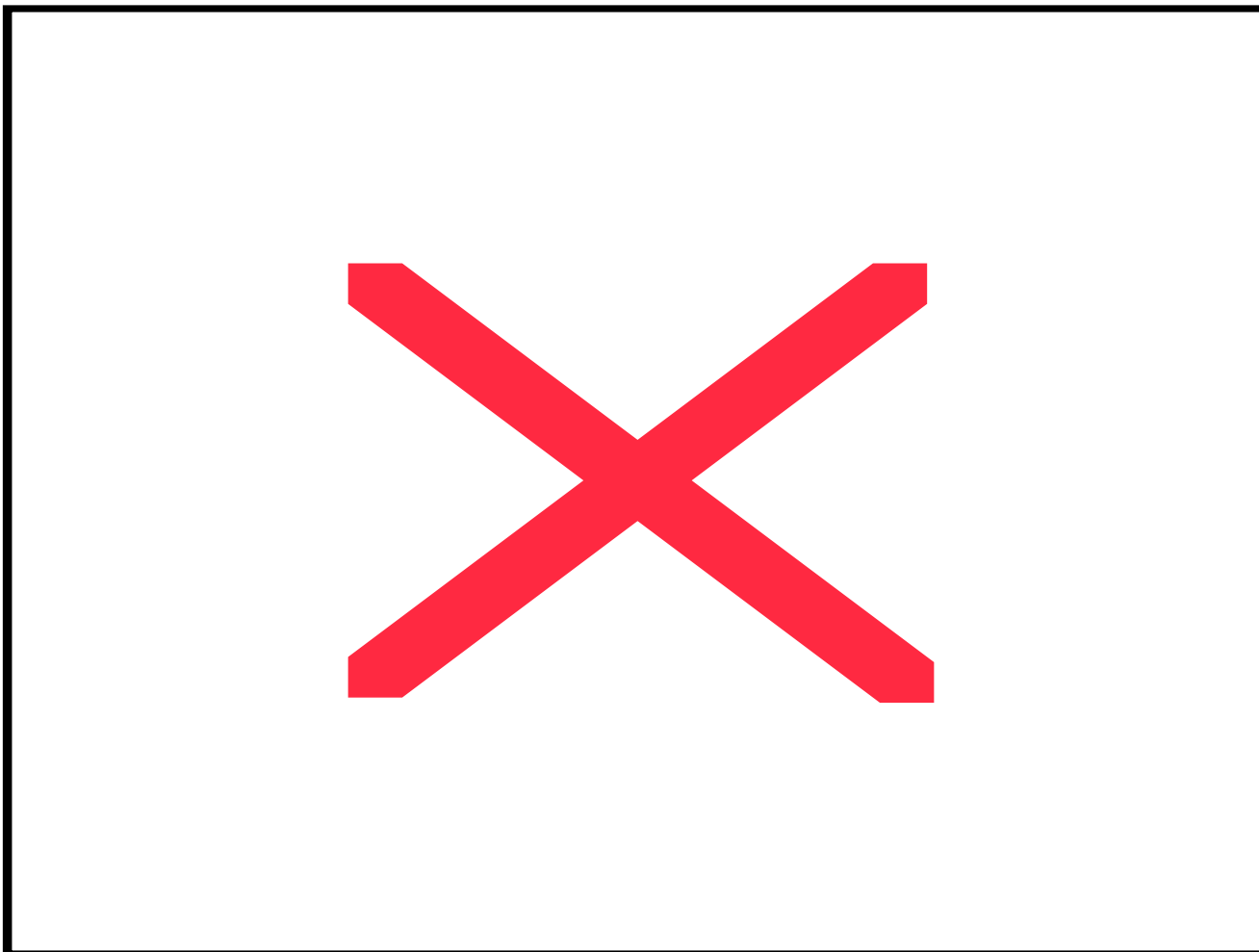
Where



For the capital replenish in 5 years horizon



Capital Accumulation



$ra = 15\%$ and $rd = 3\%$ (for BB-); $ra = 11\%$; $rd = 3\%$ (BB); $ra = 7.5\%$, $rd = 3\%$ (BBB);
 $ra = 5\%$ $rd = 3\%$ (AA)

Insurance Model

- **The economic problem facing LAPFs**
 - How to value their assets and liabilities when the assets are liquid and subject to market value while liabilities are not
 - Must be able to ensure there are always sufficient cash flow from the assets to meet the promised liability payment
 - Should be capable of delivering these pensions at the lowest economic cost to the sponsor
- **Assumptions**
 - A liability driven discrete time model
 - There are legal protections for fund members
 - The optimal asset allocation problem is solving backwards (the solvency determination process is treated purely in terms of liabilities)

Section 2 :Insurance Model

- **The basic ALM solvency analysis model**
 - **Initial endowment of assets (A^{LAPF}) to meet liabilities:**

$$A^{LAPF} \geq C + k$$

| | Life insurance schemes | Pension schemes |
|-----------------|---|--|
| where C: | The expected market of the liabilities | The expected value of claim payments under the scheme rules |
| and k: | The provision for adverse deviations provided as risk capital or equity | The margin added to the expected value of future claim payments by the actuary in establishing the scheme sponsor's contribution to the fund |

Initial assets can be re-expressed as:

$$A^{LAPF} \geq (1+\rho)*C, \text{ where } \rho = k/C \rightarrow \text{ solvency margin}$$

If actual assets > A^{LAPF} → we have an initial surplus
otherwise → the fund is solvent and closes

...Insurance Model

- ..The basic ALM solvency analysis model

- End of period solvency condition (traditional assets/credit

$$\left[\text{---} \right]$$

\times

where \times : traditional assets, \times : \times credit assets, L_t : liabilities, and \times : the cost of any particular investment strategy

$$\left[\text{---} \right]$$

\times

where

- Impact of solvency analysis on fund capital reserves

Assuming a legal protection for scheme sponsors in the event of insolvency, an initial capital reserve K such that $k \geq K$ is defined by

$$K_t = (1 + r^{\text{global}}) * \max(0, K_{t-1} + S_t)$$

r^{global} represents the risk free rate

Market clearing

- Solving $\frac{\partial \mathcal{L}}{\partial x} = 0$ for x given a quadratic cost function $C(x) = \frac{1}{2}ax^2 + bx + c$ where c is constant, the optimal demand for credit assets by LAPFs is obtained by:

$$x^* = -\frac{b}{a}$$

- Market clearing condition for credit asset cash flow in the calibrated model with both banking and LAPF sectors:

$$x^* = x^B, \text{ if } x^* \leq x^B$$

If $x^* > x^B$ Fire sale on Credit Asset,

$$x^* = x^B$$

Influences on the optimal asset allocation of LAPFs:

- **The spread between returns on credit assets and traditional assets**
- **As securitization rate in the banking sector increases, returns on credit assets increase and so does demand for such assets by LAPFs**
- **More stringent regulatory pressures on LAPFs through an increase in ρ will ultimately reduce the demand for credit assets**

LAPF Portfolio & Equity with Credit Assets

Gamma=90%

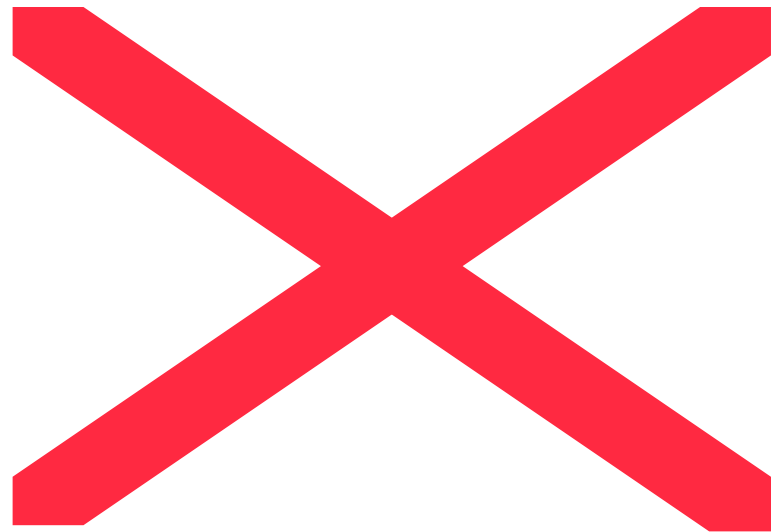
| ∞ | Asset | Liability | Optimal x | r Credit | r E | Surplus |
|--------|---------|-----------|-----------|----------|---------|----------|
| Year 0 | 100 | 92 | ∞ | ∞ | ∞ | ∞ |
| Year 1 | 100.596 | 94.76 | 0.3925 | -0.2369 | -0.2448 | -26.178 |
| Year 2 | 98.9839 | 97.6028 | 0.3862 | 0.1439 | 0.1362 | 14.82203 |
| Year 3 | 93.0362 | 100.5309 | 0 | 0 | 0.0754 | 8.255988 |
| Year 4 | 78.6531 | 103.5468 | 0 | 0 | 0.1671 | -21.0867 |
| Year 5 | 47.9359 | 106.6532 | 0 | 0 | 0.1045 | -27.8249 |

Gamma=93%

| ∞ | Asset | Liability | Optimal x | r Credit | r E | Surplus |
|--------|----------|-----------|-----------|----------|---------|----------|
| Year 0 | 100 | 92 | ∞ | ∞ | ∞ | ∞ |
| Year 1 | 104.5692 | 94.76 | 0.6023 | -0.2327 | -0.2448 | -28.7152 |
| Year 2 | 110.7908 | 97.6028 | 0.6381 | 0.1489 | 0.1362 | 15.0111 |
| Year 3 | 120.1779 | 100.5309 | 0.6922 | 0.0892 | 0.0754 | 8.6255 |
| Year 4 | 135.7018 | 103.5468 | 0.7816 | 0.1827 | 0.1671 | 18.6449 |
| Year 5 | 163.2011 | 106.6532 | 0.94 | 0.1233 | 0.1045 | 12.2005 |

Rho=17%, rA=10%, A0=100, L0=92

Solvency Analysis For LAPFs



Note: High Dutch Insurance Supervisory Board Solvency Margin ($\rho=30\%$) does not help.

Concluding Remarks

- Subprime lender with default rates in excess of 10% will be insolvent by year 4.5.
- Default on MBS resulting in insolvency of originator can result in huge loss of value. Entire portfolio of these can become worthless.
- Institutions with large portfolios up to $X=38\%$ of sub-prime credit assets (with $\gamma=90\%$ and above) will be insolvent by year 2.

High Dutch Insurance Supervisory Board Solvency Margin ($\rho=30\%$) does not help.

- **Future research to fully incorporate CDO structure**
- **Bear Raids**
- **Mark to market accounting**
- **The short money market**
- **Central Banks**