

# Correlation - Products

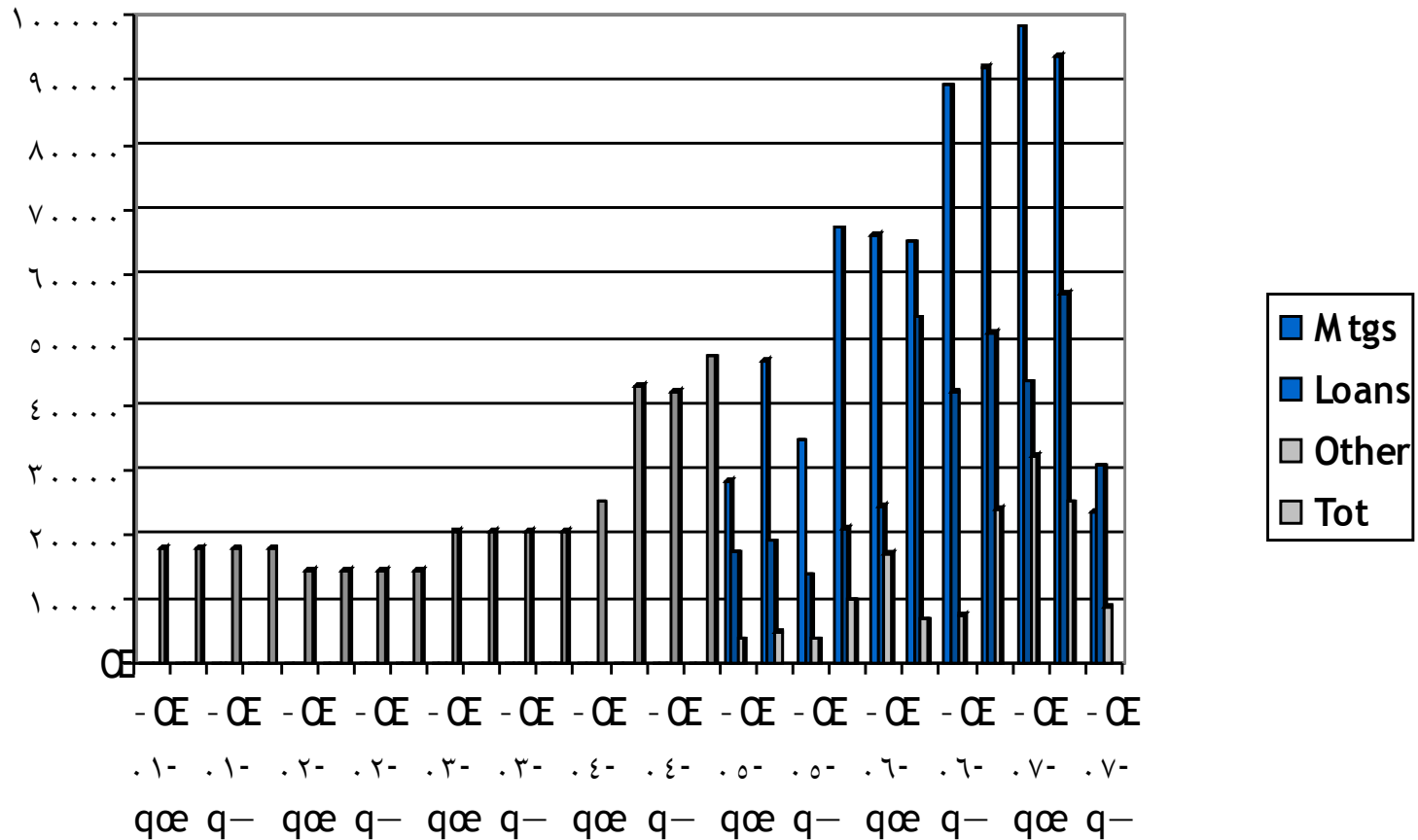
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NYU-Stern and London Business School (LBS), and LBS

Credit Risk Elective  
Spring 2009

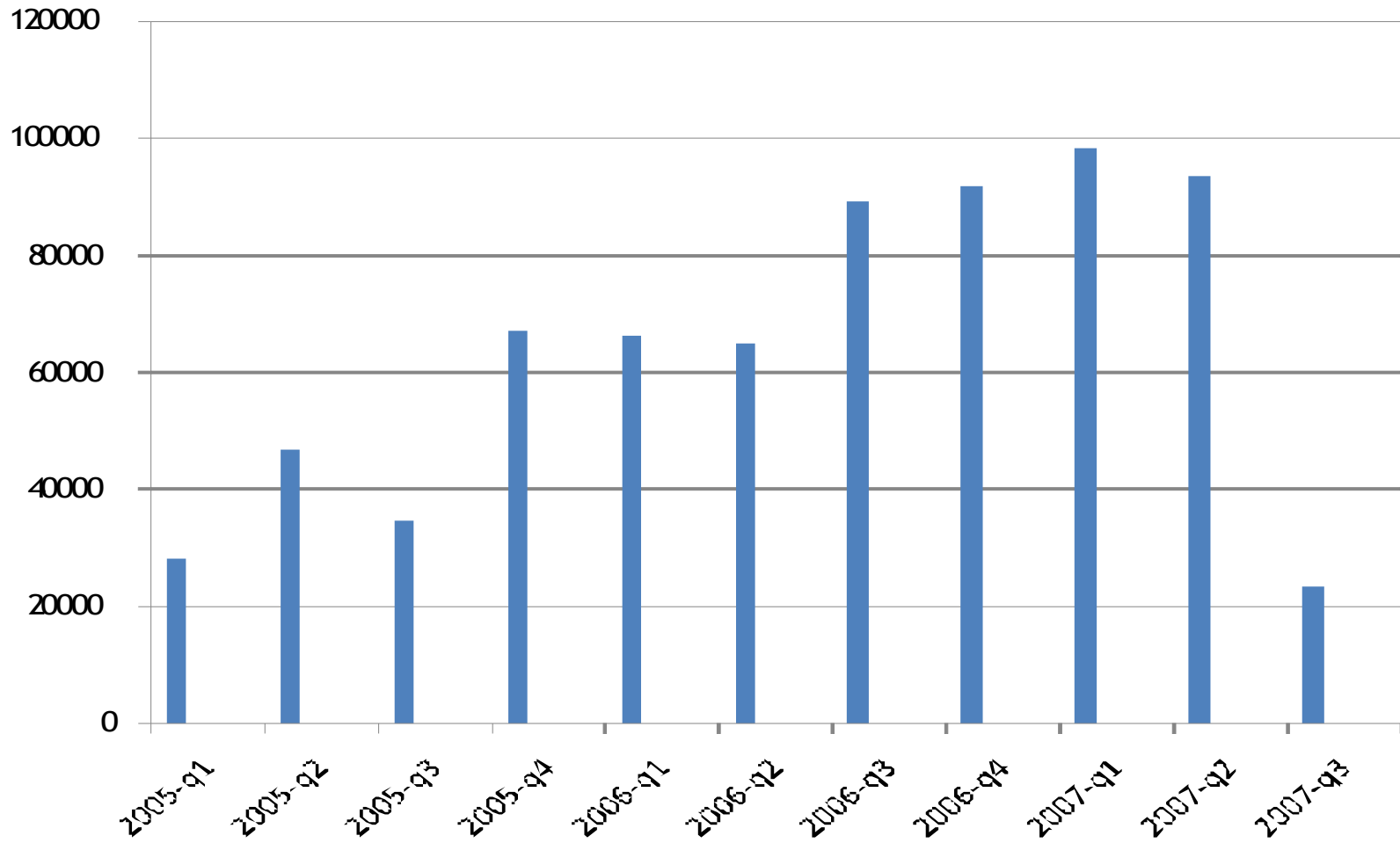
# CDO Issuance (\$millions)

Source: SIFMA



# SIZE of Mortgage-backed CDO Issuance (\$mm),

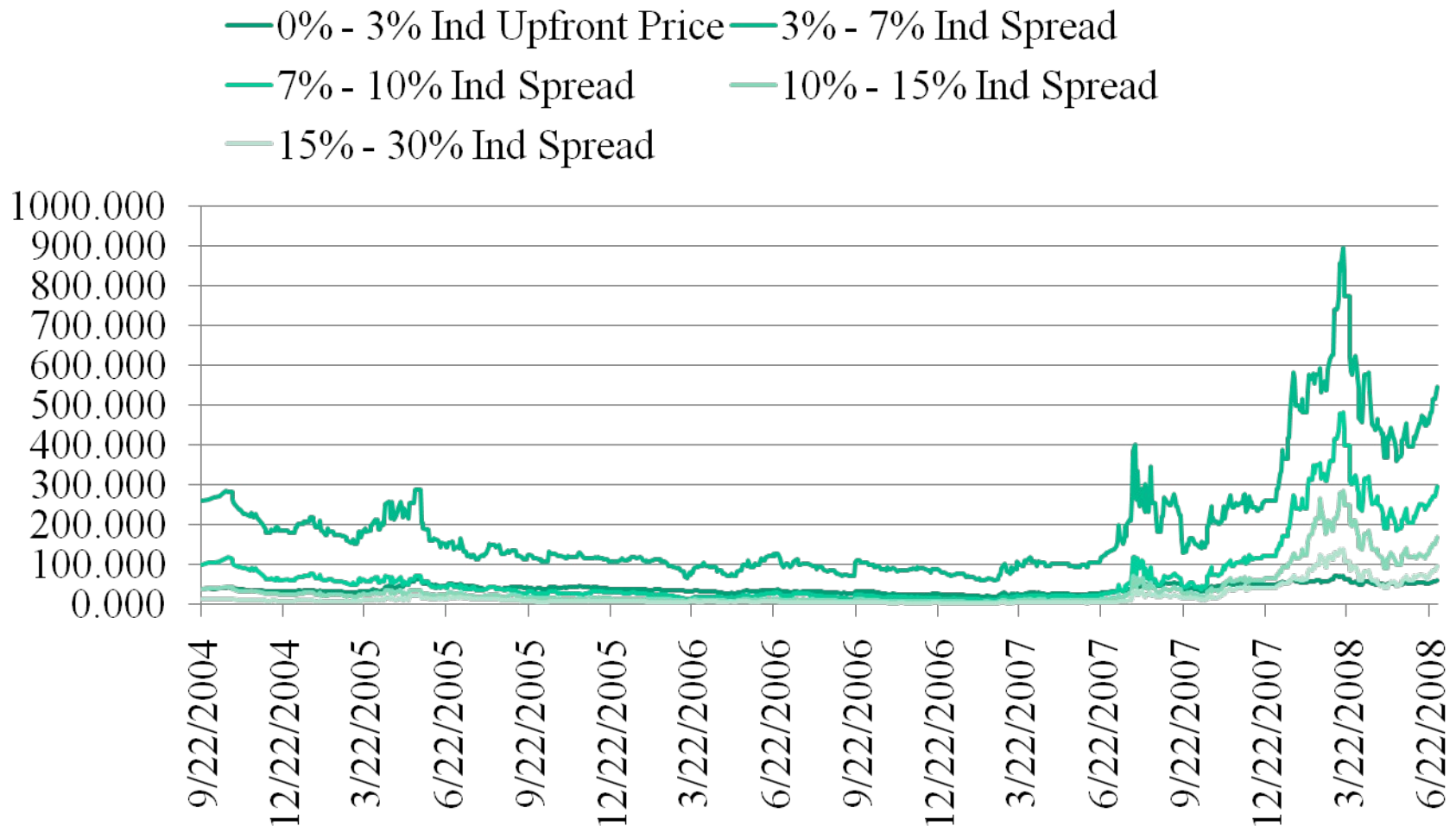
Source: SIFMA



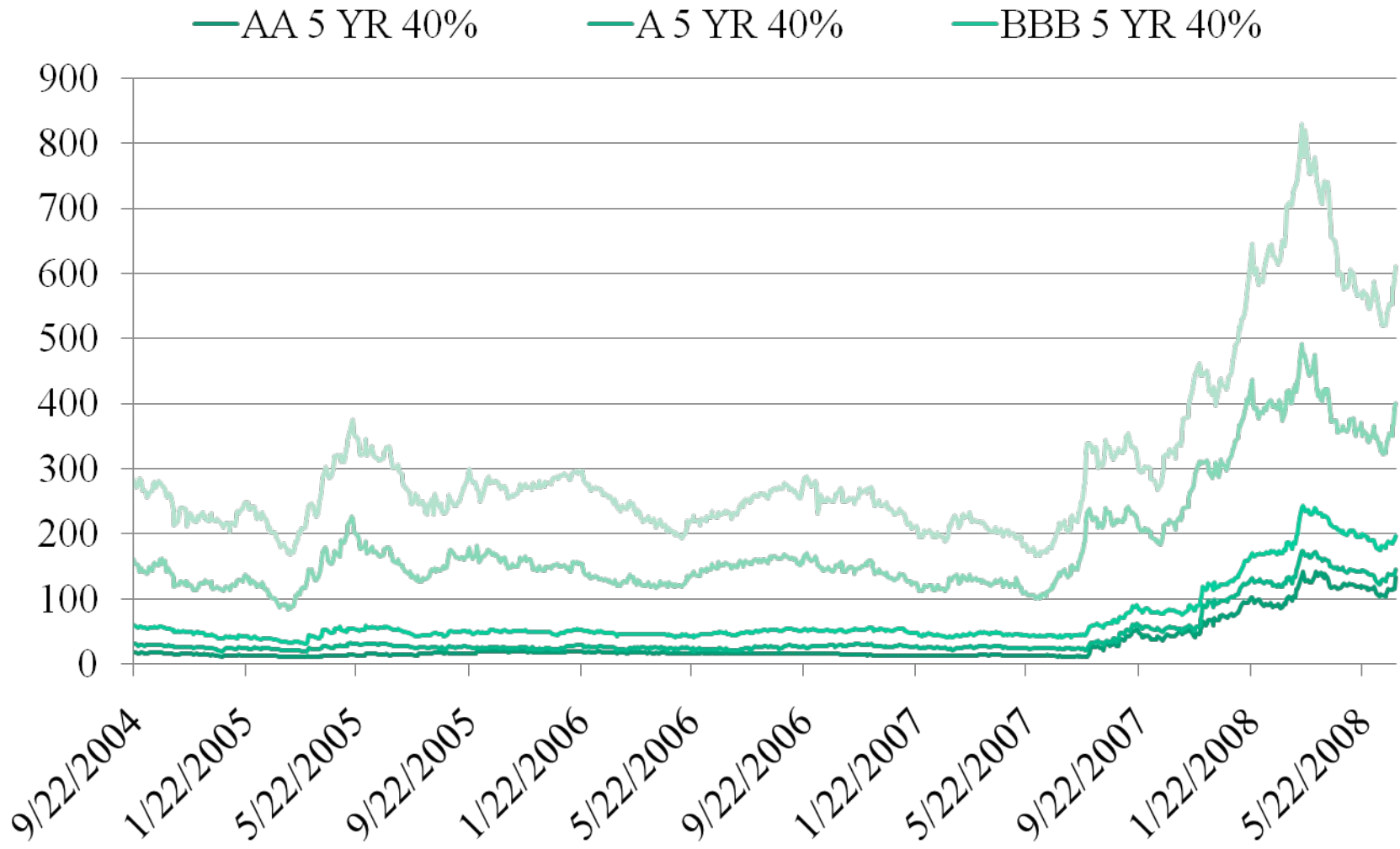
# Banks “Bet” on the AAA tranches: Holders of Mortgage-backed Debt

	Loans	HELOC	Agency MBS	<b>Non-Agency AAA</b>	CDO Subord	Non CDO Subord	Total	
Banks & Thrifts	2,020	869	852	<b>383</b>	90		4,212	39%
GSEs & FHLB	444		741	<b>308</b>			1,493	14%
Brokers/dealers			49	<b>100</b>	130	24	303	3%
Financial Guarantors		62			100		162	2%
Insurance Companies			856	<b>125</b>	65	24	1,070	10%
Overseas			689	<b>413</b>	45	24	1,172	11%
Other	461	185	1,175	<b>307</b>	46	49	2,268	21%
Total	2,925	1,116	4,362	<b>1,636</b>	476	121	10,680	
	27%	10%	41%	15%	4%	1%		

# Gyrations in the price of CDO tranches



# Gyrations in corporate bond spreads



# Outline

- Basket credit derivatives
  - ✓ FTD swaps
  - ✓ CLOs, CBOs etc.
- Correlation
  - ✓ why correlation is important
  - ✓ impact on FTD swaps
- CDOs and CDO tranches
- Index products
  - ✓ Again, why correlation is important
  - ✓ How correlations changed during the crisis of 2007-09

# Basket Default Products

- *Basket default swaps*: provides protection against one or more defaults in basket of  $n$  issuers/names
- *First-to-default swaps*: provides protection against *first default* in basket of  $n$  issuers/names
- *$k^{\text{th}}$ -to-default swaps*: provides protection against  *$k^{\text{th}}$  default* in basket of  $n$  issuers/names
- *First- $m$ -of- $n$  to default swaps*: provides protection against *first  $m$*  defaults in basket *of  $n$*  issuers/names



# Basket Products: first-to-default and first-m-of-n to default swaps

- A first *m-of-n* to default swap can always be decomposed into a portfolio of first-to-default swaps (but very cumbersome for large  $n$ )
- *Example*: a *first 2-of-3* to default swap on firms  $A$ ,  $B$  and  $C$
- This contract may be *replicated* by the following portfolio of *first to default* swaps:
  - ✓ *long* position in *three first-to-default* swaps on firms  $(A, B)$ ,  $(B, C)$  and  $(A, C)$ ;
  - ✓ *short one first-to-default swap* on firms  $(A, B, C)$ ;
- The payoffs are show on the next slide

# Constructing a “first 2 of 3” to default swap from a portfolio of FTD swaps

## Payoff on Contracts\*

		<i>Defaults</i>							
<b>Contract</b>	<b>Holding</b>	<b>None</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>AB</b>	<b>AC</b>	<b>BC</b>	<b>ABC</b>
<i>FTD on AB</i>	+1	0	-L	-L	0	-L	-L	-L	-L
<i>FTD on AC</i>	+1	0	-L	0	-L	-L	-L	-L	-L
<i>FTD on BC</i>	+1	0	0	-L	-L	-L	-L	-L	-L
<i>FTD on ABC</i>	-1	0	+L	+L	+L	+L	+L	+L	+L
<i>Total</i>		0	-L	-L	-L	-2L	-2L	-2L	-2L
<i>First 2 to Def on ABC</i>		0	-L	-L	-L	-2L	-2L	-2L	-2L

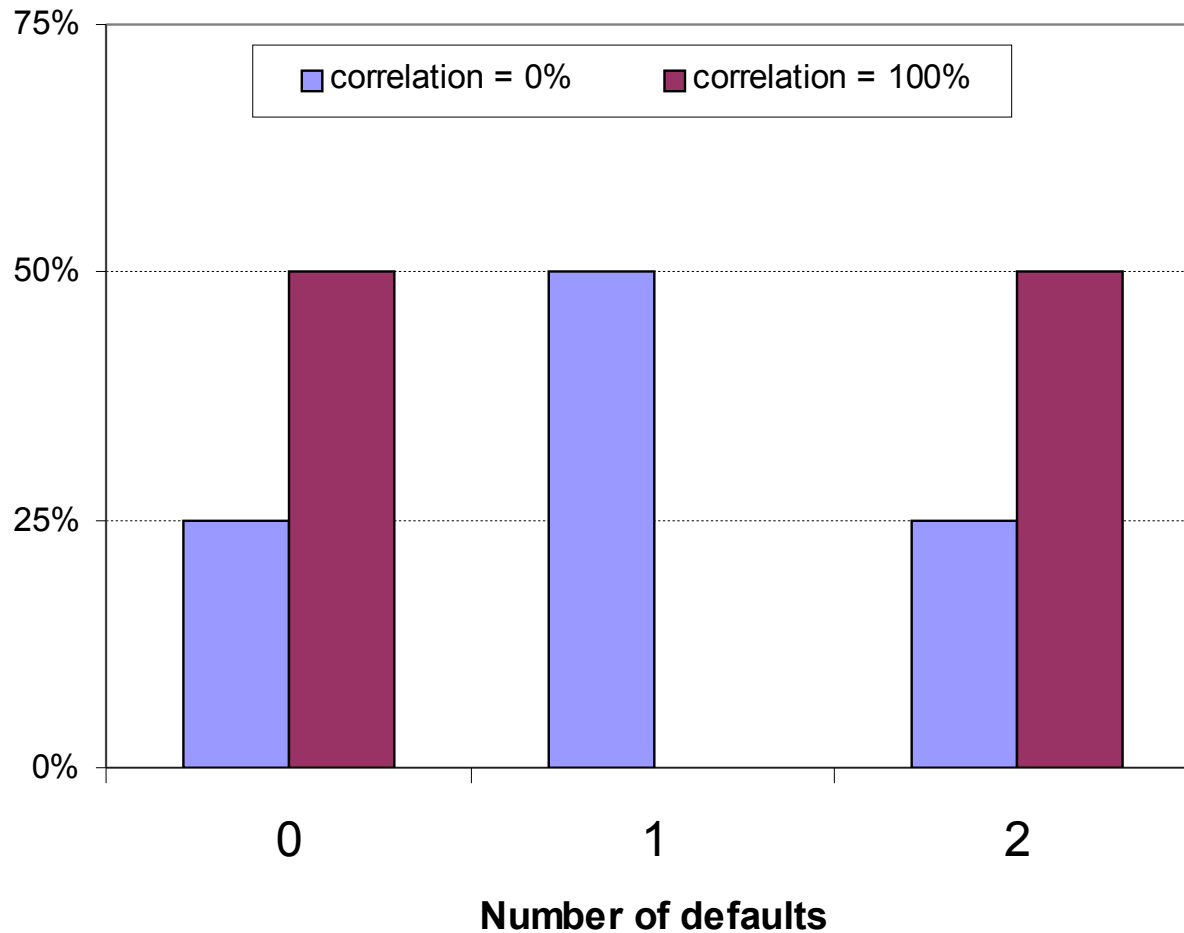
\**Note*: “L” represents the loss given default

# Effect of Correlation on FTD Swaps

- With *low correlation* a diversified portfolio of credits will have a loss distribution that is *centred* around the *expected value*
  - ✓ *small chance* of *large* portfolio *losses*
  - ✓ *small chance* of *low* portfolio *losses*
- As correlation increases the probability of both small and large portfolio losses increases
- With *perfect correlation* either
  - ✓ **0%** credits default
  - or
  - ✓ **100%** credits default

# Effect of Correlation – Two Assets

- Suppose assets A & B both have default probabilities of 0.5



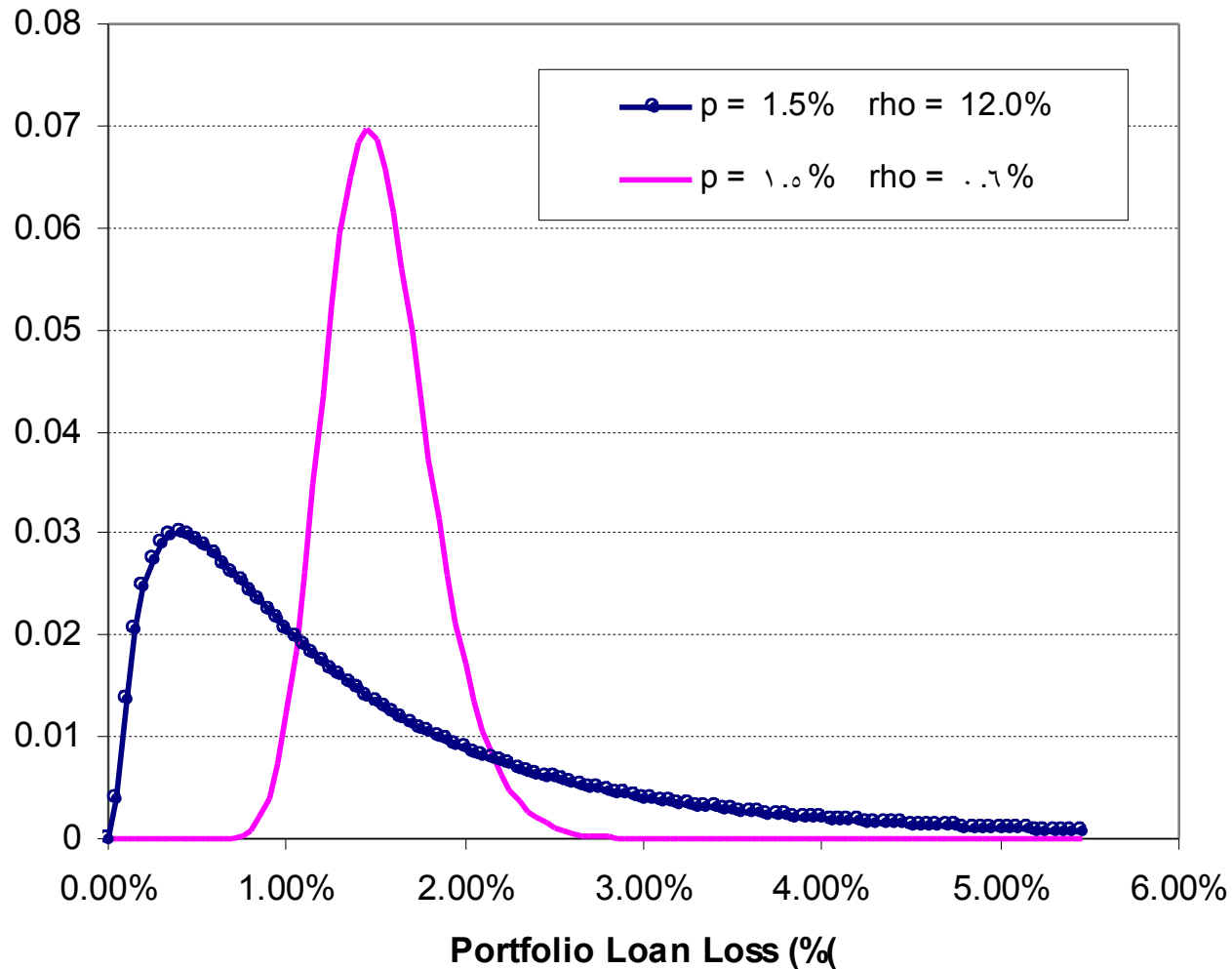
# Limits on FTD Pricing

- Zero correlation:
  - ✓ the default intensity for the first-to-default is simply the sum of the individual credit intensities.
  - ✓ FTD spread in this case is close to the sum of the spreads
- 100% correlation (not often observed)
  - ✓ FTD spread is close to the maximum spread in the basket.

# The Distribution of Portfolio Losses

- *Default* is a *binomial* event: it happens or it doesn't
- With a fixed recovery rate the distribution of portfolio losses is the distribution of the *number of defaults*
- But *difficult* to include default *correlation* directly into standard binomial framework

# Loan Loss Distribution with $p = 1\%$ and $\rho = 12\%$ and $0.6\%$



# The Basel II Capital Structure Rules and Generalisations

- Under the new *Basel II* rules, *bank capital* for banks using the so-called “internal ratings based (*IRB*) approach” is calculated using a version of this model (derived originally by Vasicek)
  - ✓ But model assumed *time-invariant* correlations!
- The approach can be generalised to accommodate multiple factors (e.g., industry sectors, geographical characteristics etc.)
  - ✓ this provides a potentially *better characterisation* of *asset correlation*
  - ✓ but at the expense of having *no simple formula* for the distribution of loan losses



# Warren Buffet on Derivatives – March 2003

- I view derivatives as *time bombs*, both for the parties that deal in them and the economic system.
- I believe, however, that the macro picture is dangerous and getting more so. *Large amounts of risk, particularly credit risk, have become concentrated in the hands of relatively few derivatives dealers*, who in addition trade extensively with one other. The troubles of one could quickly infect the others.
- In my view, *derivatives are financial weapons of mass destruction*, carrying dangers that, while now latent, are potentially lethal.

Berkshire Hathaway annual report for 2002

# Examples of Other Basket Products

- *Index* Products
  - ✓ CDX, iTraxx, etc.
- *Tranched* index products
  - ✓ structure
  - ✓ motivation
  - ✓ valuation and hedging

# Credit Index Products

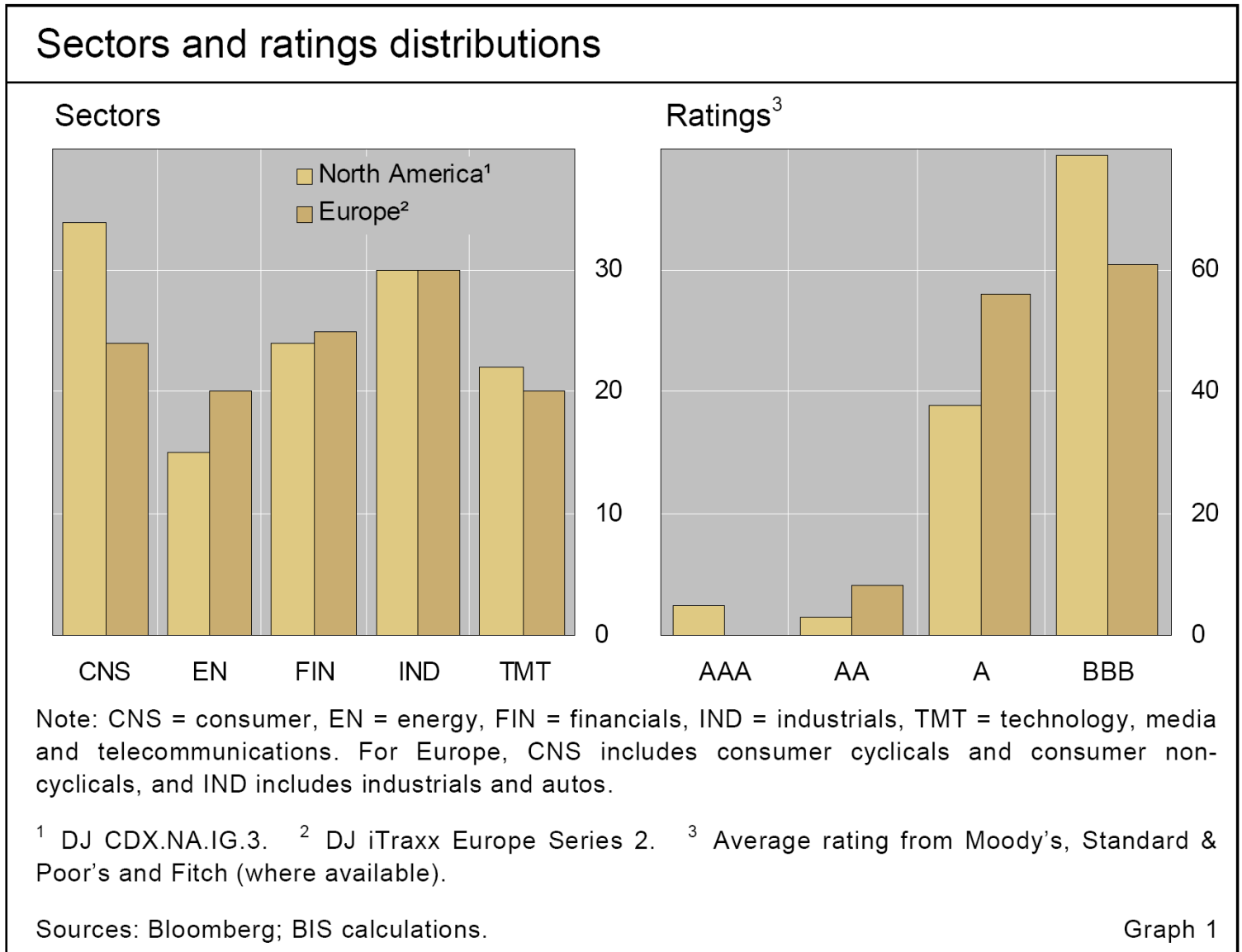
# Index Products

- *CDS index* .. just a *portfolio* of single-name CDS
  - ✓ *protection seller* provides protection (and receives premium) on *portfolio of names* (rather than on just one).
- *Wide range* of indices
  - ✓ CDX
  - ✓ iTraxx
  - ✓ .... and many sub-indices

CDS indices <sup>1</sup>						
By region						
	North America	Europe	Japan	Asia excl Japan	Australia	Emerging markets
Master	CDX.NA.IG (125) CDX.NA.HY (100)	iTraxx Europe (125) iTraxx Corporate (52) <sup>4</sup> iTraxx Crossover (30) <sup>5</sup>	iTraxx CJ (50) <sup>2</sup>	iTraxx Asia (30)	iTraxx Australia (25)	CDX.EM (14) <sup>3</sup>
Sub-indices	Financials (24) Consumer (34) Energy (15) Industrials (30) TMT (22) HiVol (30) B (44) BB (43) HB (30)	Financials (15) Autos (10) Consumer cyclicals (15) Consumer non-cyclicals (15) Energy (20) Industrials (20) TMT (20) HiVol (30)	Financials (10) Capital goods (10) Tech (10) HiVol (10)	Korea (8) Greater China (9) <sup>6</sup> Rest of Asia (13) <sup>7</sup>	None	None
<p><sup>1</sup> Earlier generations of DJ Trac-x and iBoxx indices are still traded. This table summarises the composition of the most recently issued series, DJ CDX and DJ iTraxx, which are a by-product of the merger between the DJ Trac-x and iBoxx families. The number of reference entities in each index is given in parentheses. <sup>2</sup> Maximum of 10 names in a given sector. <sup>3</sup> Includes only sovereigns: Brazil, Bulgaria, Colombia, Korea, Malaysia, Mexico, Panama, Peru, the Philippines, Romania, Russia, South Africa, Turkey and Venezuela. <sup>4</sup> Includes the largest, most liquid non-financial names from the iBoxx EUR Corporate bond index. <sup>5</sup> Most liquid non-financial names rated BBB/Baa3 or lower and on negative outlook. <sup>6</sup> Includes China, Hong Kong SAR and Taiwan (China), with at least two names from each. <sup>7</sup> Includes India, Malaysia, the Philippines, Singapore and Thailand.</p>						

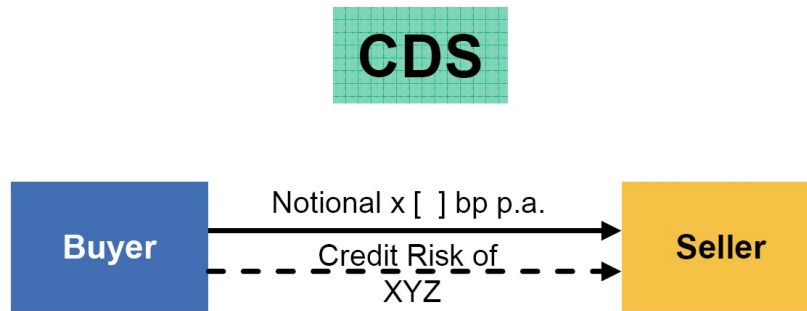
Table 1

# Credit Indices: Sector and Rating Distribution

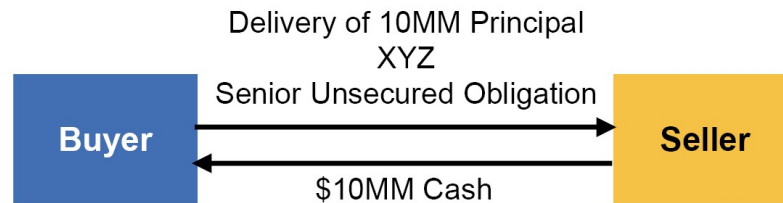


# Dow Jones CDX.NG.IG Structure

## Single Name Credit Default Swaps

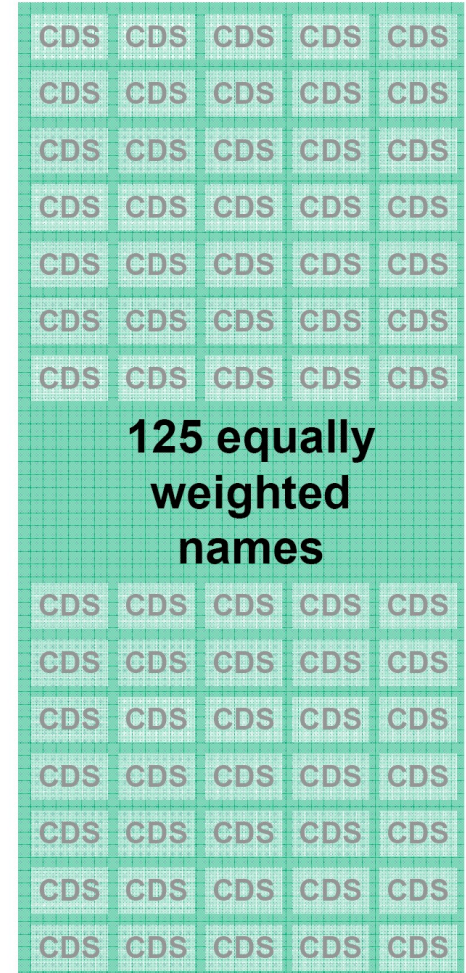


Notional: USD 10MM



Occurrence of a Credit Event  
(Physical Settlement)

## Index Products Dow Jones CDX.NA.IG



Source: Morgan Stanley

# Dow Jones CDX.NG.IG: Portfolio Characteristics

- ***Composition*** of the IG Index
  - ✓ 125 most liquid investment grade credits domiciled in North America;
  - ✓ determined by Dow Jones
  - ✓ initially strictly investment grade credits; no high yield or distressed credits are included
- ***Equal weightings*** for all credits
- ***Diverse pool*** of credits across industry sectors: represents a broad exposure to the investment grade corporate market
- ***Reference Entities cannot be added*** and will ***only*** be ***removed*** upon the triggering of a ***credit event***
- A majority vote is required by members to determine which reference entities will be removed from the Index



# Why are the Index Products Important?

- As with *single name CDS*, provides ability for investors to:
  - ✓ take *long* and *short* positions in credit
  - ✓ take credit exposure either *leveraged* or *unleveraged*
- *Index products* also provide:
  - ✓ ability to specialise exposure by
    - *geographical* region and *industry*
    - credit *quality*
  - ✓ ability to *hedge* single name credit *against* movement in *market* spread
  - ✓ high *liquidity*

# Tranched Products

# Tranched Products – Example: Cash CDO

- *Assets*

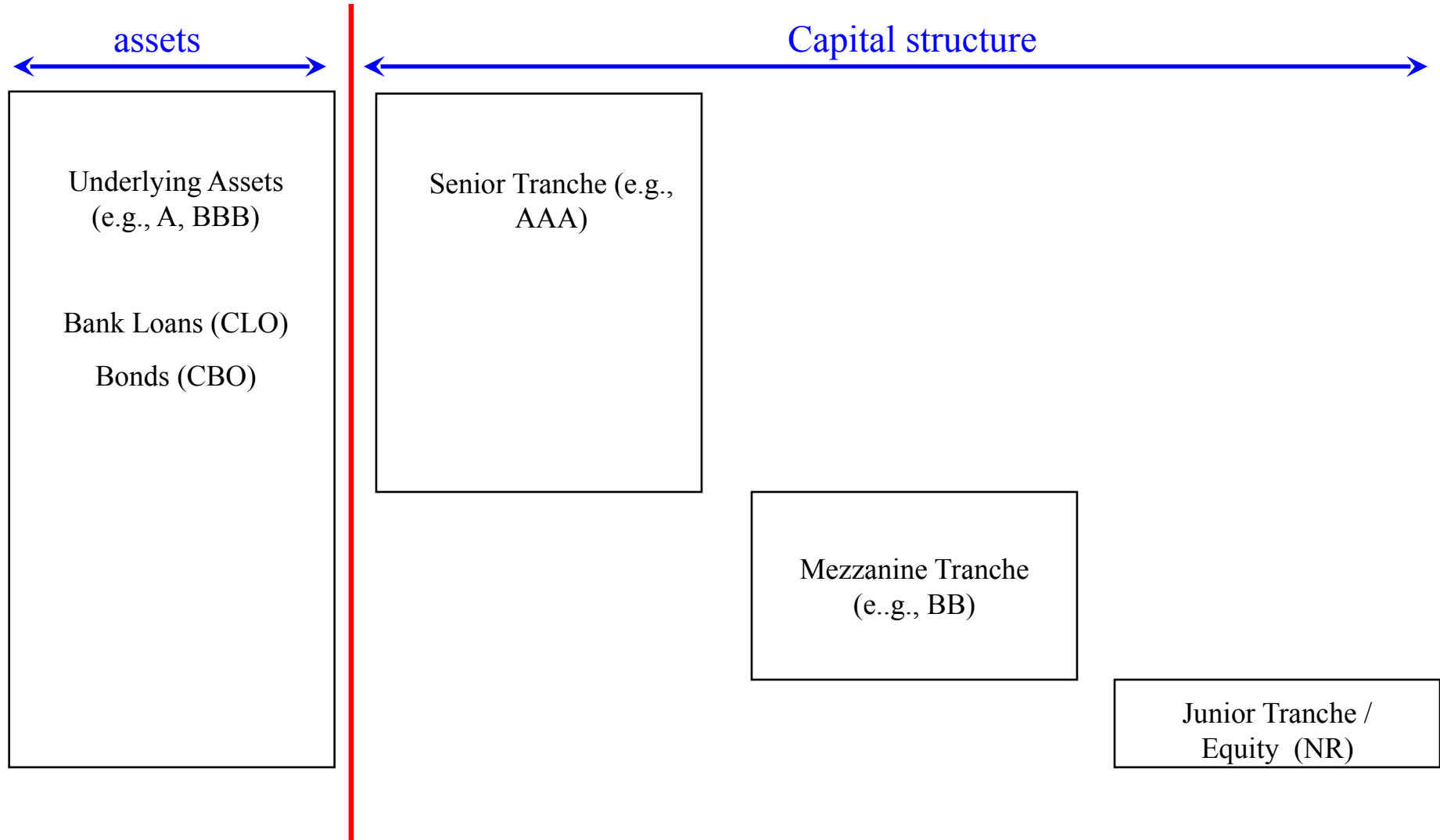
- ✓ *homogeneous* portfolio of “average” quality loans / bonds (e.g., A/BBB)

- *Liabilities*

- ✓ series of “tranches” that have *unequal exposure* to portfolio losses
- ✓ *senior tranche* – bears losses only if losses exceed 30% (say) of portfolio value
- ✓ *equity tranche* – bears initial losses (up to limit)

*“repackaging”*

# Structure of Collateralised Loan and Bond Obligations



# Investor preferences and Repackaged /Tranched Structures

- *Cash flow* and *risk* characteristics of underlying assets may not fit easily into investor portfolios
  - ✓ *Cash flow frequency* (MBS\* - monthly vs. 6-monthly)
  - ✓ *prepayment exposure* (tranching MBS redistribute prepayment risk)
  - ✓ *credit risk*: may be better market for large volume of AAA and small volume of lower grade than 100% A/BBB

\**Note*: mortgage backed securities

# Other Features of Tranched Structures

- ***Regulation***: banks reduce their capital requirements by moving credit risk off balance
  - ✓ tranced ***cash CLOs*** have been used to do this for many years (i.e., ***selling loans***)
  - ✓ with ***CDS*** ... credit risk can be moved off balance sheet by ***buying credit protection*** rather than selling loan (synthetic CDO/CLO)

# Funded vs. Unfunded Credit Exposure I

## *Selling protection via CDS*

- *Selling protection via CDS* is approximately same as *long position* in *credit risky bond* and *short position* in *riskless bond*
  - ✓ i.e., 100% leveraged position in risky bond
- Provides *unfunded exposure* to credit risk:
  - ✓ receives premium (equivalent to spread)
  - ✓ in default, seller must pay LGD (net)
- **Implication**: because payment of LGD in default not paid up front, credit protection provided by CDS is *unfunded*

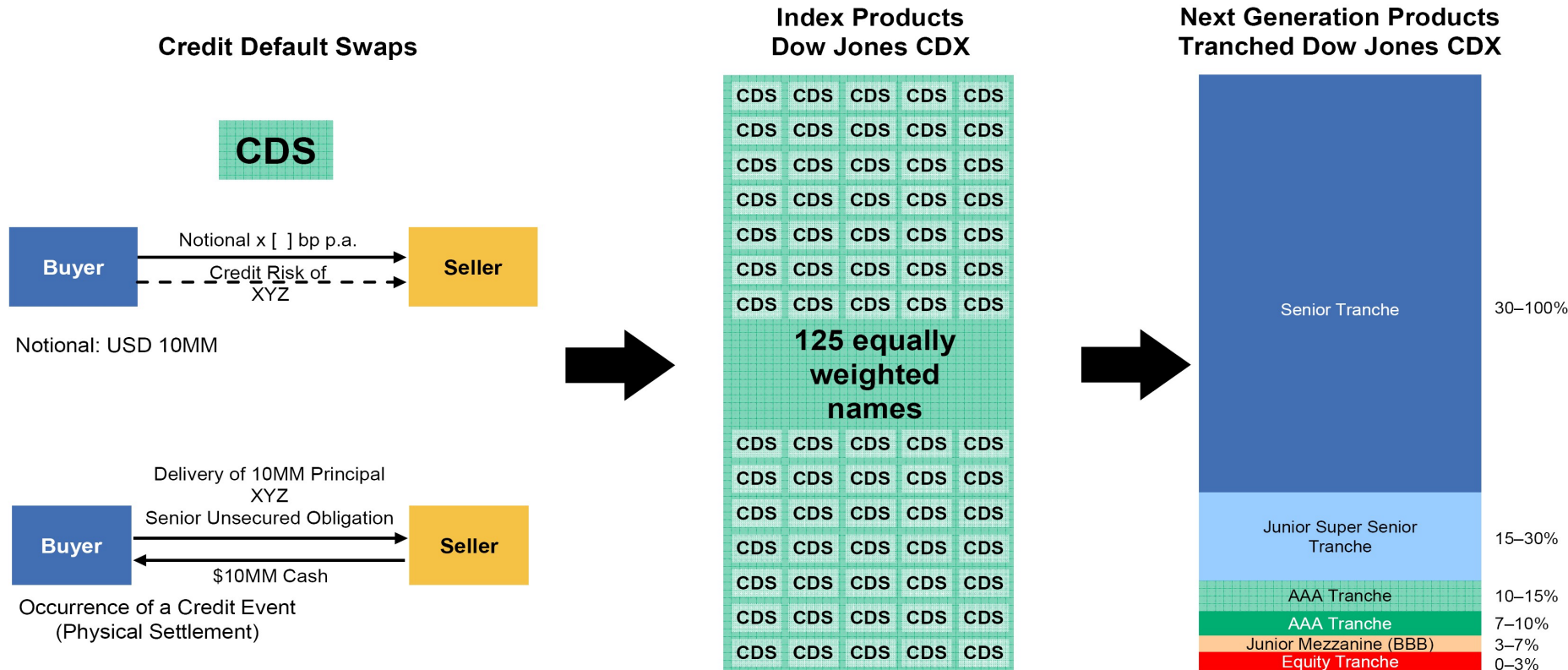
# Funded vs. Unfunded Credit Exposure II

## *Holding risky bond*

- *Bondholder* receives spread (equivalent to CDS premium)
- *In default*, bond holder “pays” LGD (net) by accepting recovery amount in exchange for giving up claim on par
- Implication: *protection is funded* – in default only payment is due from *purchaser* of protection (bond issuer) who pays recovery to *seller* of protection (holder)
- *In contrast*: CDX *indices (tranching and untranching)* and single name CDS provide *unfunded* exposure



# Tranched Dow-Jones CDX Structure



# Tranched 125 Name DJ.CDX.NA.IG Series 5

## (Illustrative Pricing 16 Feb, 2006)

<b><i>Tranche</i></b>	<b><i>Estimated Rating</i></b>	<b><i>Market Quote (bp)</i></b>
15% - 30%	AAA (junior super senior)	4/5
10% - 15%	AAA (junior super senior)	12/13
7% - 10%	AAA (junior super senior)	26/26
3% - 7%	BBB-	108/110
0% - 3%	Not rated	35.4% / 35.9% + 500 bp

*Source:* Morgan Stanley

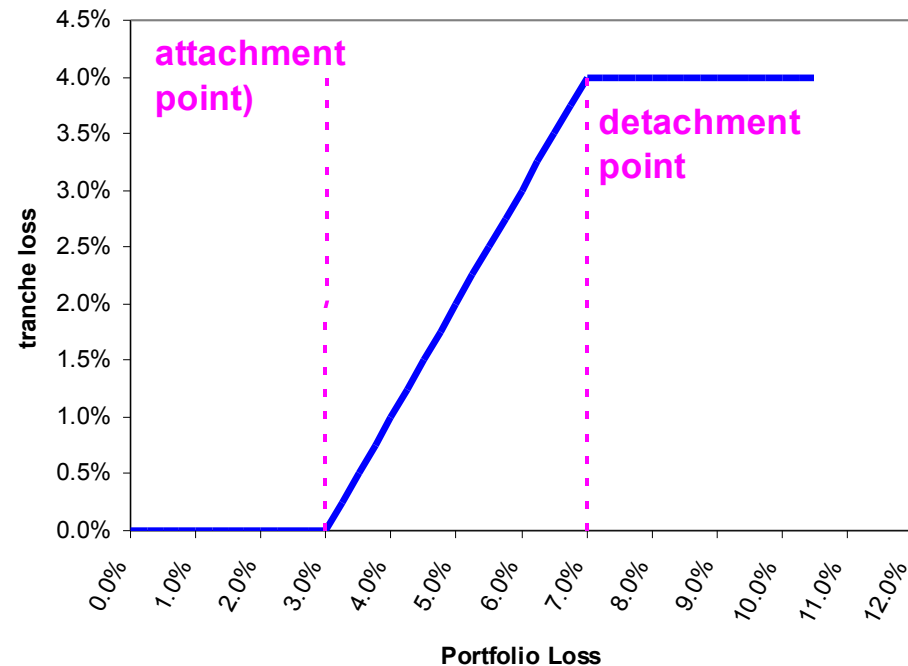
# Attachment and Detachment Points

- Each tranche is defined in terms of its *attachment* ( $\beta_A$ ) and *detachment* ( $\beta_D$ ) points
  - ✓ these are measured in terms of losses as percent of total face value of basket
- The *attachment* point defines the limit *below which* the tranche bears *none* of the *loss*
- The *detachment* point defines the limit *above which* the tranche loss *does not increase*

# Tranche Loss Payments

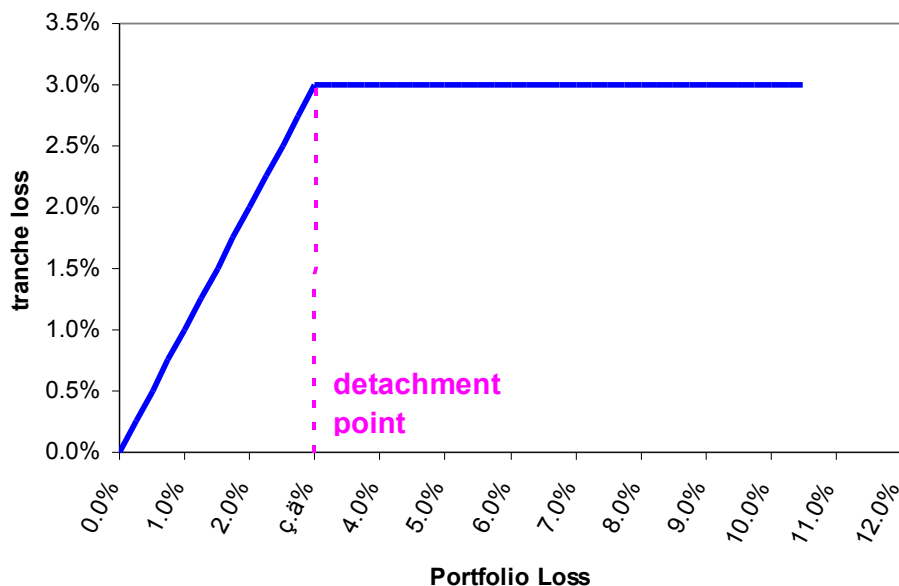
- If total losses (as a percent of the total nominal portfolio value) are  $L$ , then for a tranche with attachment and detachment points  $\beta_A$  and  $\beta_D$  the tranche loss payment is:

$$\text{Tranche Loss} = \begin{cases} 0 & L < \beta_A \\ L - \beta_A & \beta_A \leq L \leq \beta_D \\ \beta_D - \beta_A & L > \beta_D \end{cases}$$



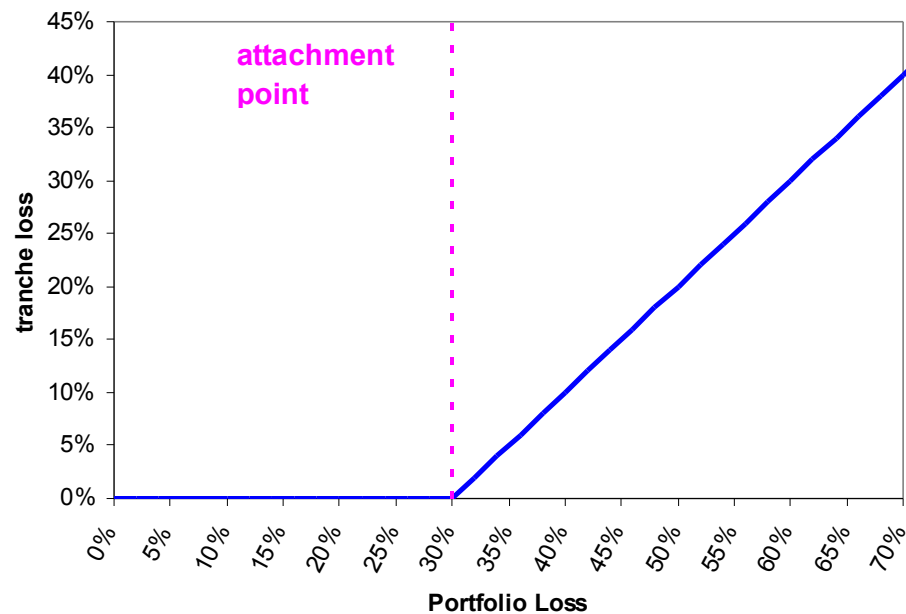
# Tranche Loss Payments: Equity and Senior Tranche

Equity Tranche



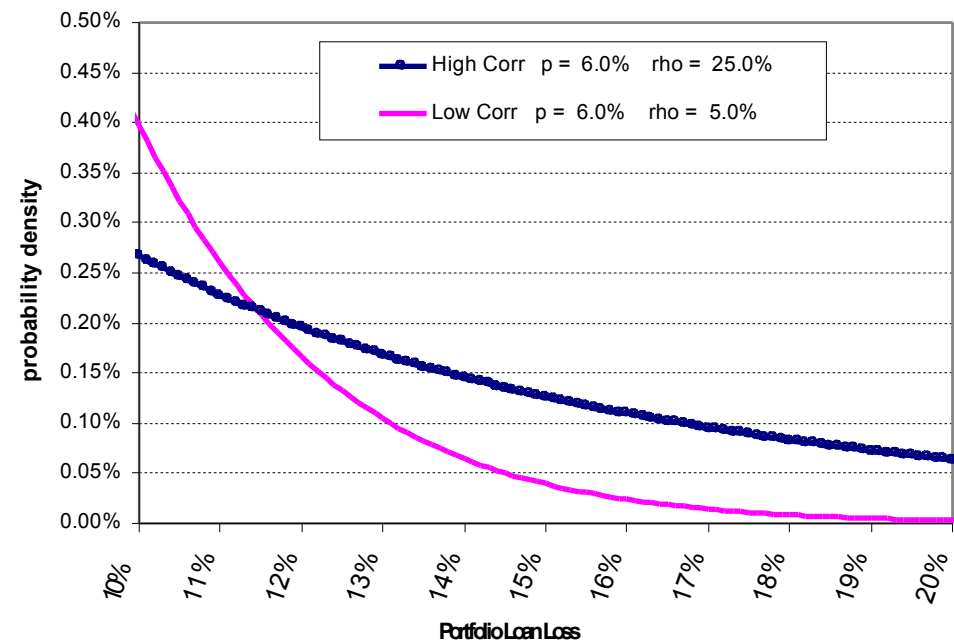
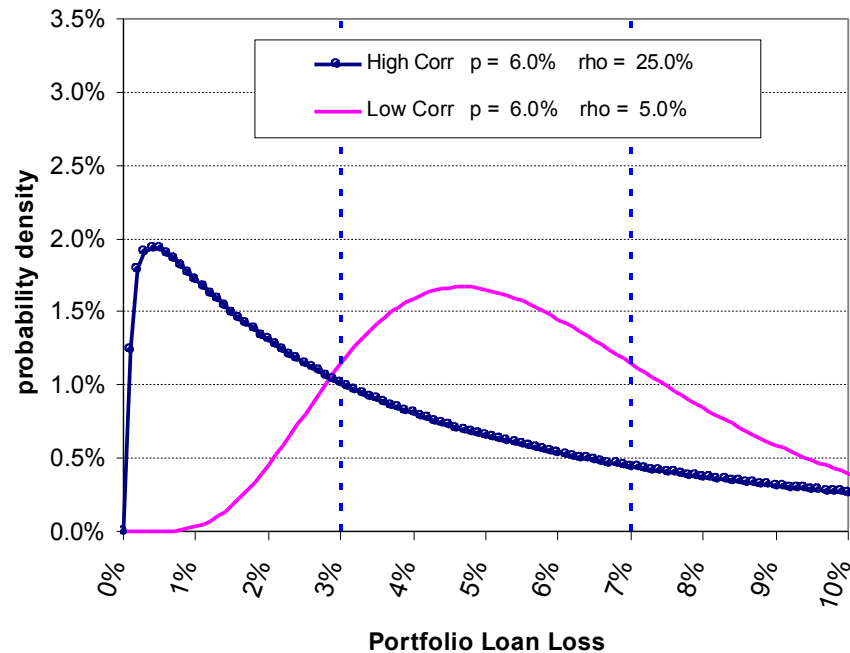
- *Equity tranche* loss is *concave* in portfolio loss: expected loss on tranche *decreases* (and *value of tranche increases*) with variance of portfolio loss

Senior Tranche



- *Senior tranche* loss is *convex* in portfolio loss: expected loss on tranche *increases* (and *value of tranche decreases*) with variance of portfolio loss

# Effect of Correlation on Loss Distribution and Tranche Values

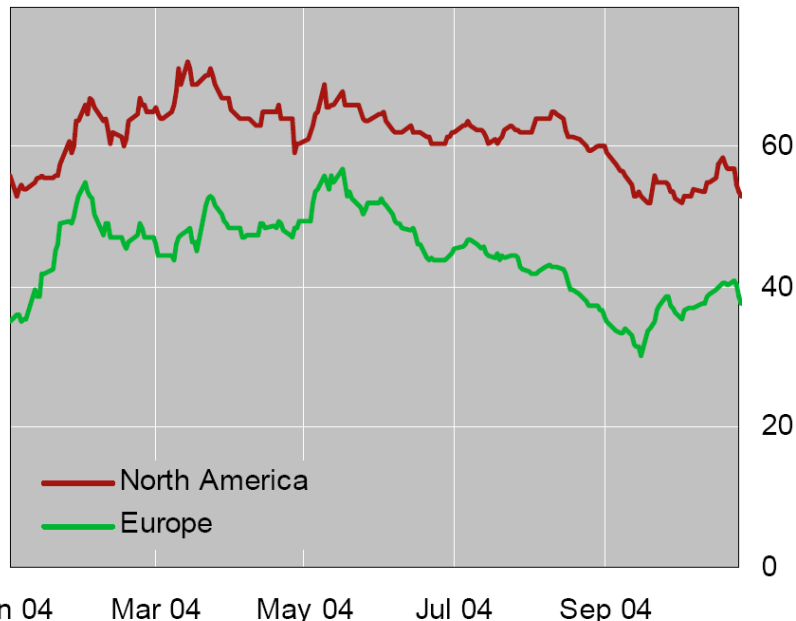


	<i>Equity</i>	<i>Mezz</i>	<i>Senior</i>	<i>Total*</i>
<b>Attachment</b>	0%	3%	7%	0%
<b>Detachment</b>	3%	7%	100%	100%
<b>Correlation</b>	<b>Expected Loss</b>			
<b>5%</b>	<b>2.94%</b>	<b>2.39%</b>	<b>0.72%</b>	<b>6.0%</b>
<b>25%</b>	<b>2.29%</b>	<b>1.64%</b>	<b>2.12%</b>	<b>6.0%</b>

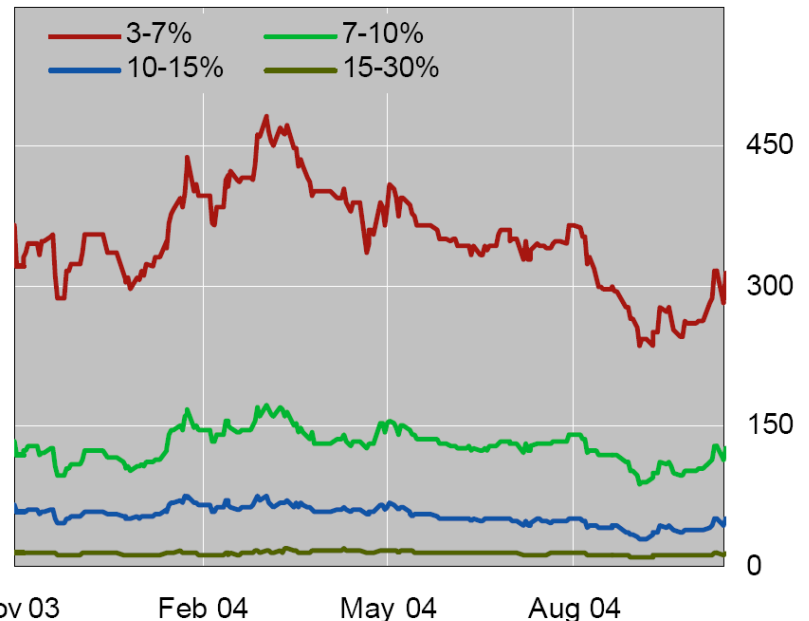
# CDS Spreads on Indices and Tranches

## CDS index spreads<sup>1</sup>

### Master investment grade indices



### Tranches<sup>2</sup>



<sup>1</sup> On-the-run five-year swap spreads, in basis points.

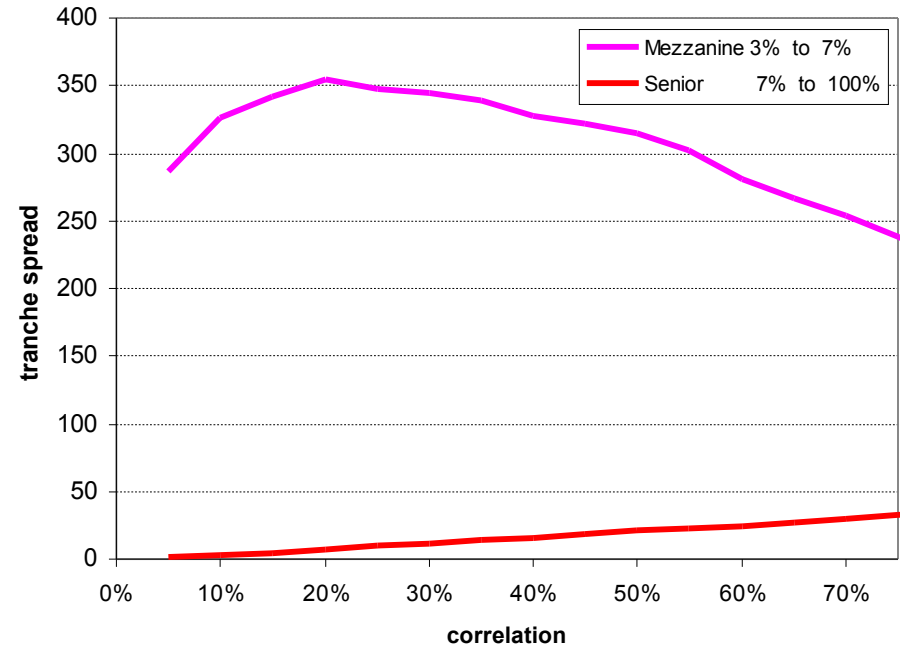
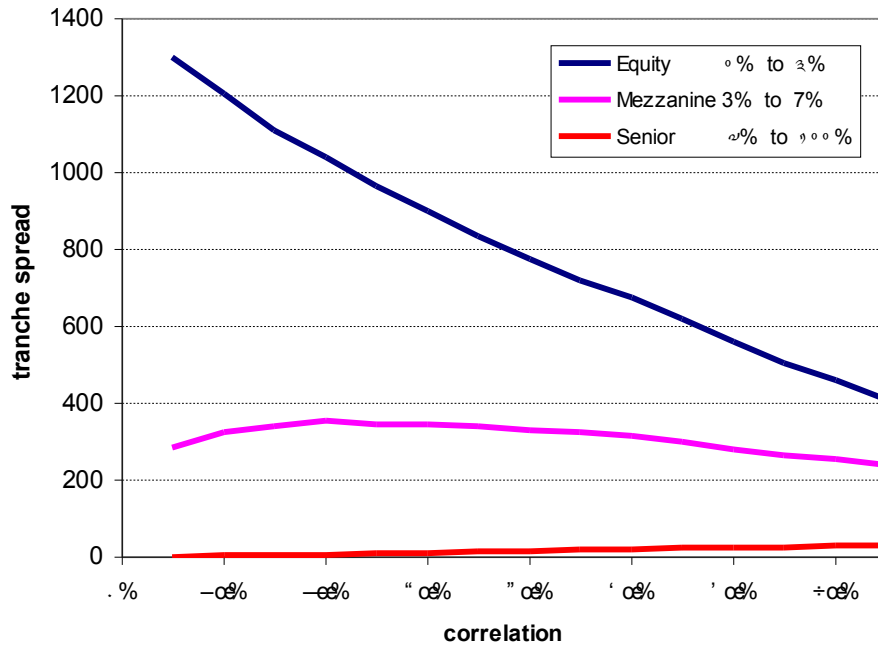
<sup>2</sup> North America master investment grade.

Source: JPMorgan Chase.

Graph 2

Source: Amato and Gyntelberg, "CDS Index Tranches and the Pricing of Credit Risk Correlations", BIS Quarterly Review, March 2005

# Tranche Spreads and Correlation



**Note:** number of names = 100; CDS spread = 100 bps; LGD = 0.6;