Introduction to focus session on Credit risk

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- Intro to Credit Risk
- The credit spread puzzle
- Credit Derivative Markets
- The credit crisis
- Conclusion

Why study Credit Risk?

- Interesting data to test 'Out-of-sample' asset pricing models developed to price equity:
  - Time varying risk-premia
  - Crash-risk
  - Liquidity risk
  - Behavioral theories
  - Market inefficiency/segmentation
- Intersection between Corporate finance and Asset pricing
  - Dynamic capital structure
  - Agency theory
  - Financing Frictions
- Understand derivative markets
  - Who trades derivatives and why?
  - What market structure (OTC dealer market versus organized exchange)?
  - Role of financial intermediaries, securitization?

Two frameworks for pricing credit

- Two frameworks for pricing credit risk:
  1. Structural models of default
  2. Reduced-form (intensity-based) models of default

- Structural models based on contingent claim pricing (Black/Scholes/Merton)
  - Debt and equity seen as "options" on firm value
  - Provides many out-of-sample predictions (e.g., distance to default sufficient statistic)
  - Provides a framework for determining optimal capital structure and endogenous default boundary (Leland (1994))

- Reduced form models often specified using "latent variables" as state vector
  - Much flexibility to choose dynamics/initial values of latent variables
  - This flexibility allows researchers to match historical credit spreads well
  - Under certain assumptions, reduced form models are very tractable: risky bond prices take same functional form as do risk-free bond prices
  - However, reduced-form model are 'statistical' models (little economics).

Structural Models of default

- Typically underestimate default probabilities over short horizons
  - Can be improved by adding jumps to firm value dynamics
- Typically underestimate credit spreads
  - Especially true for investment grade, short maturity credit (Jones, Mason and Rosenfeld (1984), Huang and Huang (2003))
- Combining insights from asset pricing models (time-varying risk-premia) with dynamic capital structure models, recent papers obtain better results. (Chen et al (2009), Chen (2010), Bhamra, Kuehn and Strebulaev (2010a,b))
- Series of recent papers, add financing frictions (debt and/or equity issuance costs) to capture liquidity/credit interactions and other features (investment/cash relation). (Bolton, Chen and Weng (2011a,b), Hugonnier, Malamud, Morellec (2011a,b), He and Xiong (2011))
- Typically underestimate default correlations.
- Realistic models often do not provide tractable bond price formula

Reduced Form Models of default

- Abstract from the firm value process.
- Model default as a unpredictable stopping time τ_i with intensity λ_i.
  - λ_i analogous to $\Phi(DD)$ for estimating default probabilities
  - However, probability of default in short run much larger
- Consistent with structural model with incomplete information
  - (Duffie and Lando (2001))
- Provide no theory for the dynamics of intensity $d\lambda$
  - In that sense, model is "empirical"
- Under certain conditions ('doubly-stochastic jump processes'), prices of risky bonds take the same functional form as do prices of risk free bonds
  - Duffie and Singleton (1998), Lando (1998)
- These conditions however rule out 'contagion' risk-premia that might be important drivers of credit spreads.

The Credit spread puzzle

- Investment-grade (IG) firms rarely default:

Average Issuer-Weighted Cumulative Default Rates 1970-2004

Exhibit 18 - Moody's 2005 report

Years	1	2	3	4	5	6	7	8	9	10
Aaa	0.00	0.00	0.00	**0.04**	0.12	0.21	0.30	0.41	0.52	**0.63**
Baa	0.19	0.54	0.98	**1.55**	2.08	2.59	3.12	3.65	4.25	**4.89**

- Further, recovery rates are substantial:

Average Recovery Rates by Seniority Class, 1982-2004

Exhibit 27 - Moody's 2005 report

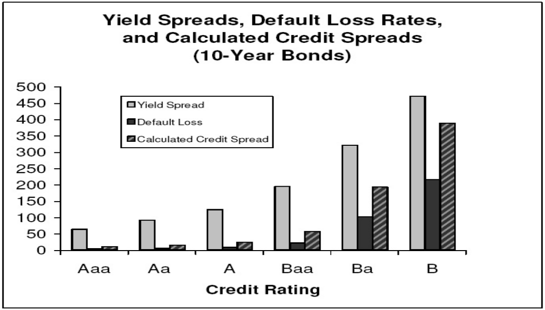
Year	Sr. Sec.	Sr. Unsec.	Sr. Subord.	Jr. Subord.	Subord.	All
Mean	0.574	**0.449**	0.391	0.320	0.289	0.422

- Structural models, when calibrated to match average loss rate, tend to underpredict yield spreads (relative to Treasury)

$\Rightarrow$ Structural models underestimate the risk-premium component of credit spreads, and/or

$\Rightarrow$ Spreads compensate for other factors (i.e, liquidity, taxes) in addition to credit risk

The Credit spread puzzle



source: Huang and Huang (2003)

- Huang and Huang (2003) find that Structural models, when calibrated to match average loss rate, tend to underpredict yield spreads
- Chen, Collin-Dufresne, Goldstein (2008) find that standard models cannot explain the level of observed spreads because:
  - (i) historical expected loss rates have been low, **and**
  - (ii) Idiosyncratic risk on typical IG bonds is very high ($\sim 3/4$ of total risk).

High credit spreads can (in theory) be explained by high systematic risk

- Consider simple Merton (1974) model

$$\frac{dV}{V} + \delta\, dt = (r + \theta\sigma)\, dt + \sigma\, dz$$

where θ is the asset value Sharpe ratio.

- Default occurs at T if $V(T)$ falls below B. in that case recover $1 - L$.

- Risky debt payoff is:

$$\min(F, V_T) = F - \max(F - V_T, 0)$$

$\Rightarrow$ risky debt is equal to risk-free debt minus a put option.

- Spread $(y - r)$ on a date-T zero coupon bond is:

$$(y - r) = -\left(\frac{1}{T}\right) \log\left\{ 1 - L\, N\Big[N^{-1}\left(\pi^P\right) + \theta\sqrt{T}\Big]\right\}.$$

$\Rightarrow$ Even though the model is specified by 7 parameters $\{r,\ \mu,\ \sigma,\ \delta,\ V(0),\ B,\ L\}$, credit spreads only depend on historical default probability, recovery and asset sharpe ratio $\{\pi^P, L, \theta\}$.

High credit spreads can (in theory) be explained by high systematic risk

	T = 4Y			T = 10Y		
Sharpe	Baa	Aaa	Baa-Aaa	Baa	Aaa	Baa-Aaa
0.15	44.0	1.6	42.4	67.7	12.0	55.7
0.20	54.9	2.2	52.7	88.1	17.4	70.7
0.25	68.1	3.0	65.1	112.8	24.6	88.2
0.30	83.7	4.1	79.6	141.7	34.2	107.5
0.35	102.0	5.5	96.5	175.1	46.6	128.5
0.40	123.4	7.4	116.0	212.9	62.2	150.7

Table: (Baa - Aaa) spreads as a function of Sharpe ratio. 4Y Baa default rate = 1.55%. 4Y Aaa default rate = 0.04%. 10Y Baa default rate = 4.89%. 10Y Aaa default rate = 0.63%. Recovery rate = 0.449.

source: Chen, Collin-Dufresne, Goldstein (2008)

- Typical Baa firm asset value Sharpe ratio estimated around 0.22.

⇒ The credit spread puzzle says that historically, strategy going long corporate bonds seems very appealing (i.e., typical models cannot explain the level of observed spreads) because:
  - (i) historical expected loss rates have been low, **and**
  - (ii) Idiosyncratic (diversifiable!) risk on typical IG bonds is very high ($\sim$ 3/4 of total variance).

Credit markets characterized by rapid financial innovation

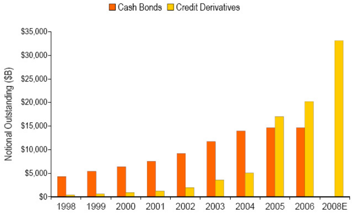
- Innovation in contracts,
  - from traditional *funded* securities: corporate bonds
  - to new *unfunded* derivatives: credit default swaps (CDS)
- And increased liquidity,
- Allow investors to express views on:
  - Single-names CDS
  - Baskets of names (CDX.IG, CDX.HV, iTraxx)
  - Correlation (Synthetic liquid CDO, Bespoke CDO, $\text{CDO}^2\ldots$)
  - Emerging Market Countries (EMCDS)
  - Basket of Countries (EMCDX)
  - Asset Backed Securities such as credit card receivables or Home equity loans (ABS-CDS)
  - Baskets of Asset Backed Securities (ABX)
  - Correlation (TABX)
  - Senior secured Loans (LCDS)
  - Basket of Loans (LCDX)

Single name CDS, CDX Index & CDX Tranche Markets

- Credit Default Swaps (CDS)
  - Buyer of protection makes regular (quarterly) payments = CDS spread
  - Seller of protection makes buyer whole if underlying bond defaults
  - CDS spread $\approx$ corporate bond spread $(y - r_f)$
- CDX Investment Grade (IG) Index
  - portfolio of 125 IG credits
  - Buyer of protection makes regular payments on **remaining portfolio notional**
  - Seller of protection makes buyer whole at time of each bond default
  - CDX index spread $\approx$ weighted average of CDS spreads
- CDX (IG) Tranches written on same portfolio
  - Associated with standard attachment/detachment points (subordination levels):
    - 0-3% (Equity tranche)
    - 3-7% (Mezzanine tranche)
    - 7-10%
    - 10-15%
    - 15-30% (Senior tranche)
    - 30-100% (Super-senior tranche)
  - Buyer of protection makes regular payments on **remaining tranche notional**
  - Seller of protection makes buyer whole for each bond default which reduces tranche notional
- CDS, CDX index spreads determined from **marginal** default probabilities.
- CDX tranche spreads need entire **joint** distribution (correlation market).

CDS Market Statistics

Exhibit 1.1: The notional amount of credit derivatives globally is larger than the global amount of debt outstanding



Sources: British Bankers' Association Credit Derivatives Report 2006, Bank for International Settlements and ISDA.

Note: Cash bonds through June 2006.

Exhibit 7.1: Participants in the credit derivatives market. Some favor one direction over the other.

Source: *British Bankers' Association Credit Derivatives Report 2006.*

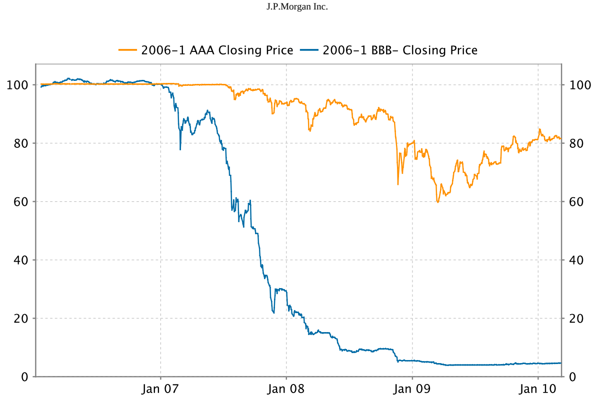
Securitized Credit Markets Crisis

- Pre-crisis saw large growth in securitized credit markets (CDO).
- Pooling and tranching used to create 'virtually risk-free' AAA securities, in response to high demand for highly rated securities.
- During the crisis **all** AAA markets were hit hard:
  - Home equity loan CDO prices fell (ABX.HE AAA $<$ 60%).
  - Super Senior (30-100) tranche spreads $>$ 100bps.
  - CMBX.AAA (super duper) $>$750bps.
- Raises several questions:
  - Q? Were ratings incorrect (ex-ante default probability higher than expected)?
  - Q? Are ratings sufficient statistics (risk $\neq$ expected loss)?
  - Q? Were securitized products mispriced? If yes, why?
- Many other surprises:
  - Corporate Credit spreads widened (CDX-IG $>$ 200bps).
  - Cash-CDS basis **negative** (-200 bps for IG; -700bps for HY).
  - LIBOR-Treasury and LIBOR-OIS widened ($>$ 400bps).
  - Long term Swap spreads became negative (30 year swap over Treasury < -50 bps).
  - Defaults on the rise (Bear Stearns, Lehman).

Evidence from ABX markets

- ABX.HE (subprime) AAA and BBB spreads widened dramatically (prices dropped)

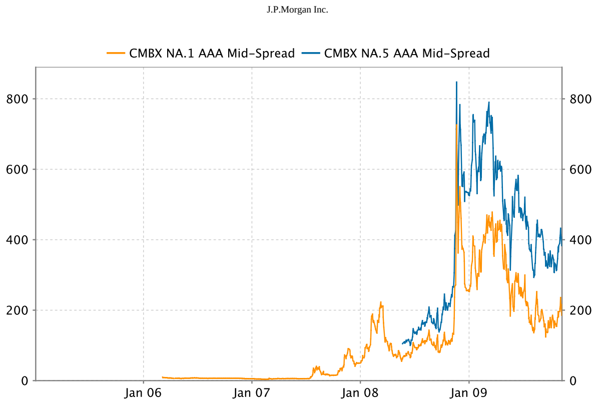
J.P.Morgan DataQuery



Evidence from CMBX markets

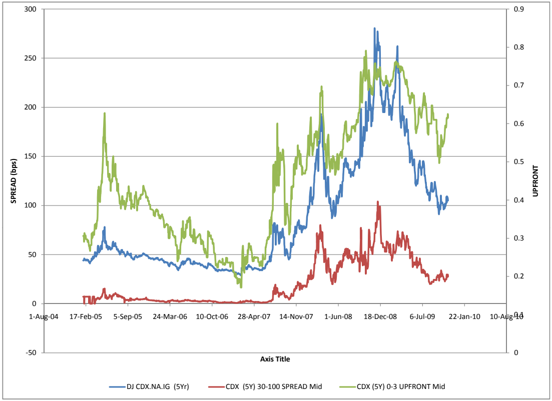
- CMBX (commercial real estate) AAA spreads widened even more dramatically

J.P.Morgan DataQuery



Corporate IG CDX Tranche spreads

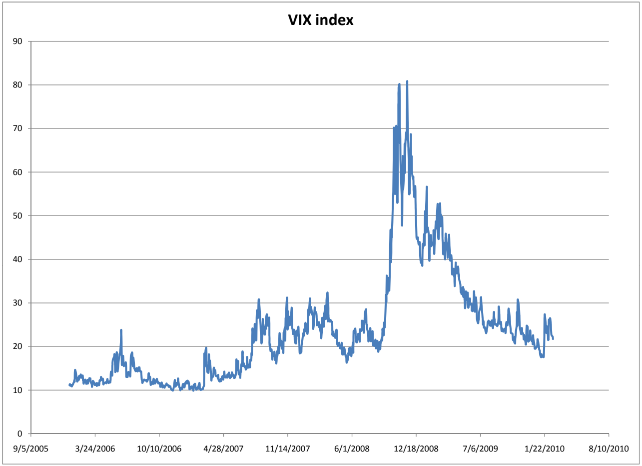
- The impact on tranche prices was dramatic



- Implied correlation on equity tranche hit $> 40\%$
- Correlation on Super-Senior tranches $> 100\%$(!) with standard recovery assumption
- Relative importance of expected loss in senior tranche versus in equity tranche indicates increased crash risk.

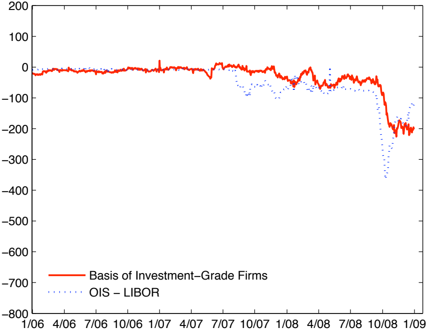
Evidence from S&P500 Option markets

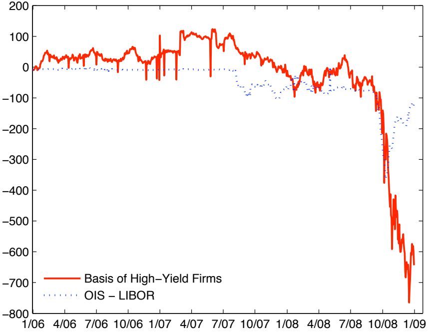
- Implied volatility index widened dramatically: increased market and crash risk.



The Cash-Basis during the crisis

- Basis during the crisis became tremendously negative:





- In a frictionless market, negative basis is a free lunch:
  - Borrow at Libor
  - Buy the bond
  - Buy protection

  $\Rightarrow$ Earn the basis **risk-free**! (Basis package $\sim$ 'AAA' asset)

Trading the negative basis in practice

- In practice, a negative 'basis package' typically consists in:
  - Fund the haircut ($h\,B$) at your own funding cost: Libor$+x$ where x reflects your risk
  - Borrow $(1-h)B$ at repo rate to purchase the bond.
  - Buy protection and post initial margin (M) funded at Libor$+x$

⇒ Exposure to:
  - Basis becoming more negative,
  - Funding/trading cost widening ($Libor + x \uparrow$, $Repo \uparrow$, $M \uparrow$, Bid-ask spread $\uparrow$)
  - Collateral quality deteriorating ($h \uparrow$)
  - Counterparty risk (affects the value of insurance purchased)

- There were substantial changes in funding costs during the period:

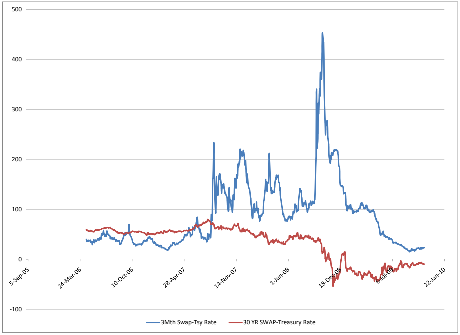
date	07-Jun	07-Dec	08-Jun	08-Sep	09-Feb
haircut (h)	5%	8%	10%	12-15%	20-25%
spread (x)	0	10bps	15-20bps	35-50 bps	100-125bps
Margin	0				2-10%

(source: JP Morgan)

⇒ Exploiting cross-sectional variation in CDS basis provides interesting testing ground for various theories of 'limits to arbitrage' (behavioral, market segmentation, frictions. . .)

Evidence from LIBOR-Swap markets

- Long term swap spread became negative ($\sim$ funded vs. unfunded spread?)
- In unconstrained world arbitrage for a insurance company:
  - Buy a Long-term Treasury: receive fixed coupon
  - Finance via repo: pay short term GC-repo
  - Swap into fixed: receive fixed swap rate pay LIBOR (notional adjusted to match fixed payments from Treasury).
  - $\Rightarrow$ Net cash-flow is LIBOR-Repo spread (which is positive and a crisis hedge!).
- Points to funding constraints: return on collateral not 'juicy' enough.



Conclusion

- Interesting data (CDS, CDX, CDO tranches) to test various asset pricing theories:
  - Time varying risk-premia
  - Crash-risk
  - Liquidity risk
  - Behavioral theories
  - Market inefficiency/segmentation
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