Credit Modeling after the Crisis

DERIVATIVES 2009: LOOKING TOWARDS THE FUTURE

Pierre Collin-Dufresne
Columbia University

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- Motivation
- The CDS-Cash Basis
- Tranche (CDO) Markets
- Final thoughts

Motivation

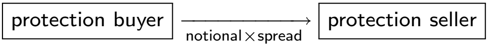
- Significant disruptions in corporate credit markets:
  - Cash-CDS basis **negative** (-200 bps for IG; -700bps for HY)
  - Credit spreads widened (CDX-IG $>$ 200bps)
  - Tranche Spread widened (Super Senior (30-100) $>$ 70bps).
  - Default frequency (Bear Stearns, Lehman)
  - LIBOR-Treasury and LIBOR-OIS widened.
  - Long term Swap spreads became negative.
- Derivative modeling widely discredited
  - "financial weapons of mass destruction" (Warren Buffett, investor)
  - "the secret formula that destroyed wall street" (Wired, news)
  - "Crime contre l'humanité" (Michel Rocard, French politician)

What can/should financial engineers do?

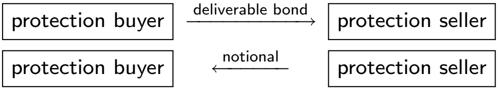
- Should we give up (credit) derivative models (Black Swan excuse)?
- Certainly, there are lessons to draw (even from observing just one Black Swan):
  - Regulators (counter-cyclical risk-based capital requirements, too-big-to fail...),
  - Market structure (central clearing of OTC derivatives...),
  - Risk-management in banks (macro-hedging, incentives...)
- For (credit) derivative models, focus on:
  - Funding cost risk (market frictions)
  - Counterparty risk (and its mitigation via specific ISDA/CSA)
  - Calibration risk
  - Price taking assumption (vs. contagion risk)
- My (self-serving) conclusion: we cannot afford to give up models.
  - Internal risk-management: Credit Valuation Adjustments (CVA).
  - Accounting: Non-performing risk-adjustment (FAS157)
  - FED Bail-out: TARP, TALF, PPIP ($\sim$ CDO^2).

CDS Basis

- A CDS is an insurance contract against a credit event of Counterparty:
  - Prior to credit event:



  - Upon arrival of credit event:



- Definition of credit event:

  Bankruptcy
  Failure to pay
  Obligation acceleration or default
  Repudiation/moratorium
  Restructuring (Full R, Mod R, ModMod R, No R)

Arbitrage Relation

- Buy XYZ bond + Buy XYZ protection $\sim$ Earn risk-free rate

- Buy risk-free bond + Sell XYZ protection $\sim$ Earn XYZ bond yield

$$\boxed{\text{CDS spread} \approx Y_{XYZ} - R_f}$$

- Empirical evidence **pre-crisis** on *Basis* = CDS spread − ($Y_{XYZ} - R_f$).

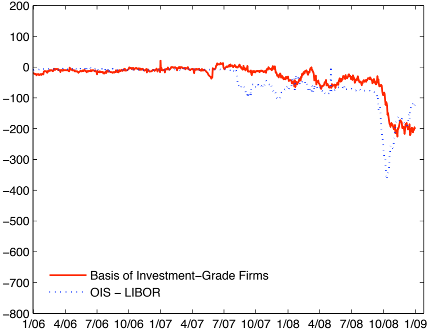
	Basis wrt Tsy (bp)		Basis wrt Swap (bp)		implied R_f/ Tsy	
	Mean	S.E. (of mean)	Mean	S.E.	Mean	S.E.
Aaa/Aa	-51.30	1.97	9.55	1.31	0.834	0.0250
A	-64.33	1.82	5.83	1.59	0.927	0.0229
Baa	-84.93	3.63	2.21	2.79	0.967	0.0364
All Categories	-62.87	1.38	6.51	1.06	0.904	0.0160

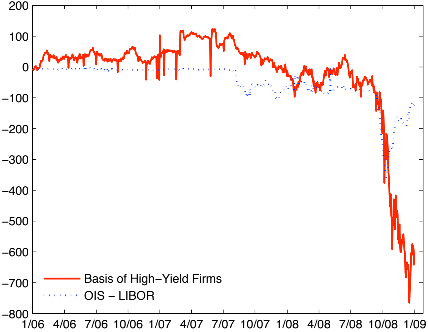
source: Hull, Pedrescu, White (2006)

⇒ Appropriate funding cost benchmark (risk-free rate?) is closer to LIBOR/swap than Treasury.
⇒ Under that **funding cost assumption** the arbitrage relation holds pretty well.
⇒ Violation of 'arbitrage' mostly on positive side, explained by (i) difficulty to short bonds, (ii) cheapest to deliver option (Blanco, Brennan, Marsh (2001)).

The 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**!

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
- There are subtleties about how to size the trade (JtD risk versus Recovery risk).
- Return on the basis trade using $\$(hB+m)$ capital is approximately:

$$\sim \text{Duration} \cdot \Delta\text{Basis} - B\,(h(\text{Libor}+x) + (1-h)\text{Repo}) - M(\text{Libor}+x)$$

$\Rightarrow$ Exposure (conditional on trade not converging) to:

- funding/trading cost widening ($Libor, x \uparrow$): market liquidity?
- collateral value deteriorating ($h \uparrow$): funding liquidity?
- counterparty risk (affects the value of insurance purchased)

$\Rightarrow$ Use cross-sectional evidence on the basis to test these three hypothesis **(Joint work with Jennie Bai from the NY-FED)**.

- Use Markit data and PECDS method from JPM to construct basis for 500 firms from Jan 2006 to Jan 2009.
- Match CDS data with Thomson-Reuters corporate bond data.

Cross-sectional Evidence: Can we explain the negative basis?

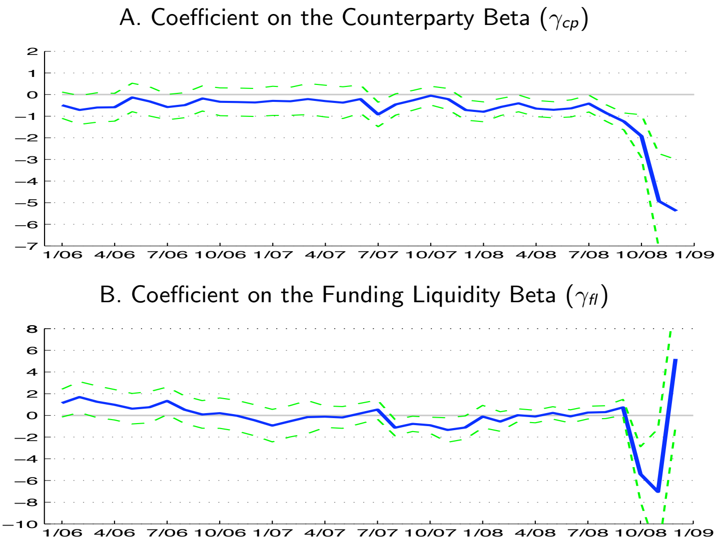
- Build measures of:
  - Counterparty risk: $\beta^i_{cp} = \frac{cov(R^i,(R^{index} - R^{mkt})}{var(R^{index} - R^{mkt})}$
  - Funding cost risk: $\beta^i_{fl} = \frac{cov(\Delta cds^i, \Delta RepoSpread)}{var(\Delta RepoSpread)}$
  - Collateral quality: Index based on average decile sorts on bond characteristics that correlate with hair cut (Rating, Tangible assets, Leverage, CDS volatility. . .)
- Perform cross-sectional regressions (daily Fama-mcBeth type)

$$Basis^i = \gamma_{cp}\beta^i_{cp} + \gamma_{fl}\beta^i_{fl} + \gamma_{mkt}\beta^i_{mkt} + \gamma_{collateral}\text{Collateral}^i + \gamma_{industry}\text{Industry}^{\ i} + \gamma\ \text{Sign}^i + \epsilon_i$$

Panel D: Crisis II (post-Lehman bankruptcy (9/1/2008))

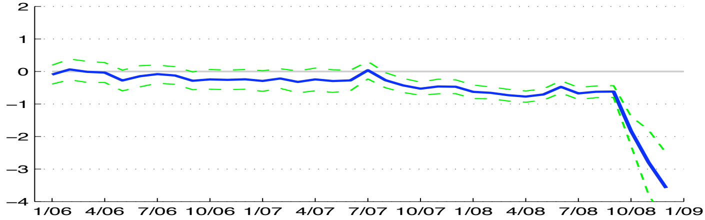
	(1)	(2)	(3)	(4)	(5)
γ_{cp}	-6.83*** (0.35)				-6.05*** (1.11)
γ_{fl}		-2.46*** (0.74)			-1.97*** (0.50)
γ_{mkt}			-3.46*** (0.21)		-0.69 (0.53)
$\gamma_{collateral}$				0.41*** (0.11)	0.39*** (0.08)
$\gamma_{industry}$					1.99** (0.61)
Sign	✓	✓	✓	✓	✓

Time series coefficients in the Cross-sectional Regressions

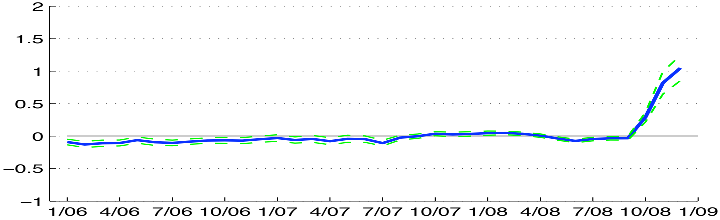


Time series coefficients in the Cross-sectional Regressions

C. Coefficient on the Market Beta (γ_{mkt})

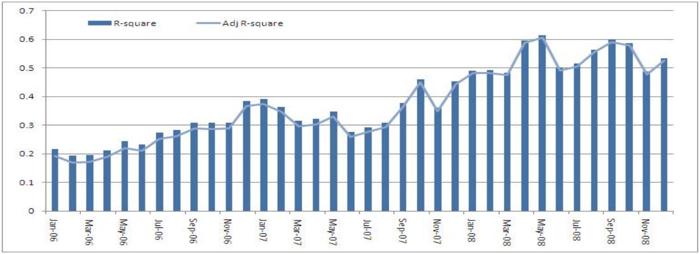


D. Coefficient on the Collateral Index ($\gamma_{collateral}$)

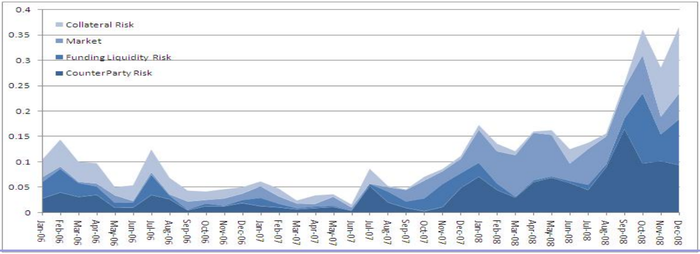


Explanatory power of the Cross-sectional Regressions

Time series of R-square



Variance Decomposition of independent variables



What do we learn?

- Counterparty risk, Collateral Quality and Funding Risk have strong explanatory power for cross-section of basis during the post Lehman collapse period.

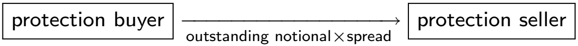
- Collateral quality always seems to have some explanatory power to explain cross-section of basis (even pre-crisis period) albeit with different level of economic significance (suggests that capital is never completely 'unconstrained').

- Relative importance of Counterparty risk versus Funding Risk is sensitive to the proxy used for funding risk measure:
  - If use change in repo-Treasury spread, then counterparty risk dominates.
  - If use Libor-OIS spread, then Funding risk dominates.

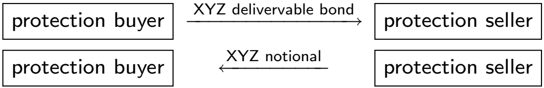
  $\Rightarrow$ difficult to disentangle funding risk from counterparty risk when using LIBOR-OIS.

The CDX index

- The CDX index is an insurance contract against credit events of a portfolio of counterparties (e.g., 125 names in CDX.IG):
  - Prior to credit event:



  - Upon arrival of credit event of XYZ:

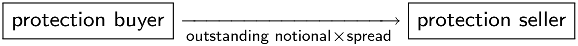


  - Following credit event outstanding notional is reduced by notional of XYZ in portfolio (i.e., $\frac{1}{125}$ in CDX.IG).
  - Contract expires at maturity or when notional exhausted.

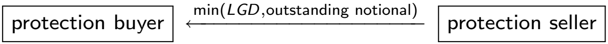
- N.B.: CDX contract $\neq$ equally weighted portfolio of single name CDS contracts
  CDX spread $\neq$ average of single name CDS spreads

Synthetic CDO Tranches

- Selling protection on CDO tranche with attachment points $[L, U]$ (i.e., notional $= U - L$) written on underlying basket of 125 single names (CDX):
  - Prior to a credit event:



  - Upon arrival of credit event ($LGD =$ notional $-$ deliverable bond price), if cumulative loss exceeds lower attachment point (i.e., $\mathcal{L}_t = \sum_{i=1}^{125} LGD_i \mathbf{1}_{\{\tau_i \leq t\}} > L$) then

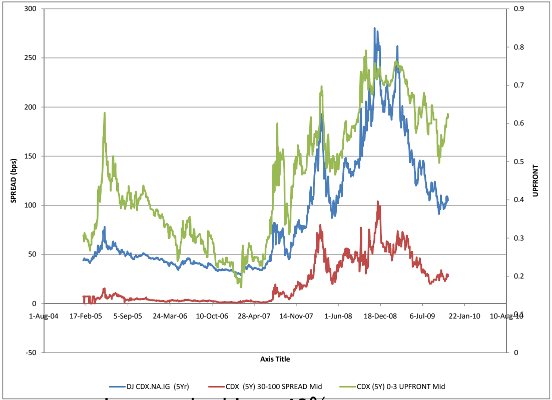


  - Following credit event outstanding tranche notional is reduced by LGD (up to exhaustion of outstanding notional).
  - Also, super senior tranche notional is reduced by recovery (to satisfy 'adding up constraint').
  - Contract expires at maturity or when tranche notional is exhausted.
- Tranche payoff is call spread on cumulative loss: $\max(\mathcal{L}_t - L, 0) - \max(\mathcal{L}_t - U, 0)$.

⇒ Tranche valuation depends on entire distribution of cumulative portfolio losses and crucially on default event correlation model.

Tranche spreads through the crisis

- The impact on tranche prices was dramatic



- Implied correlation on equity tranche hit $> 40\%$
- Correlation on Super-Senior tranches > 1(!) with standard recovery assumption
- Relative importance of expected loss in senior tranche versus in equity tranche indicates increased crash risk.

What does it tell us?

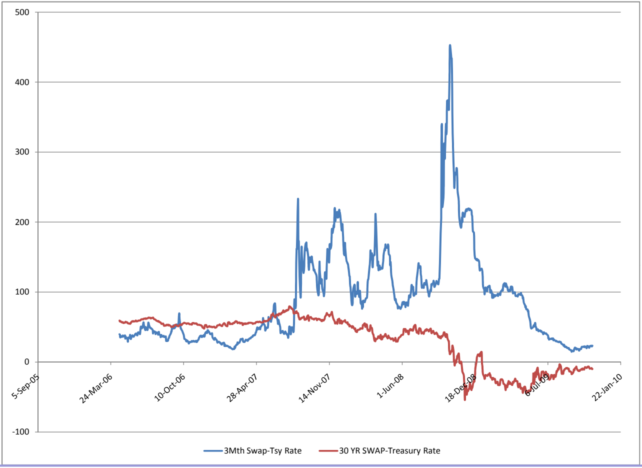
- Counterparty risk seems to be relatively well mitigated by current collateral/ISDA agreements.
- Else, who would want to pay 70bps to buy protection on "end-of-the-world" trade?
- Suggests that these contracts are very much **marking to market** trades:
  - Not clear we actually believe the counterparty will be solvent when/if the event where more than 60% of the IG firms in the US default.
  - But along the paths that lead us closer to that event, we will receive marking to market payments that are guaranteed via collateral agreements and margin calls.
  - $\Rightarrow$ We are really contracting on changes in the risk-neutral probability of the remote event.

$\Rightarrow$ The price of the senior tranches intrinsically tied to ISDA agreement and CSA:
  - Under zero counterparty risk mitigation, super senior insurance would be (close to) worthless (moral hazard).

- Alternative (complementary?) stories:
  - Scarcity of capital/insurance providers (require extra-premium to hedge against further adverse MtM move $\sim$ Basis trade collateral risk).
  - Regulatory requirement to hedge/free balance sheet: hedging via unfunded trades is less costly.

Evidence from Swap markets

- What is the correct funding cost ('risk-neutral' discount rate) benchmark?
  - Consensus had shifted from Treasury to LIBOR/swap rates.
  - Many are switching to OIS based curve?



Conclusions

- We need to model explicitly:
  - Collateral costs,
  - Funding, and
  - Counterparty risk.
- The value of a specific derivative depends on:
  - The net credit risk of the counterparty relative to our own and conditional on the moneyness of the trade!
  - The interaction (risk-neutral correlation) between market and credit risk matters.
  - The specific Credit Support Annex matters (if there is collateral or not, if there are margin calls or not. . .).
  - If capital is relatively scarce, then collateral 'efficiency' matters.

We need (better) models

- Regulators
  - TARP (convertible preferred warrants),
  - TALF, PPIP (CDO^2),
  - CCP (nth to default protection on basked of dealers)
- Internal Risk Management (Credit Valuation Adjustment)
  - Internally banks allow CVA trading across desks to manage aggregate counterparty exposure (these are effectively Contingent CDS).
- Accounting principles ('Non-performing risk-adjustment' in FSB 157):
  - First Quarter 2009, Citi declared in its Schedule B "A net $2.5 billion positive CVA on derivative positions, excluding monolines, mainly due to the widening of Citis CDS spreads. A net $30 million positive CVA of Citis liabilities at fair value option."
- Further challenges:
  - Calibration, model and parameter uncertainty.
  - Price taking (Black-Scholes-Merton) assumption vs. Contagion risk/feedback effects