Class 17: Corporate Bonds and Credit Pricing

Financial Markets, Fall 2020, SAIF

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Outline

- Corporate Bonds:
  - Default Intensity.
  - Loss Given Default.
- Modeling Default:
  - Structural Approach.
  - Reduced-Form Approach .
- Credit Default Swaps.

Fixed Income

- Key Risk Factors
  - Yield curve uncertainties: **Level, Slope**, and interest rate **Volatility**.
  - **Counterparty risk** in OTC derivatives.
  - **Credit risk** in corporate bonds, CDS, bank loans, mortgages, muni's, commercial paper, CDO/CLO.
  - **Liquidity risk**, often coupled with credit events.
  - **Optionalities:** callable and puttable bonds, prepayment in MBS, etc.
- Measures of Risk:
  - **Term Spreads:** long-term yield minus short-term yield.
  - **Volatility:** swaption implied vol.
  - **Credit/Liquidity Spreads:** LIBOR-Treasury, LIBOR-OIS, Swap-Treasury, Old Bond/New Bond, Corp Spread, CDS, etc.

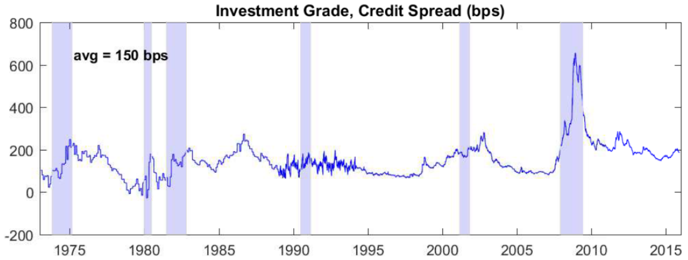
Outstanding US Bond Market Debt (USD Billions)

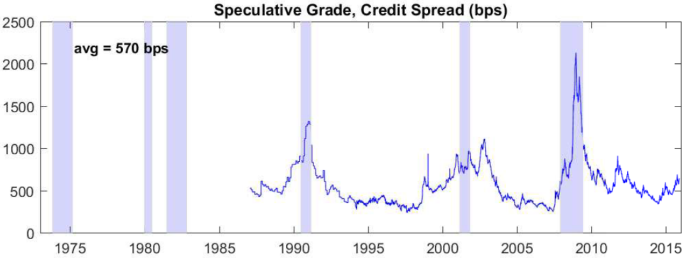
	Municipal	Treasury	Mortgage Related	Corporate Debt	Federal Agency Securities	Money Markets	Asset-Backed	Total
2004	2,876.1	3,945.8	6,301.7	4,563.4	2,700.6	1,399.1	1,100.2	22,887.0
2005	3,098.9	4,170.0	7,218.1	4,637.5	2,616.0	1,644.2	1,281.4	24,666.0
2006	3,284.7	4,328.0	8,389.9	4,883.5	2,634.0	1,958.4	1,656.9	27,135.3
2007	3,549.8	4,522.6	9,386.0	5,322.1	2,906.2	1,788.9	1,963.5	29,439.1
2008	3,665.9	5,783.6	9,467.4	5,500.0	3,210.6	1,599.8	1,829.5	31,056.9
2009	3,850.3	7,260.6	9,352.5	6,090.3	2,727.5	1,138.0	1,712.1	32,131.3
2010	3,967.3	8,853.0	9,258.4	6,726.9	2,538.8	1,057.6	1,507.8	33,909.8
2011	3,930.2	9,928.4	9,075.5	6,840.5	2,326.9	969.3	1,359.0	34,429.8
2012	3,931.6	11,046.1	8,838.1	7,249.6	2,095.8	952.3	1,280.3	35,393.9
2013	3,866.4	11,854.4	8,742.6	7,674.7	2,056.9	951.6	1,285.7	36,432.3
2014	3,822.1	12,504.8	8,842.0	8,040.7	2,028.7	930.4	1,349.4	37,518.2
2015	3,838.4	13,191.6	8,894.8	8,272.8	1,995.4	941.5	1,376.6	38,511.0
2016	3,885.0	13,908.2	9,023.4	8,675.9	1,971.7	884.9	1,391.8	39,740.8
2017	3,899.3	14,468.8	9,304.5	8,996.8	1,934.7	965.9	1,457.9	41,027.9
2018	3,842.1	15,608.0	9,732.3	9,231.5	1,841.6	996.0	1,615.6	42,867.0
2019	3,862.2	16,673.3	10,307.6	9,566.4	1,726.2	1,045.2	1,677.6	44,858.5
2020								
Q1	3,867.8	17,154.0	10,294.4	9,869.8	2,049.1	1,088.8	1,754.7	46,078.6
Q2	3,887.6	19,898.7	10,698.7	10,414.5	1,834.2	1,006.6	1,808.4	49,548.7
Q3	3,922.7	20,367.7	10,906.9	10,439.4	1,765.5	956.9	1,777.3	50,136.4

Average Daily Trading Volume (USD Billions)

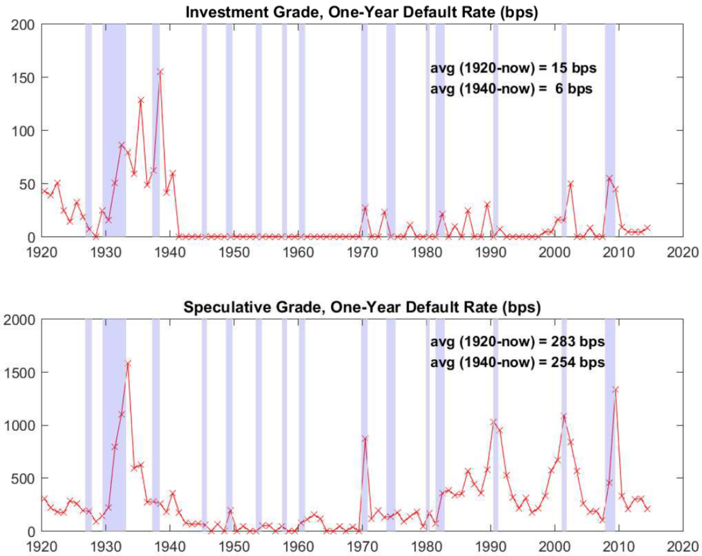
	Municipal	Treasury	Agency MBS	Non-Agency MBS	ABS	Corporate Debt	Federal Agency Securities
2004	14.8	499.0	207.4	-	-	17.3	78.8
2005	16.9	554.5	251.8	-	-	16.6	78.8
2006	23.1	524.7	254.6	-	-	16.9	74.4
2007	25.1	570.2	320.1	-	-	16.4	83.0
2008	19.4	553.1	344.9	-	-	14.3	104.5
2009	12.5	407.9	299.9	-	-	19.9	77.7
2010	13.3	528.2	320.6	-	-	20.5	11.2
2011	11.3	567.8	243.3	4.4	1.5	20.6	9.6
2012	11.3	518.9	280.4	4.5	1.5	22.6	9.7
2013	11.2	545.4	222.8	4.1	1.3	24.7	6.6
2014	9.9	505.0	178.0	3.7	1.5	26.7	5.3
2015	8.6	490.0	193.0	3.1	1.4	27.9	4.5
2016	10.6	519.1	206.6	2.9	1.3	29.6	5.4
2017	10.8	505.2	209.1	2.5	1.4	30.6	4.1
2018	11.6	547.8	218.1	2.4	1.4	31.2	3.5
2019	11.5	593.6	247.6	2.7	1.5	33.9	4.1
2020							
Jan	12.0	531.2	300.7	3.4	1.9	39.0	4.8
Feb	12.6	649.5	321.3	2.8	1.9	40.4	4.7
Mar	23.4	915.5	332.5	6.5	3.6	49.9	6.8
Apr	13.3	721.9	278.4	3.9	2.0	48.9	6.9
May	11.7	627.8	268.3	3.3	1.8	46.3	5.4
Jun	11.1	626.4	248.4	3.1	2.0	43.0	5.9
Jul	11.1	492.5	276.4	2.8	1.6	32.7	5.8
Aug	9.6	517.0	293.7	2.4	1.7	31.1	5.1
Sep	10.4	554.6	281.9	2.4	1.6	34.5	4.7
Oct	11.4	498.8	299.5	2.7	1.6	34.6	4.3
Nov	7.9	624.6	307.7	2.1	1.6	38.3	3.8

Credit Spreads

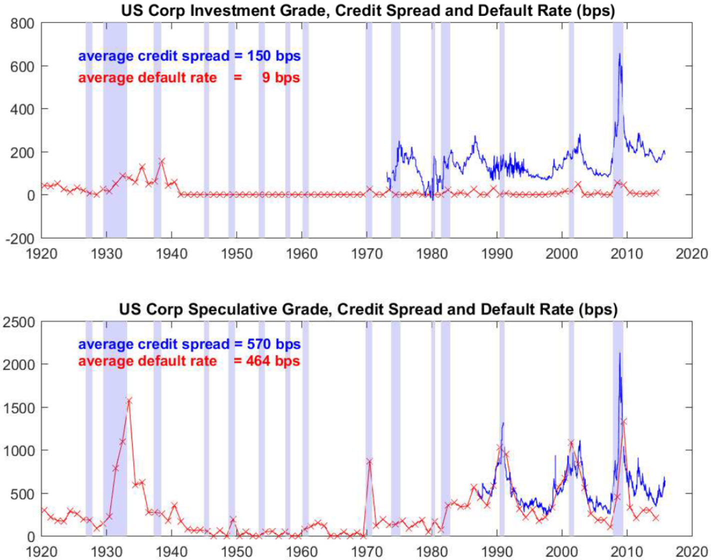




One-Year Default Rates



Credit Spreads and Default Rates



Defaults in 2008, by Industry Distribution

Broad Industry	Percent of Issuer Counts	Percent of Dollar Volume
Banking	8.9%	25.4%
Capital industries	29.7%	5.2%
Consumer Industries	22.8%	5.1%
Energy & Environment	6.9%	2.0%
FIRE	9.9%	53.8%
Media & Publishing	8.9%	6.7%
Retail & Distribution	4.0%	0.7%
Technology	5.0%	0.8%
Transportation	4.0%	0.4%
Utilities	0.0%	0.0%
2008 Total	101	$281.2 bil

- Lehman was the largest default in history: $120.2B.
- 84 of the 101 defaulters were in North American with 74 in the US.
- North American defaulted debt volumes: $226.2B.

Defaults in 2008 by Financial Institutions

Senior Unsecured Bond Recovery Rates for Financial Institution Defaults in 2008[1]

Company	Domain	Default Volume ($Mil)	Sr. Unsecured Bond Recovery
Lehman Brothers Holdings, Inc.	United States	120,164	9.3%
Kaupthing Bank hf	Iceland	20,063	4.0%
Glitnir banki hf	Iceland	18,773	3.0%
GMAC LLC	United States	17,190	69.9%
Washington Mutual Bank	United States	13,600	26.5%
Residential Capital, LLC	United States	12,315	51.7%
Landsbanki Islands hf	Iceland	12,161	3.0%
Washington Mutual, Inc.	United States	5,746	57.0%
GMAC of Canada Ltd	Canada	265	70.7%
Downey Financial Corp.	United States	200	0.5%
Fremont General Corporation	United States	166	46.0%
Luminent Mortgage Capital, Inc.	United States	131	27.3%
Triad Financial Corporation	United States	89	76.5%
Franklin Bank Corp.	United States	80	0.0%
GMAC International Finance B.V.	Netherlands	51	85.5%
Average	35.4%	Median	27.3%

1. Based on 30-day post-default market prices.

Recovery Rates

Recovery Rates based on debt trading prices 30 days after the default date

EXHIBIT 7

Average corporate debt recovery rates measured by post-default trading prices

	Issuer-weighted			Volume-weighted		
Lien Position	2014	2013	1982-2014	2014	2013	1982-2014
1st Lien Bank Loan	78.4%	75.1%	66.6%	80.6%	67.7%	62.5%
2nd Lien Bank Loan*	10.5%	78.7%	31.8%	10.5%	69.2%	28.5%
Sr. Unsecured Bank Loan	n.a.	n.a.	47.1%	n.a.	n.a.	40.2%
Sr. Secured Bond	59.5%	59.8%	52.8%	76.5%	59.5%	52.4%
Sr. Unsecured Bond	43.3%	43.8%	37.4%	34.3%	29.2%	33.6%
Sr. Subordinated Bond*	46.9%	20.7%	31.1%	28.3%	26.6%	26.0%
Subordinated Bond**	38.8%	26.4%	31.4%	38.0%	33.7%	26.3%
Jr. Subordinated Bond	n.a.	n.a.	24.7%	n.a.	n.a.	17.1%

* The average recovery rates for 2014's and 2013's second lien bank loans and senior subordinated bonds were each based on fewer than five defaults.

** The average recovery rates for 2014's subordinated bonds were based on fewer than five defaults.

Recovery Rates

Recovery Rates based on ultimate recoveries

EXHIBIT 8

Average corporate debt recovery rates measured by ultimate recoveries, 1987-2014

	Emergence Year			Default Year		
Lien Position	2014	2013	1987-2014	2014	2013	1987-2014
Loans*	81.0%	76.7%	80.2%	68.4%	76.6%	80.2%
Senior Secured Bonds**	57.1%	84.2%	63.0%	59.4%	56.9%	63.0%
Senior Unsecured Bonds***	44.6%	61.3%	48.8%	0.0%	34.4%	48.8%
Subordinated Bonds	0.0%	21.0%	28.2%	0.0%	21.0%	28.2%

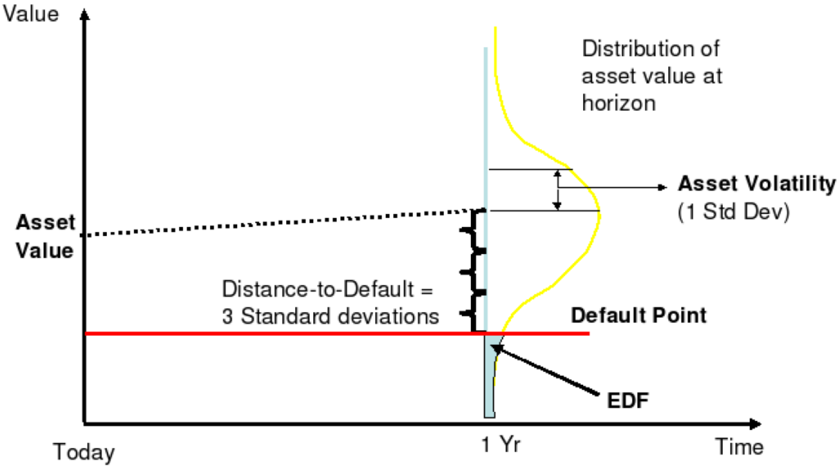
Various Sources to Estimate Default Probability

- We will now focus on modeling and estimating the default probability, while keeping the recovery rate, which is 1 minus the loss rate, at a constant level.
- Information about default probability can be collected from:
  - **Rating:** credit ratings (S&P, Moody's, Fitch) and the historical default rates by rating category.
  - **Equity Market:** firm fundamentals, financial statements and equity-market information (Moody's KMV).
  - **Credit Market:** the market prices of securities with exposure to default risk: corporate bond yield spreads or credit-default swap (CDS) spreads.

Modeling Default

- Structural Models: focus on the firm's fundamentals (enterprise values or earnings).
- Reduced-Form Models: treat default as the outcome of a Poisson process.
- The main outputs of defaultable models: term structure of default probabilities.
- When defaultable securities are pooled together, then the valuation involves crucially on the model-implied probability of correlated default.

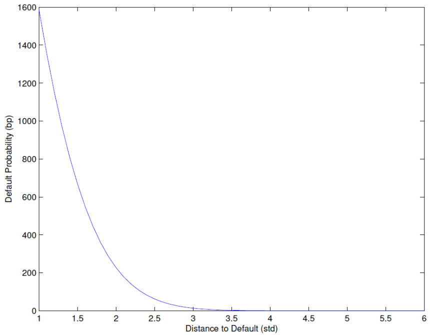
Model Default using Structural Approach (Merton 1974)



Distance to Default and Probability of Default

$$DD = \frac{\ln(V/K) + \left(\mu - \sigma_A^2/2\right) t}{\sigma_A \sqrt{t}}$$

$$\text{Default Probability} = N(-DD)$$



- The market value of assets V
- Asset volatility σ_A
- The book value of liabilities K
- Debt-to-Asset ratio: K/V
- The expected growth rate of asset value μ
- t = the time horizon
- DD = distance to default = number of std the firm is away from default

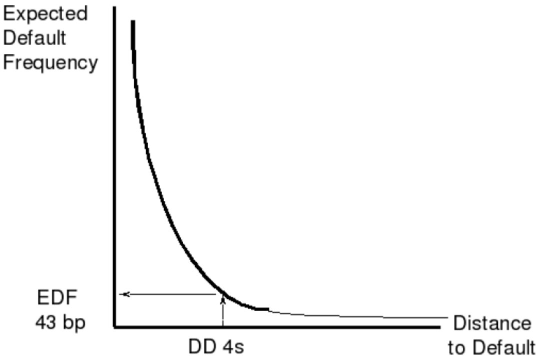
Key Determinants of the Distance to Default

$$DD = \frac{\left(\mu - \sigma_A^2/2\right) t - \ln(K/V)}{\sigma_A \sqrt{t}}$$

debt ratio K/V	asset growth μ	asset vol σ_A	horizon t	distance to default DD
15%	10%	40%	1yr	4.79
15%	10%	20%	1yr	9.89
15%	20%	40%	1yr	5.04
50%	10%	40%	1yr	1.78
15%	10%	40%	10yr	1.66
15%	10%	20%	10yr	4.26

Moody KMV's Expected Default Frequency

- Probabilities implied by the normal distribution: too low.
- Moody's KMV: use actual default experiences to map DD to EDF.
- This procedure requires a large database of actual defaults.



Modeling Default using Reduced-Form Approach

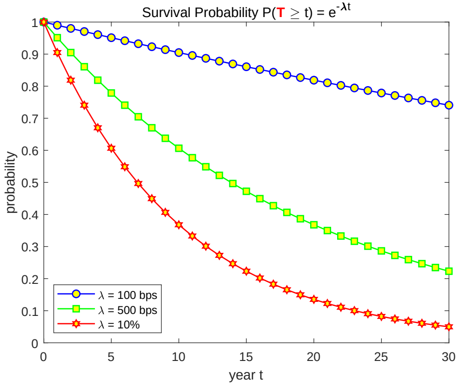
- Let $\widetilde{T}$ be the random default time.
- The probability of survival up to time t:

$$\text{Prob}\left(\widetilde{T} \geq t\right)$$

- The probability of default before time t:

$$\text{Prob}\left(\widetilde{T} < t\right) = 1 - \text{Prob}\left(\widetilde{T} \geq t\right)$$

Constant Default Intensity λ



Pricing a Zero-Coupon Bond

- Assume the constant default intensity λ of a firm is 100 bps.
- **The one-year default probability:** $1 - e^{-\lambda} \approx \lambda$**.**
- Assume zero recovery (100% loss given default):
  - Consider a one-year zero-coupon bond with \$1 face value:

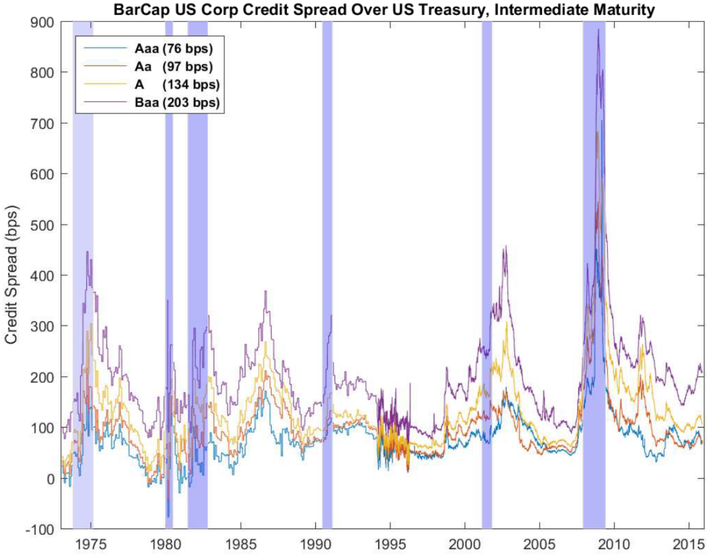
$$P = e^{-r}\,\text{Prob}\,(\widetilde{T} > 1) = e^{-r} \times e^{-\lambda} = e^{-(r+\lambda)}$$

  - The yield to maturity of the defaultable bond: $r + \lambda$
  - **The credit spread of the defaultable bond:** λ
- Assume constant loss given default (L):

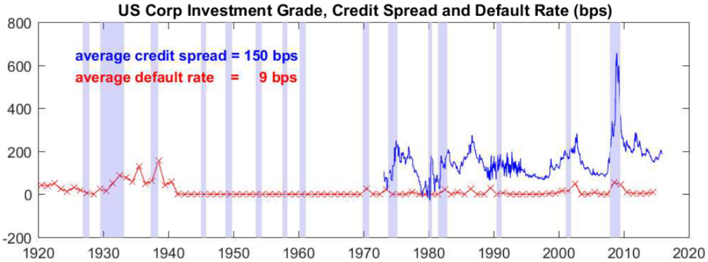
$$\begin{aligned} P &= e^{-r}\,\text{Prob}\,(\widetilde{T} > 1) + e^{-r}\,\text{Prob}\,(\widetilde{T} \le 1) \times (1 - L) \\ &= e^{-r} \times e^{-\lambda} + e^{-r} \times (1 - e^{-\lambda}) \times (1 - L) \end{aligned}$$

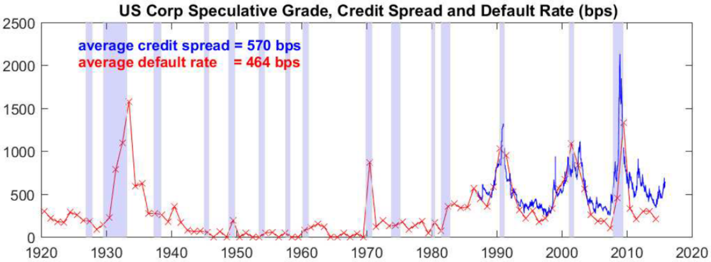
For small λ**, the credit spread is approximately:** $\lambda \times L$.

Credit Spreads and Business Cycle



Credit Spreads and Default Rates

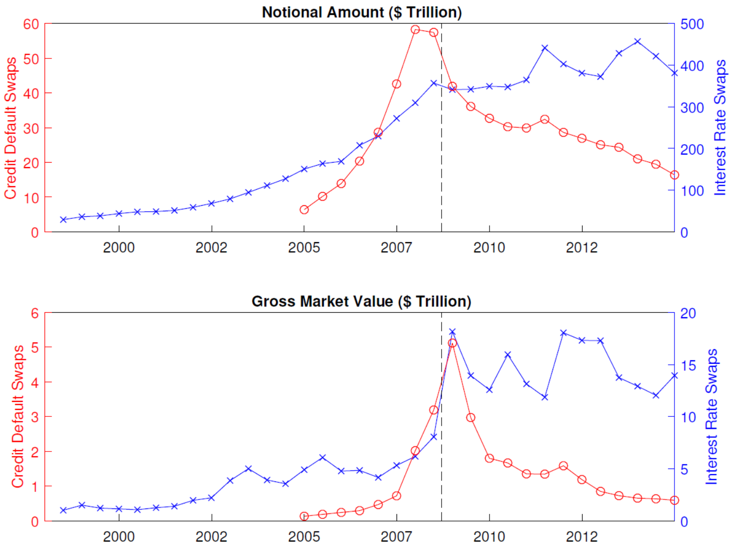




Credit Default Swaps

- The US corporate bond market is among the most illiquid markets. For a market of \$8T in 2015, the average daily trading volume is only \$25B. By comparison, the average daily volume is \$499B for US Treasury and \$321B for US Equity.
- In buying a corporate bond, investors take on both duration and credit exposures. To have a pure positive exposure to credit risk, investors have to hedge out the duration risk. To have a pure negative exposure to credit risk, investors have to locate, borrow, and then sell the bonds and buy back the duration exposure.
- The emergence of credit derivatives was in part a response to the limitations of corporate bonds as a vehicle for credit risk.

CDS and Interest Rate Swaps



Valuation: One-Year Credit Default Swap

- Consider a one-year CDS and assume constant interest rate r.
  - The present value of the annuity:

$$\text{CDS} \times P\left(\tilde{T} > 1\right) \times e^{-r}$$

  - The present value of the insurance:

$$\text{Loss} \times P\left(\tilde{T} \leq 1\right) \times e^{-r}$$

- Set CDS so that the two legs have the same present value:

$$\text{CDS} = \frac{P\left(\tilde{T} \leq 1\right) \times \text{Loss}}{1 - P\left(\tilde{T} \leq 1\right)}$$

- **For small $P(\tilde{T} \leq 1)$, CDS $\approx$ "1yr Default Probability" $\times$ "Loss"**

Applying Constant Default Intensity Model

- Let's use the constant default intensity model:

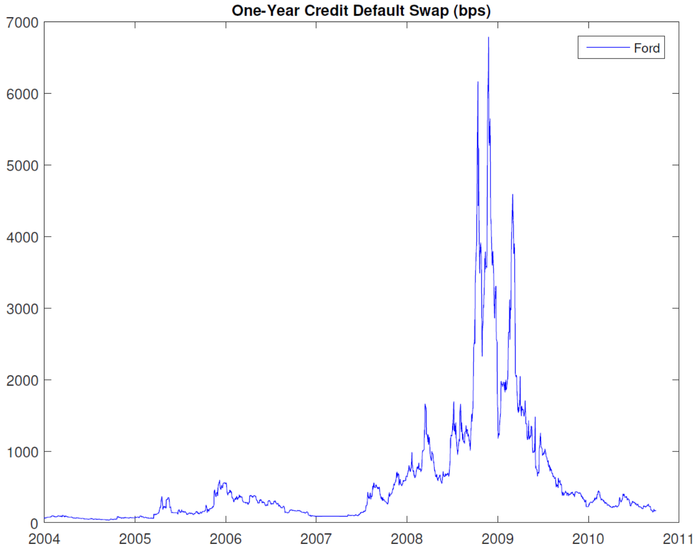
$$\text{one-year default probability} = 1 - e^{-\lambda}$$

- The one-year CDS price is

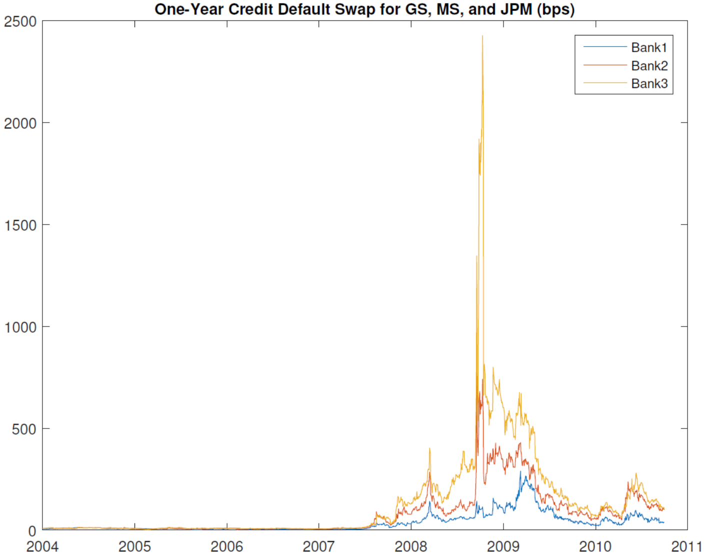
$$\text{CDS} = \frac{\left(1 - e^{-\lambda}\right) \times \text{Loss}}{e^{-\lambda}} \approx \lambda \times \text{Loss}\,,$$

where the approximation works well for small λ.

CDS on Ford Motors

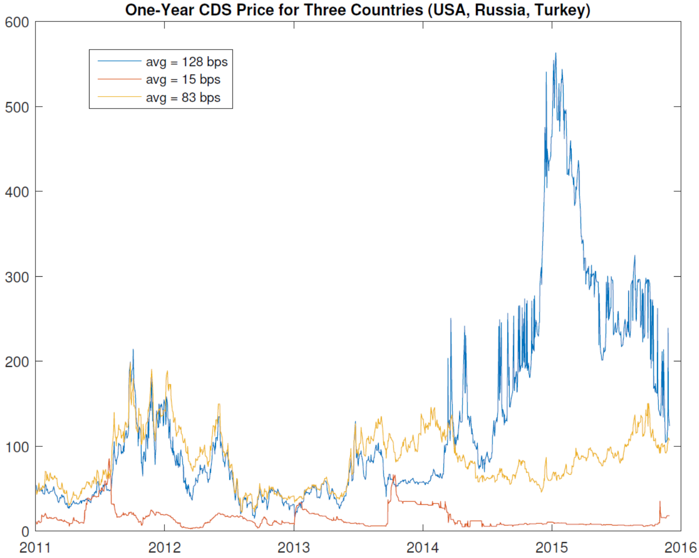


CDS on Banks

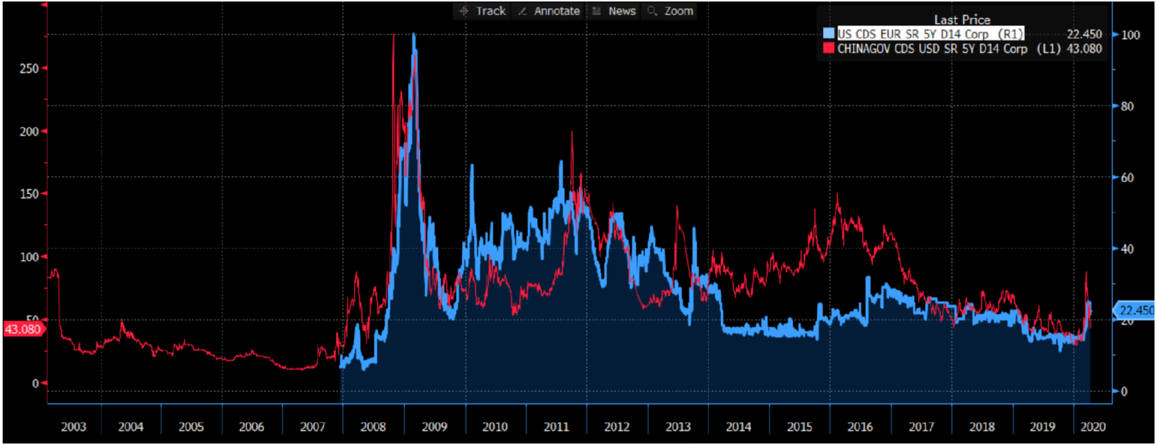


One-Year Credit Default Swap for GS, MS, and JPM (bps)
2500
2000
1500
1000
500
0
2004
2005
2006
2007
2008
2009
2010
2011
Bank1
Bank2
Bank3

CDS on Sovereign Bonds



5YR CDS, China and US



CDS-Bond Basis

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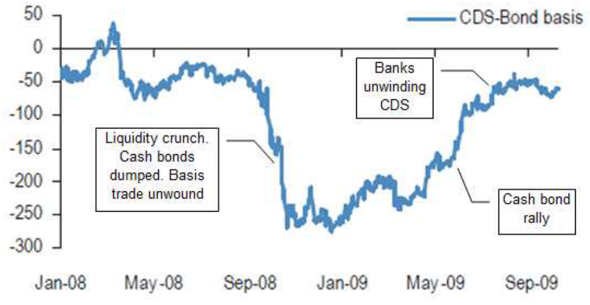

Source: J.P. Morgan.