Reduced-form Models: Preliminaries

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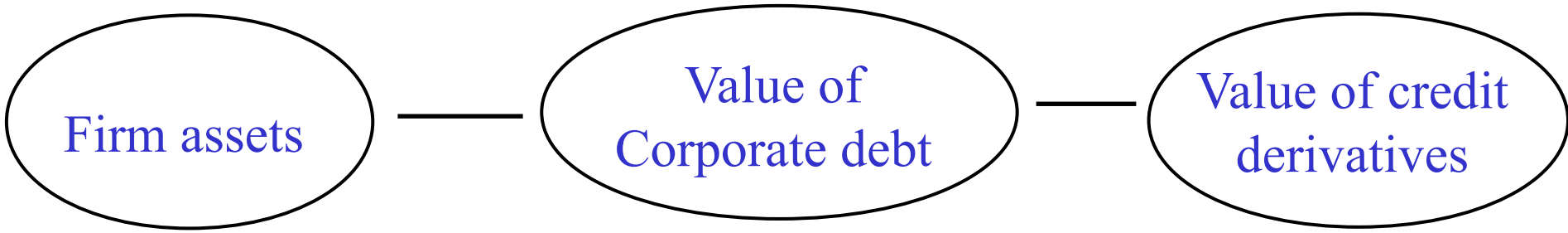
Credit Risk Elective
Spring 2009

Reduced-form Models – Motivation

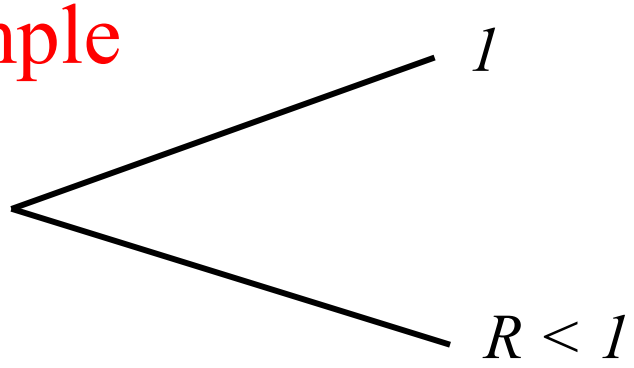


- For many credit derivatives (especially single-name credit default swaps - CDS) there is a "close-to-no-arbitrage" relation between the corporate bond / riskless bond yield spread and the CDS premium
- Most structural models – so far – do a relatively poor job of explaining the bond price (it is not just about default risk!) and so would do equally poor job of explaining CDS premia
- What is needed is a method of relative pricing that connects the CDS premium to the yield on the underlying bond. This is what reduced-form models do.
- Trade off: Lack economics of default, but price credit derivatives well (relative to corporate bonds)

Reduced-form Model: Ingredients

- Interest-rate process
  - ✓ This course: Black-Derman-Toy model-based interest rates
  - ✓ Others: Several possibilities
  - ✓ Details: Lecture notes will be available for background reading
- Default likelihood process
  - ✓ This course: Litterman and Iben model which assumes per-period probability of default
  - ✓ Others: Intensity models are natural extensions of Litterman-Iben
  - ✓ Details: Will be covered extensively in class
- Recovery or loss given default (LGD) assumption
  - ✓ This course: Recovery of par, Recovery of treasury
  - ✓ Others: Recovery of market value
  - ✓ Details: Focus of the next several slides

Simple example

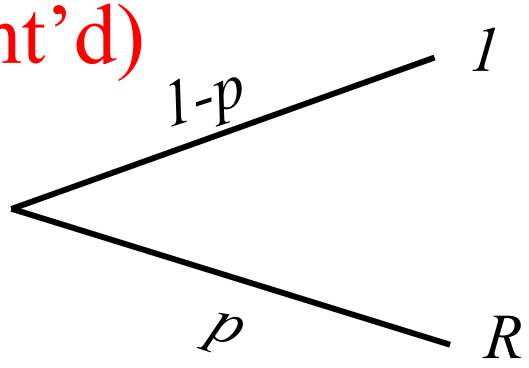


- Riskless bond price = B
- Risky bond price = B*

- What is the no-arbitrage price of a credit insurance product that pays (1 – R) in case of default, and nothing otherwise?
  - ✓ Risky bond + Credit insurance = Riskless bond

- Can we use ideas from option-pricing and risk-neutral probabilities to this setup?

Example (cont'd)



- Risky bond price:
  $B^* = [\ (1-p)\ .1 + p.R\ ]\ B$
  (Risk-neutral) Expected loss $= p.(1-R) = (B - B^*)/B$
- Price of credit insurance product
  $[\ (1-p).0 + p.(1-R)\ ]\ B = B - B^*$
- Simple? At a fundamental level, this is all there is to reduced-form models
- This course:
  - ✓ Back out term-structure of risk-neutral probabilities of default
  - ✓ Use RNP's of default to price other instruments (in a relative sense)
  - ✓ However, we will be able to isolate RNP's of default only to a given assumption on the recovery rate
  - ✓ Recovery or loss given default (LGD): Focus of next few slides

Recovery

Recovery of par

- All instruments of a firm upon default recover a fraction of their face values
- That is, recoveries are *identical* within a class of instruments (by seniority, security)
- What is the rationale?
  - ✓ Institutional: Bond covenants
  - ✓ Empirical: Evidence from real-world examples
  - ✓ Market: Convergence of bond prices as default approaches is a popular strategy to bet on default

Institutional: Enron covenant

"If an Event of Default has occurred and is continuing with respect to Indenture Securities of any series, the Indenture provides that the Trustee or the holders of not less than 25% in principal amount of the outstanding Indenture Securities of that series may declare the principal amount of all of the Indenture Securities of that series to be due and payable immediately, and upon any such declaration such principal amount shall become immediately due and payable."

– *Prospectus supplement of the 6.875% Enron Corp bond, maturing 15 October 2007*

Evidence: Worldcom's default

Table I: Worldcom Bonds: Prices Leading up to Bankruptcy

Shown below are the prices of 9 selected Worldcom bonds with final maturity shown. All bonds are senior unsecured debt. The official initial default event date defined by when Worldcom misses an interest payment is 15 July, 2002. The Chapter 11 bankruptcy filing occurs on 21 July, 2002. On 26 June, 2002 it became public information that the firm had concealed $3.9 billion of losses for more than a year.

Bond Maturity	31-Jan-02	28-Feb-02	28-Mar-02	30-Apr-02	31-May-02	18-Jun-02
18-May-03	103.27	99.69	95.62	75	84.5	81
01-Apr-04	103.06	98.50	91.47	60	73.5	70
15-Aug-05	99.22	96.45	86.51	50	57	54.5
15-Jan-06	100.00	97.66	87.40	49	56	53
01-Apr-07	101.96	97.80	86.65	45.5	54	49.5
15-May-10	103.09	101.06	88.83	48	50	47.5
15-May-11	97.68	96.35	83.88	47	49	46.5
15-Aug-28	85.28	82.31	69.66	42	38.5	39
15-May-31	99.05	96.12	80.66	44	43	42
Bond Maturity	21-Jun-02	25-Jun-02	26-Jun-02	27-Jun-02	15-Jul-02	22-Jul-02
18-May-03	75	68.5	14	17	14.25	13.25
01-Apr-04	61.5	57.5	11.5	13.75	14.25	13.25
15-Aug-05	49	46.5	11.5	13.75	14.25	13.25
15-Jan-06	48.5	45	11.5	13	14	13.25
01-Apr-07	45.5	42	11.5	13	14	13.25
15-May-10	44	42	11.25	14	14	13.25
15-May-11	43.5	41	11.5	13.5	14	13.25
15-Aug-28	37.5	36.5	11	14	14	13.25
15-May-31	40	38	11.25	13	14	13.25

Evidence: Enron's default

Table II: Enron Bonds: Prices and Yields Leading up to Bankruptcy

Shown below are the dealer-bid prices and yields of 9 selected Enron bonds whose contractual details are found in Table I. All bonds are senior unsecured debt. The initial default event date defined by when Enron files for Chapter 11 bankruptcy is 2 December, 2001. On 28 November, 2001 it became apparent that a potential merger bid by a rival company would not take place.

Panel A: Prices

ID	31-Jul-01	31-Aug-01	28-Sep-01	31-Oct-01	21-Nov-01	23-Nov-01
1	106.23	106.28	106.89	87.09	69.89	64.95
2	104.87	104.91	105.47	82.19	62.88	63.92
3	102.61	102.74	103.75	78.19	57.76	61.84
4	101.13	101.78	103.13	77.7	57.74	60.82
5	104.3	104.59	105.74	77.9	56.72	59.82
6	102.53	103.25	104.33	76.89	65.4	59.81
7	100.49	100.81	100.68	77.73	61.66	58.76
8	101.04	101.93	97.69	74.66	56.63	57.81
9	94.5	96.15	91.37	73.93	54.86	56.81
ID	26-Nov-01	27-Nov-01	28-Nov-01	29-Nov-01	30-Nov-01	03-Dec-01
1	50.01	58.07	21	22.03	19	21
2	49.99	57.07	21	22.03	19	21
3	47.95	56.12	21	22.1	19.01	21
4	46.97	55.14	21	22.12	19.01	21
5	44.99	54.15	21	22.12	19.01	21
6	44.99	53.16	20.99	22.13	19.01	21
7	44.98	53.19	21.01	22.13	19	21
8	41.97	49.2	22	22.12	19	21
9	40.99	47.99	21.99	22.08	18.98	21

- Rajiv Guha (London Business School MPhil Thesis)

Determinants of Recovery of Par

- Two notions:
  - ✓ Price at default (Pd)
  - ✓ Price at emergence (Pe)
    - Must be suitably discounted
  - ✓ Results are similar for Pd and Pe discounted at high yield returns

- Determinants:
  - ✓ Seniority
  - ✓ Security
  - ✓ Industry (?)
  - ✓ Business cycle
  - ✓ Business cycle * Industry

Across Seniority classes (1982-1999)

Seniority Code	Seniority Description	Def	Firm defaults	Avg	Mdn	St.Dev.
	Overall	1511	829	51.11	49.09	36.58
1	Bank Loans	358	219	81.12	91.55	26.26
2	Senior Secured	267	119	59.14	61.99	30.18
3	Senior Unsecured	236	98	55.92	54.63	34.58
4	Senior Subordinated	266	172	34.37	26.78	30.39
5	Subordinated	346	186	27.07	16.66	30.37
6	Junior Subordinated	38	35	18.28	6.25	27.11

Source: Acharya, Bharath and Srinivasan (2006), based on S&P data on defaulted bond and loan recoveries

Across Security classes (1982-1999)

		Pehyld				
Collateral Code	Collateral Description	Def	Firm defaults	Avg	Mdn	St.Dev.
	Overall	1511	644	51.11	49.09	36.58
1	Current Assets	52	46	94.19**	98.81	15.96
2	PP and E	83	44	71.36	77.74	27.51
3	Real Estate	38	23	71.83	77.77	31.07
4	All or Most assets	228	126	80.05	89.16	26.35
5	Other	33	20	60.94	53.67	31.21
6	Unsecured	32	25	63.71	63.79	33.48
7	Secured	40	17	63.59	67.42	36.43
8	Information Not available	1005	343	38.64**	30.91	33.48

Source: Acharya, Bharath and Srinivasan (2006), based on S&P data on defaulted bond and loan recoveries

Across Industries (1982-1999)

		Pehyld				
S&P Code	Industry Description	Def	Firm defaults	Avg	Mdn	St.Dev.
	Overall	1511	424	51.11	49.09	36.58
1	Utility	82	9	74.49**	76.94	18.79
2	Insurance and Real Estate	77	23	37.13	27.92	30.96
3	Telecommunications	26	6	53.01	49.49	44.29
4	Transportation	99	20	38.92	18.69	40.76
5	Financial Institutions	76	24	58.79	51.94	42.13
6	Healthcare / Chemicals	111	35	55.67	49.41	38.13
7	High Technology/ Office Equipment	63	22	47.05	40.11	38.07
8	Aerospace / Auto / Capital Goods	138	46	52.08	48.43	37.18
9	Forest,Building Prod / Homebuilders	114	30	53.50	53.33	32.35
10	Consumer / Service Sector	472	126	47.22	41.09	35.57
11	Leisure Time / Media	167	54	51.82	48.50	36.05
12	Energy and Natural Resources	86	29	60.41	58.80	35.41

Source: Acharya, Bharath and Srinivasan (2006), based on S&P data on defaulted bond and loan recoveries

Over time (1982-1999)

Year	Defaults	Firm defaults	Average	Median	St.Dev.
Overall	1511	465	51.11	49.09	36.58
1982	12	5	44.86	51.66	16.57
1983	5	4	46.17	35.94	34.95
1984	6	3	50.70	48.57	26.91
1985	12	8	21.71	10.82	30.13
1986	37	16	21.53	15.48	23.49
1987	56	11	55.59	58.80	36.11
1988	101	24	56.59	64.64	33.73
1989	110	29	43.76	36.02	37.49
1990	245	69	41.24	34.14	35.78
1991	326	81	48.97	47.62	35.06
1992	137	53	58.80	62.58	33.89
1993	103	36	55.84	49.09	38.18
1994	60	25	66.02	82.54	38.23
1995	97	35	63.22	68.30	36.96
1996	75	27	60.64	62.40	36.55
1997	38	11	61.18	73.71	40.27
1998	49	16	36.69	38.76	29.47
1999	42	12	67.18	80.00	37.19

Source: Acharya, Bharath and Srinivasan (2006)

Industry-level Distress (1982-1999)

S and P Code	Description	Year
4	Transportation	1984
12	Energy and Natural Resources	1986
5	Financial Institutions	1987
6	Healthcare/Chemicals	1987
2	Insurance and Real Estate	1990
4	Transportation	1990
5	Financial Institutions	1990
6	Healthcare/Chemicals	1990
7	High Technology/Office Equipment	1990
8	Aerospace/Auto /Capital goods	1990
9	Forest, Building Products/Home Builders	1990
10	Consumer/Service Sector	1990
11	Leisure Time/Media	1990
5	Financial Institutions	1991
10	Consumer/Service Sector	1993
2	Insurance and Real Estate	1994
6	Healthcare/Chemicals	1994
11	Leisure Time/Media	1994
6	Healthcare/Chemicals	1995
10	Consumer/Service Sector	1995
11	Leisure Time/Media	1995
10	Consumer/Service Sector	1996
6	Healthcare/Chemicals	1998

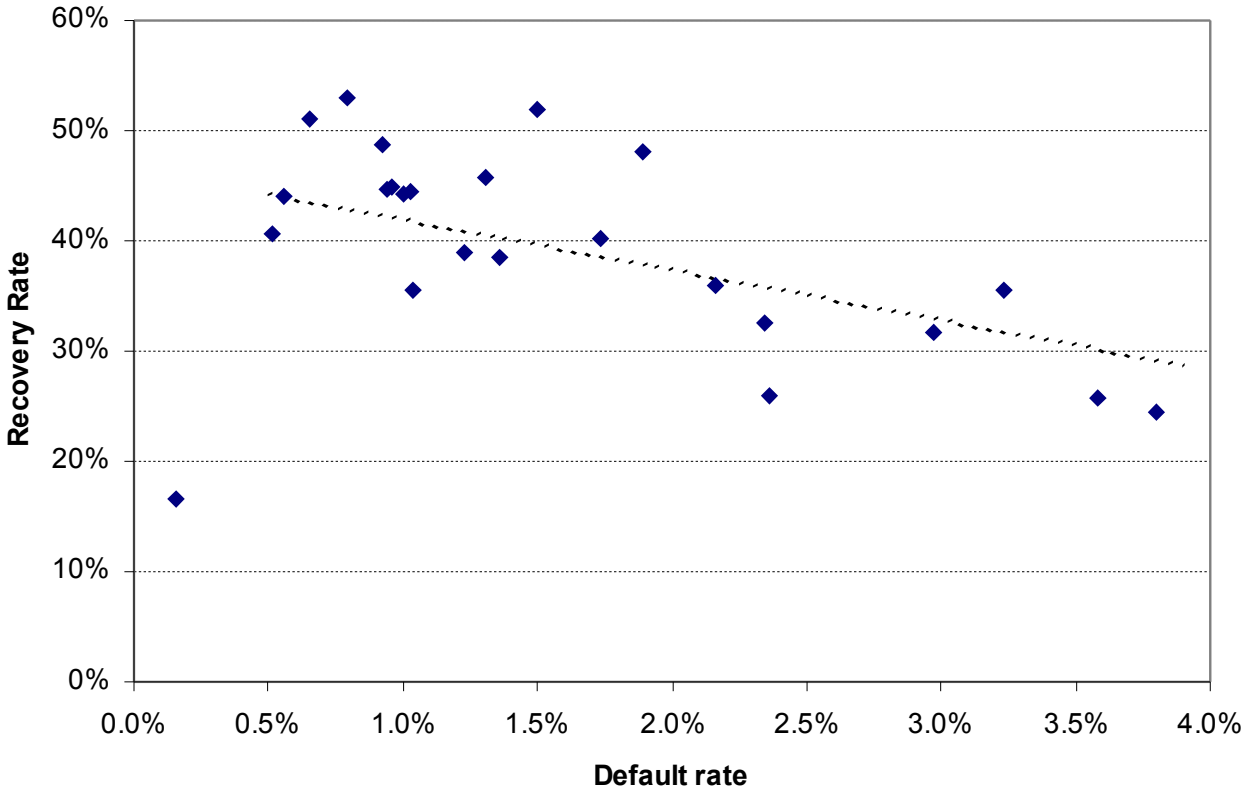
Source: Acharya, Bharath and Srinivasan (2006)

Industry-level Distress (cont'd)

Recovery rates	Full sample	Obs	No Industry Distress (B)	Obs	Distress (C)	Obs	t-statistic (z- statistic)
Pehyld	50.8	1443	52.4	1285	37.8	158	4.77***
	(48.4)		(50.3)		(24.9)		(4.92)***
Pehyld (excl. 1990)	52.8	1209	53.2	1167	40.2	42	2.30**
	(50.5)		(51.2)		(27.5)		(2.33)**
Pehyld (excl. utilities	49.0	1293	51.1	1154	31.9	139	5.92***
and finl instns)	(43.4)		(47.6)		(18.5)		(6.07)***

Source: Acharya, Bharath and Srinivasan (2006)

Evidence that Recovery Rate is Negatively Related to Default Frequency (Speculative Grade, 1981-2004)



*Source: Moody's

Altman, Brady, Resti and Sironi

- BDA: aggregate face value of defaulted bonds measured at mid-year
  - ✓ 10 bln $ increase -> 5% decrease in recoveries
- BDR: aggregate weighted average default rate of high yield bonds
  - ✓ 1% increase -> 4% decrease in recoveries

- Total Depressed prices of defaulted securities in 2001-2002 period

  "As the huge volume of defaulted debt floods the market, trading prices for distressed debt have become depressed, a response to increased supply meeting a generally shallow, illiquid market."

  - Standard and Poors, January 2002

Alternate view: United Airlines case (2003)

- A large number of aircraft leaseholders
  - ✓ GE, Disney, Whirlpool, Boeing, Morgan Stanley, Bank of New York, Philip Morris, Pitney Bowes, Fort Motor Credit
  - ✓ Total exposure to airlines of 20 bln $
- The problem:
  - ✓ 400 Parked Planes at the Mojave Boneyard!
  - ✓ Prices of used jets down by 40% since 2000.
  - ✓ Gives tremendous leverage to bankrupt airlines during bankruptcy negotiations

"... Ford and Philip Morris are facing billions of dollars of losses on United Airlines leases... The US airline believes it can slash its costs by renegotiating its $8bln of aircraft leases ... It plans to send revised terms to leaseholders over the next three days... United's advisers argue it is in a strong negotiating position because of the weak market for used aircrafts."

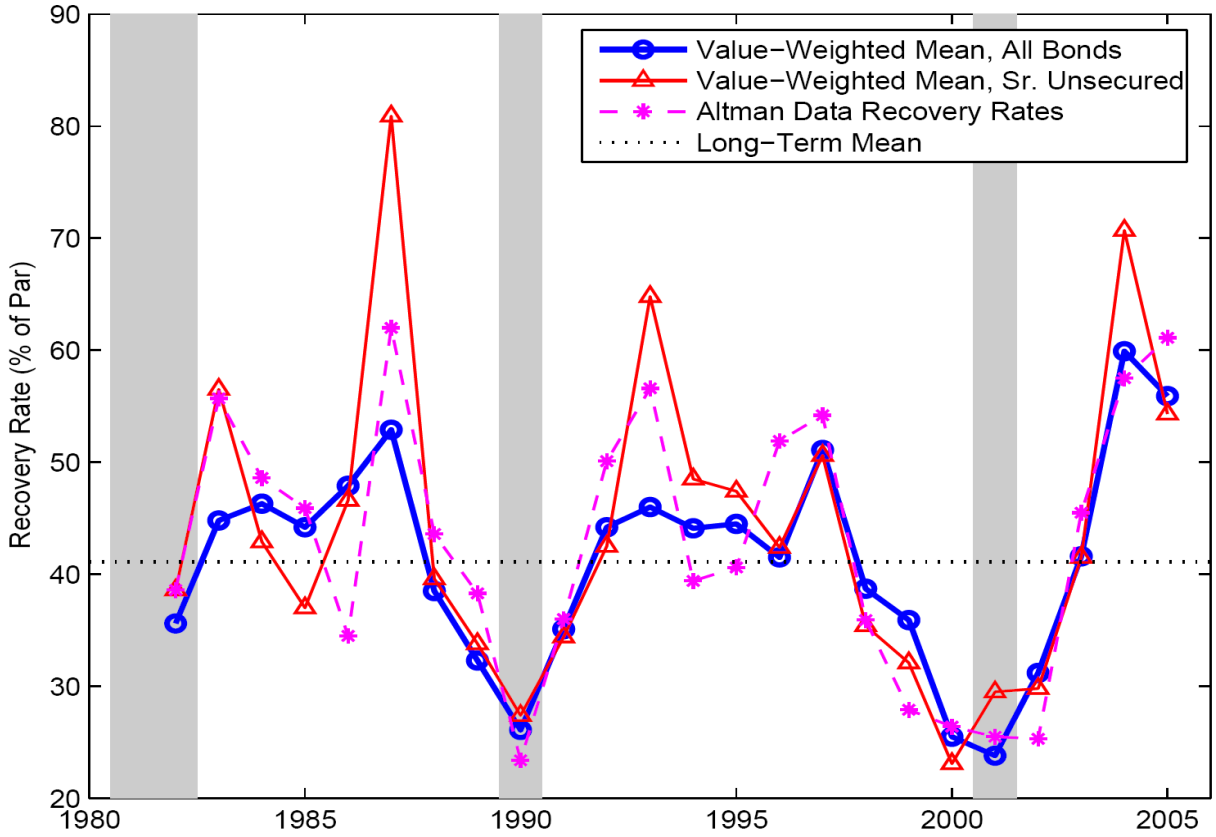
- Financial Times, December 13 2002

Exact terms

- United has asked its airplane owners to accept a reduction in monthly payments
  - ✓ Inspired by US Airways bargains
  - ✓ 50% for less desirable models: Boeing 757-200s and older 737s
    - Aircraft price discount: 60% (Morgan Stanley)
  - ✓ Hard bargains even for newer Boeing 737s
    - Aircraft price discount: 16%

- So, is it bond-market supply effects, or is it liquidity in the market for sale of bankrupt firms?
- Interesting, but for this course, what matters is that there is cyclicality in recovery rates regardless of the exact cause

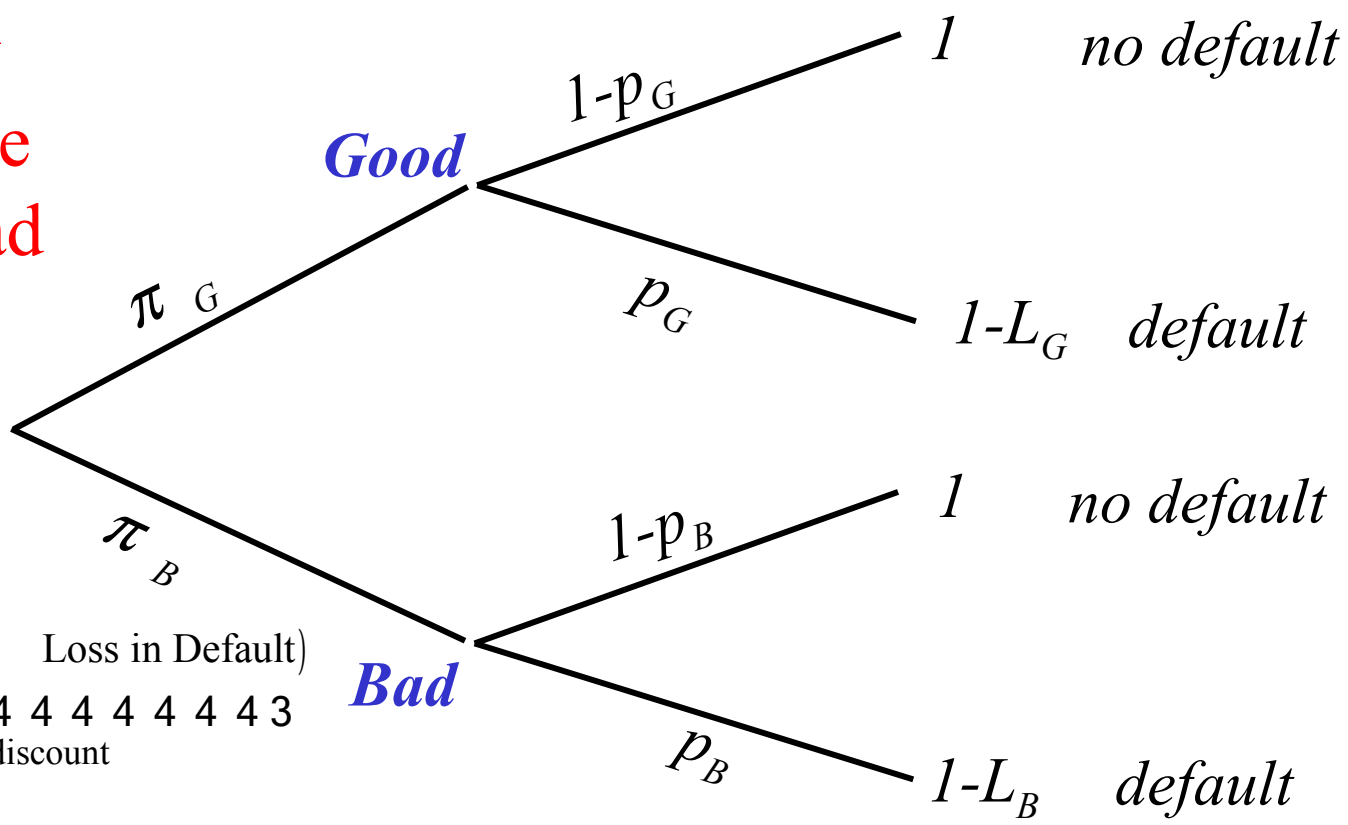
Recovery Rates are *Cyclical*



Data source: Value-weighted average recovery rates for "All Bonds" and "Sr. Unsecured" are from Moody's. "Altman Data Recovery Rates" are from Altman and Pasternack (2006). Shaded areas are NBER-dated recessions.

Source: "Macroeconomic Conditions and the Puzzles of Credit Spreads and Capital Structure", Hui Chen, Working Paper, Graduate School of Business, University of Chicago, Jan. 2007.

Cyclicality Increases the Credit Spread



$$\frac{1}{1+R_f}\underbrace{\left(\text{RN-Prob(default)} \quad \text{Loss in Default}\right)}_{\text{Credit risk price discount}}$$

$$= \frac{1}{1+R_f}\left(\pi_G p_G L_G + \pi_B p_B L_B\right)$$

- Cyclicality increases credit spread since, in "bad" state:
  - ✓ higher market value of losses (π high relative to natural probability)
  - ✓ higher default probabilities (p) *and* loss-given-default (L)

Other Recovery Assumptions

- In default intensity models three forms for recovery have been assumed:
  - ✓ **Recovery of Par** (RP) – a fraction of the face value of the bond, that we have examined so far and justified as being realistic
  - ✓ **Recovery of Treasury** (RT) – recovery of a fraction of an otherwise identical riskless ("Treasury") bond
    - Employed in Litterman-Iben model, but not necessary
  - ✓ **Recovery of Market Value** (RMV) – recovery of fraction of value bond would have at that time if default had not occurred
    - Duffie and Singleton model
    - Unnatural, but leads to a convenient analytical result
  - ✓ Evidence mixed on the impact of different assumptions