Agenda

- Credit Risk.
- Historical Perspective.
- Merton Credit Model.
- Empirical Performance.
- State of the Art Models.
- Poisson Processes.
- Credit Case Part 1.
- Credit Default Swaps.
- Credit Case Part 2.
- Structured Credit Products: CDOs.

MFE Week 9

Credit Risk

- Two types of credit risk:
  - Default risk; zero-one event of default.
  - Market risk: spreads fluctuate.
- Example:
  - Default probability 5 percent.
  - Recovery rate after default is zero percent.
  - Corporate zero-coupon bond price: $D(T) \times 0.95$.
  - Imagine that default probablity now increases to 6 percent.
  - Corporate zero-coupon bond price becomes: $D(T) \times 0.94$.
- In this example, investor realized loss in market value even though default did not occur.

Historical Perspective

- Ratings agencies.
- Bond ratings.
- Default rates.
- Ratings transitions.
- Recovery rates.
- Long-term US experience.

Default, Transition, and Recovery:

2018 Annual Global Corporate Default And Rating Transition Study

April 9, 2019

GLOBAL FIXED INCOME RESEARCH

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Key Takeaways

- Despite escalating market volatility and political uncertainty in 2018, funding conditions remained accommodative, and the global speculative-grade corporate default rate fell to 2.1% in 2018 from 2.5% at the end of 2017. The number of corporate defaults globally fell to 82. More companies were upgraded than downgraded, and 73% of companies retained the same ratings by year-end.
- All companies that defaulted in 2018 that were rated at the start of the year were speculative grade (rated 'BB+' or lower), and 74% of these were in the 'CCC'/'C' rating category. As a result, the one-year global Gini ratio rose to 93% in 2018 from 92.7% in 2017, reaching its highest since 2014.
- Emerging markets experienced the largest increases in the number of downgrades in 2018. Corporate downgrades in Brazil, Argentina, and Turkey more than doubled, mostly as a result of sovereign downgrades for each of these countries during the year.
- For the first time in the 38-year history of the ratings covered in our global corporate default and transition studies, speculative-grade issuers represented the majority of global ratings as of year-end. In large part, this resulted from the growing number of newly rated speculative-grade issuers over the past several years.

Despite greater market volatility and political uncertainty in 2018, funding conditions for companies remained accommodative for much of the year, and the global corporate default rate declined. By many measures, 2018 showed improved performance for S&P Global Ratings' corporate credit globally. Even amid rising trade tensions, populism's growing political influence, and Brexit, companies were largely able to brush aside the noise and benefit from the continued growth of the global economy. Against this backdrop, many of S&P Global Ratings' measures for rating performance and rating stability, as well as the proportion of upgrades, rose to their highest levels since 2014. Meanwhile, the number of defaults fell to 82, its lowest level since that year (see chart 1 and table 1).

Over half of all defaults in 2018 came from two sectors: the consumer services sector and energy

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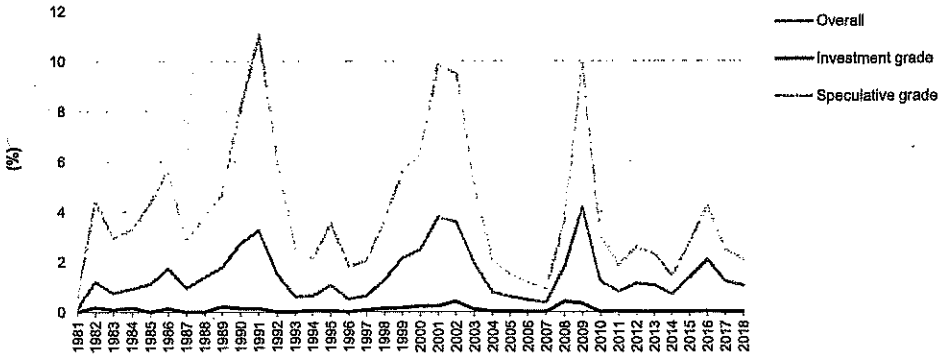
and natural resources (with 22 defaults each). These were the only two sectors with default rates in 2018 that exceeded their long-term weighted averages (see chart 2). Residual stress has continued to weigh on energy and natural resources, and brick-and-mortar retailers in consumer services are facing structural changes. Even though both sectors exhibited above-average default rates in 2018, these default rates (and the number of defaults for each sector) modestly declined from 2017.

This study includes industrials, utilities, financial institutions (banks, brokerages, asset managers, and other financial entities), and insurance companies globally with long-term local currency ratings from S&P Global Ratings. We calculated all default rates on an issuer-weighted basis. The default rates that we refer to as weighted averages in this study use the number of issuers at the beginning of each year as the basis for each year's weight. (For a detailed explanation of our data sources and methodology, see Appendix I.)

Chart 1

Global Default Rates: Investment Grade Versus Speculative Grade



Sources: S&P Global Fixed Income Research and S&P Global Market Intelligence's CreditPro®.

Table 1

Global Corporate Default Summary

Year	Total defaults*	Investment-grade defaults	Speculative-grade defaults	Default rate (%)	Investment-grade default rate (%)	Speculative-grade default rate (%)	Total debt outstanding (bil. $)
1981	2	0	2	0.14	0.00	0.62	0.06
1982	18	2	15	1.19	0.18	4.41	0.90
1983	12	1	10	0.76	0.09	2.94	0.37
1984	14	2	12	0.91	0.17	3.27	0.36
1985	19	0	18	1.11	0.00	4.33	0.31
1986	34	2	30	1.72	0.15	5.70	0.46

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nearly 2.5 percentage points below its long-term weighted average (see table 4). Once again, the default rate in the 'AAA' rating category was zero, continuing the unblemished default record for corporate ratings in this category and consistent with historical trends.

Table 3

Global Corporate Annual Default Rates By Rating Category

(%)	AAA	AA	A	BBB	BB	B	CCC/C
1981	0.00	0.00	0.00	0.00	0.00	2.27	0.00
1982	0.00	0.00	0.21	0.34	4.22	3.13	21.43
1983	0.00	0.00	0.00	0.33	1.16	4.58	6.67
1984	0.00	0.00	0.00	0.67	1.14	3.41	25.00
1985	0.00	0.00	0.00	0.00	1.49	6.47	15.38
1986	0.00	0.00	0.18	0.33	1.32	8.39	23.08
1987	0.00	0.00	0.00	0.00	0.38	3.09	12.28
1988	0.00	0.00	0.00	0.00	1.05	3.64	20.37
1989	0.00	0.00	0.18	0.60	0.72	3.38	33.33
1990	0.00	0.00	0.00	0.58	3.57	8.56	31.25
1991	0.00	0.00	0.00	0.55	1.69	13.84	33.87
1992	0.00	0.00	0.00	0.00	0.00	6.99	30.19
1993	0.00	0.00	0.00	0.00	0.70	2.62	13.33
1994	0.00	0.00	0.14	0.00	0.26	3.08	16.67
1995	0.00	0.00	0.00	0.17	0.99	4.58	28.00
1996	0.00	0.00	0.00	0.00	0.45	2.91	8.00
1997	0.00	0.00	0.00	0.25	0.19	3.51	12.00
1998	0.00	0.00	0.00	0.41	0.82	4.63	42.86
1999	0.00	0.17	0.18	0.20	0.95	7.29	33.33
2000	0.00	0.00	0.27	0.37	1.16	7.70	35.96
2001	0.00	0.00	0.27	0.34	2.97	11.53	45.45
2002	0.00	0.00	0.00	1.02	2.89	8.20	44.44
2003	0.00	0.00	0.00	0.23	0.58	4.07	32.73
2004	0.00	0.00	0.08	0.00	0.44	1.45	16.18
2005	0.00	0.00	0.00	0.07	0.31	1.74	9.09
2006	0.00	0.00	0.00	0.00	0.30	0.82	13.33
2007	0.00	0.00	0.00	0.00	0.20	0.25	15.24
2008	0.00	0.38	0.39	0.49	0.81	4.10	27.27
2009	0.00	0.00	0.22	0.55	0.75	10.98	49.46
2010	0.00	0.00	0.00	0.00	0.58	0.87	22.62
2011	0.00	0.00	0.00	0.07	0.00	1.68	16.30
2012	0.00	0.00	0.00	0.00	0.30	1.58	27.52
2013	0.00	0.00	0.00	0.00	0.10	1.64	24.67
2014	0.00	0.00	0.00	0.00	0.00	0.78	17.51

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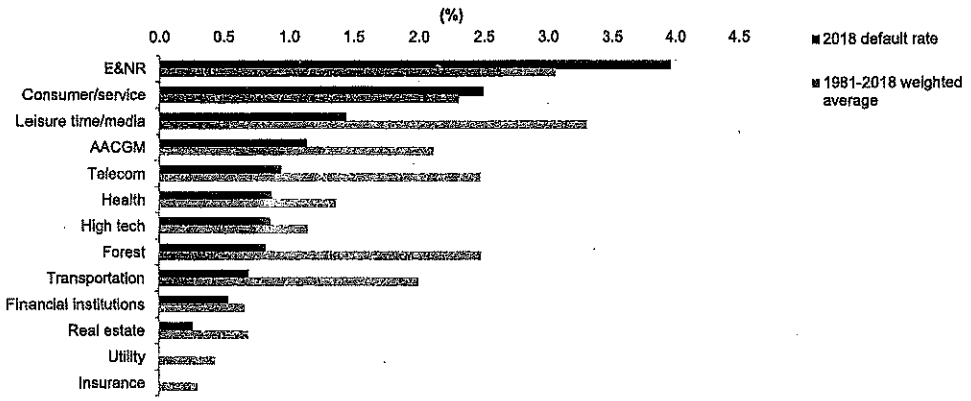
Chart 2

Global Corporate Default Rates By Industry: 2018 Versus Long-Term Average



E&NR--Energy and natural resources. AACGM--Aerospace/auto/capital goods/metals. Health--Health care/chemicals. High tech--High technology/computers/office equipment. Forest--Forest and building products/homebuilders. Sources: S&P Global Fixed Income Research and S&P Global Market Intelligence's CreditPro®.

Of the 82 defaults in 2018, 72 were from companies rated as of the beginning of the year. The 10 defaults from companies that were not rated at the beginning of 2018 included five for which the ratings were withdrawn before the beginning of 2018 and five that were first rated by S&P Global Ratings after Jan. 1, 2018. We consider companies reemerging from a prior default to be separate entities, with their rating histories beginning with the postdefault rating. As in 2017, there were no ults by companies that were rated investment grade ('BBB-' or higher). Each of the rated ulters was rated speculative grade ('BB+' or lower) at the beginning of 2018, and 74% of these were rated in the lowest rating category of 'CCC'/'C'.

With such a large share of defaults coming from companies at the lowest rating levels in 2018, the one-year Gini ratio rose to its highest since 2014, to 93% from 2017's 92.7% (see chart 3). The Gini ratio is a measure of the rank-ordering power of ratings over a given time horizon, from one through seven years. It shows the ratio of actual rank-ordering performance to theoretically perfect rank ordering. The one-year Gini in 2018 was well above the one-year weighted-average (since 1981) Gini ratio of 82.5% (see table 2 and chart 30). (For details on the Gini methodology, refer to Appendix II.)

quarters (see chart 10). The median rating for all recently defaulted entities was solidly in the speculative-grade category in the seven years preceding default, and for most of that period, it was at least one notch below that of the long-term equivalent.

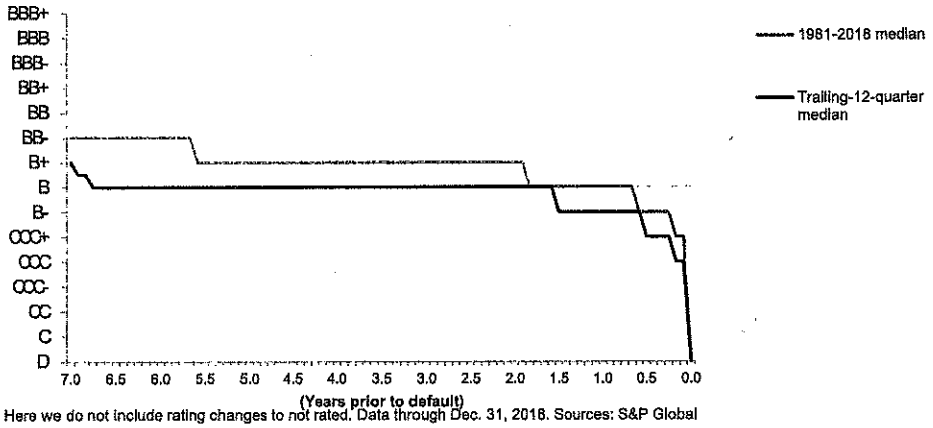
Financial services companies are typically more sensitive to sudden declines in investor and stakeholder confidence than nonfinancial companies, which can contribute to a rapid decline in funding liquidity and credit quality. In turn, this can result in a relatively fast descent into default (see chart 11). This was especially evident during the global financial crisis, when many highly rated banks defaulted within a short amount of time from their initial downgrades. Since 1981, financial services defaulters show a median rating in the 'BBB' category five years prior to default. But now that a decade has passed since the crisis, financial services defaulters from the past three years show a median rating in the 'B' category five years prior to default.

Historically, nonfinancial defaulters tend to have a much smoother and shorter path to default (see chart 12). One key reason is that financial services companies typically start with investment-grade ratings, while most nonfinancial issuers have speculative-grade initial ratings, particularly over the past 10 years.

Another major difference between financial and nonfinancial companies is the incidence of default. Defaults are much less frequent for financial services companies than for nonfinancials, which can allow outliers to bias the averages. For instance, in the three years ended Dec. 31, 2018, 308 nonfinancial companies defaulted, while only 32 financials did. Despite the much smaller sample of financial services defaults over the past three years, most of these defaulters were rated in the lowest rating categories several years ahead of their eventual default.

Chart 10

Median Rating Path Of Corporate Defaulters



Note: Here we do not include rating changes to not rated. Data through Dec. 31, 2018. Sources: S&P Global Fixed Income Research and S&P Global Market Intelligence's CreditPro®.

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;age One-Year Corporate Transition Rates (1981-2018)

(%)

From/to	AAA	AA	A	BBB	BB	B	CCC/C	D	NR
U.S.									
AAA	87.33	8.66	0.58	0.04	0.12	0.04	0.04	0.00	3.18
	(10.17)	(10.34)	(1.16)	(0.21)	(0.36)	(0.27)	(0.27)	(0.00)	(2.49)
AA	0.51	87.15	7.45	0.57	0.08	0.10	0.03	0.03	4.07
	(0.52)	(6.23)	(4.55)	(0.83)	(0.23)	(0.28)	(0.11)	(0.16)	(2.44)
A	0.04	1.72	88.00	5.32	0.38	0.15	0.03	0.07	4.29
	(0.12)	(1.19)	(4.11)	(2.50)	(0.49)	(0.33)	(0.11)	(0.16)	(1.87)
BBB	0.01	0.12	3.49	86.33	3.67	0.58	0.11	0.20	5.49
	(0.05)	(0.18)	(1.91)	(4.69)	(1.78)	(0.84)	(0.16)	(0.31)	(1.92)
BB	0.02	0.05	0.18	4.84	77.29	7.60	0.56	0.75	8.81
	(0.08)	(0.12)	(0.31)	(2.30)	(5.32)	(3.90)	(0.71)	(0.86)	(2.49)
B	0.00	0.03	0.10	0.19	4.53	75.46	4.59	3.63	11.45
	(0.00)	(0.10)	(0.23)	(0.25)	(2.03)	(4.52)	(2.40)	(3.33)	(2.34)
CCC/C	0.00	0.00	0.16	0.25	0.66	11.88	43.86	28.89	14.30
	(0.00)	(0.00)	(0.55)	(0.80)	(1.15)	(7.72)	(8.47)	(11.17)	(5.18)
Europe									
AAA	82.79	11.07	0.61	0.20	0.00	0.00	0.20	0.00	5.12
	(7.87)	(8.49)	(1.70)	(1.22)	(0.00)	(0.00)	(1.01)	(0.00)	(5.03)
AA	0.27	85.28	10.02	0.55	0.00	0.00	0.00	0.00	3.88
	(0.49)	(7.13)	(6.46)	(1.16)	(0.00)	(0.00)	(0.00)	(0.00)	(2.13)
A	0.01	1.83	87.03	5.79	0.17	0.01	0.00	0.04	5.12
	(0.05)	(1.40)	(4.41)	(3.37)	(0.35)	(0.06)	(0.00)	(0.09)	(1.82)
	0.00	0.09	4.30	84.42	3.52	0.32	0.10	0.07	7.18
	(0.00)	(0.20)	(1.85)	(3.83)	(2.68)	(0.54)	(0.29)	(0.21)	(2.51)
BB	0.00	0.00	0.08	5.34	73.66	6.89	0.35	0.35	13.35
	(0.00)	(0.00)	(0.64)	(2.38)	(6.54)	(3.63)	(1.02)	(0.87)	(4.18)
B	0.00	0.00	0.03	0.28	5.84	71.79	4.15	2.14	15.77
	(0.00)	(0.00)	(0.23)	(0.55)	(3.06)	(6.24)	(2.24)	(2.98)	(5.22)
CCC/C	0.00	0.00	0.00	0.31	0.00	13.98	41.30	25.47	18.94
	(0.00)	(0.00)	(0.00)	(0.74)	(0.00)	(11.05)	(16.42)	(16.24)	(10.02)
Emerging markets									
AAA	89.29	9.52	0.00	0.00	0.00	0.00	0.00	0.00	1.19
	(21.46)	(21.09)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(6.37)
AA	1.13	87.98	8.16	0.23	0.00	0.00	0.00	0.00	2.49
	(5.32)	(12.08)	(9.65)	(1.45)	(0.00)	(0.00)	(0.00)	(0.00)	(3.70)

Table 25

Average Cumulative Default Rates For Corporates By Region (1981-2018) (cont.)

(%)	--Time horizon (years)--														
Rating	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
All rated	1.51	2.89	4.07	5.09	5.87										

Note: Figures for Europe and the emerging markets are calculated for the period 1996-2018 due to sample size considerations. Sources: S&P Global Fixed Income Research and S&P Global Market Intelligence's CreditPro®.

Table 26

Global Corporate Average Cumulative Default Rates By Rating Modifier (1981-2018)

(%)	--Time horizon (years)--														
Rating	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AAA	0.00	0.03	0.13	0.24	0.35	0.45	0.51	0.59	0.65	0.70	0.73	0.76	0.79	0.85	0.92
AA+	0.00	0.05	0.05	0.10	0.15	0.21	0.26	0.32	0.38	0.44	0.50	0.56	0.62	0.69	0.76
AA	0.02	0.03	0.08	0.22	0.36	0.48	0.60	0.71	0.80	0.89	0.97	1.03	1.14	1.20	1.27
AA-	0.03	0.08	0.17	0.25	0.32	0.44	0.50	0.55	0.61	0.66	0.72	0.79	0.81	0.86	0.90
A+	0.05	0.09	0.20	0.33	0.43	0.53	0.64	0.76	0.89	1.03	1.17	1.31	1.47	1.66	1.83
A	0.06	0.14	0.23	0.35	0.48	0.65	0.83	1.00	1.19	1.41	1.59	1.73	1.86	1.95	2.12
A-	0.06	0.16	0.26	0.38	0.54	0.70	0.93	1.10	1.23	1.34	1.45	1.58	1.71	1.83	1.92
BBB+	0.10	0.29	0.50	0.73	0.97	1.25	1.46	1.68	1.93	2.17	2.41	2.58	2.80	3.07	3.37
BBB	0.16	0.41	0.64	1.01	1.36	1.72	2.04	2.36	2.72	3.08	3.46	3.77	4.01	4.12	4.33
BBB-	0.24	0.73	1.35	2.04	2.77	3.42	4.00	4.55	5.00	5.39	5.83	6.19	6.51	7.00	7.37
BB+	0.32	1.04	1.91	2.79	3.69	4.56	5.29	5.81	6.42	7.04	7.45	7.95	8.43	8.77	9.27
BB	0.53	1.61	3.19	4.68	6.17	7.36	8.43	9.35	10.22	10.98	11.76	12.39	12.81	13.12	13.53
BB-	0.95	2.98	5.11	7.33	9.27	11.15	12.71	14.21	15.42	16.46	17.28	17.99	18.74	19.48	20.15
B+	2.01	5.52	8.95	11.88	14.15	15.89	17.54	18.97	20.30	21.49	22.48	23.14	23.80	24.45	25.09
B	3.41	7.84	11.69	14.73	17.09	19.27	20.74	21.77	22.74	23.74	24.48	25.18	25.77	26.30	26.85
B-	6.75	13.73	19.04	22.70	25.43	27.42	29.01	30.11	30.82	31.37	32.13	32.67	32.91	33.18	33.50
CCC/C	26.69	36.27	41.13	43.94	46.06	46.99	48.20	49.04	49.80	50.44	50.96	51.51	52.16	52.72	52.80
Investment grade	0.09	0.25	0.43	0.66	0.90	1.14	1.36	1.56	1.77	1.96	2.16	2.32	2.48	2.63	2.80
Speculative grade	3.66	7.13	10.12	12.56	14.55	16.18	17.55	18.69	19.70	20.62	21.39	22.02	22.60	23.13	23.65
All rated	1.48	2.91	4.16	5.21	6.08	6.82	7.44	7.97	8.44	8.88	9.26	9.58	9.87	10.13	10.41

Sources: S&P Global Fixed Income Research and S&P Global Market Intelligence's CreditPro®.

Gini Ratios And Lorenz Curves

A quantitative analysis of the performance of S&P Global Ratings' corporate credit ratings shows that they continue to correlate with default risk across several time horizons. As one measure of

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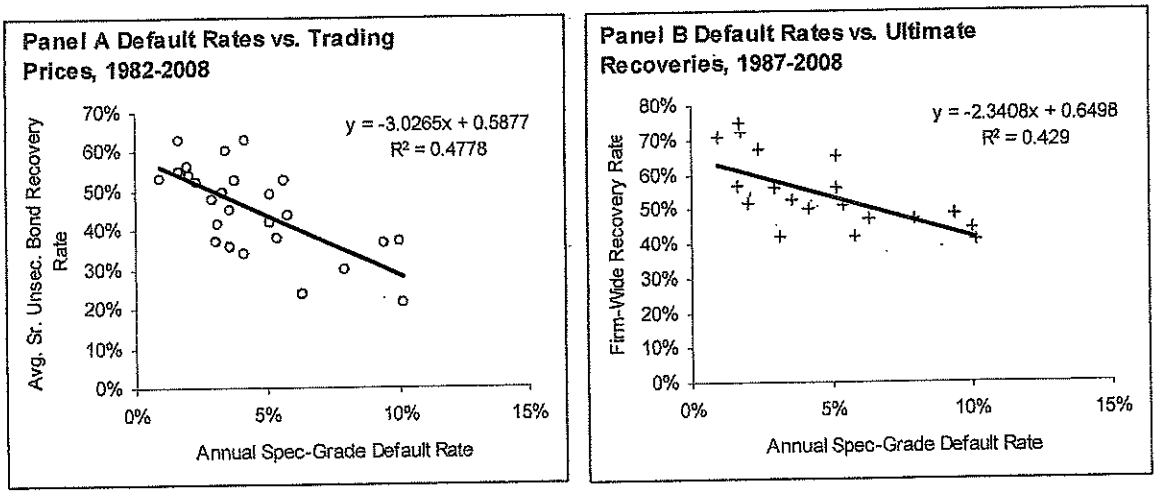
Corporate Default and Recovery Rates, 1920-2008

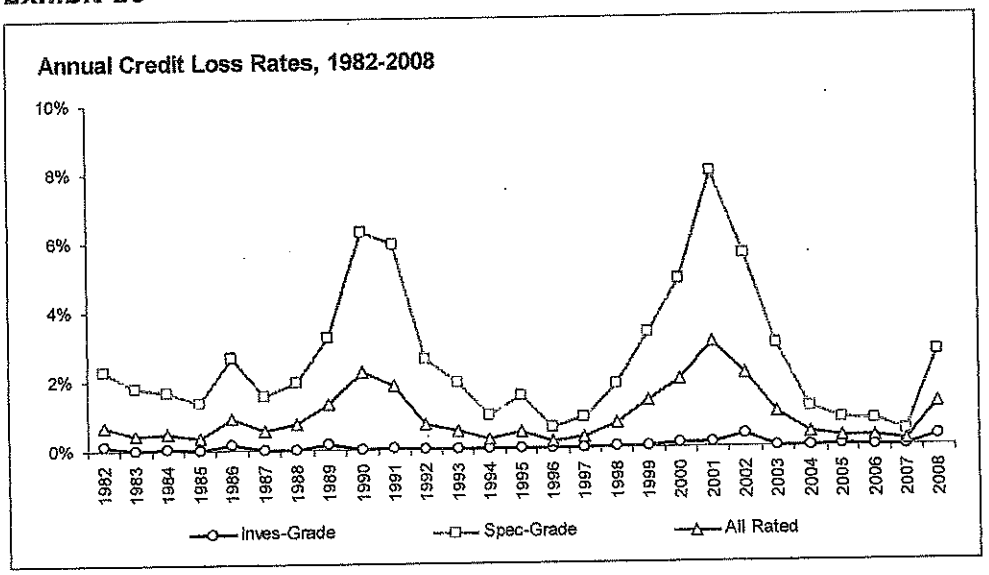
Exhibit 9

Correlation between Default and Recovery Rates



Moody's credit ratings are opinions of relative expected credit losses upon default, which are functions of both the probability of default and severity of default (LGD). Exhibit 10 shows annual credit loss rates from 1982 to 2008 for Moody's-rated corporate issuers. In 2008, the rising default rate, coupled with a higher loss severity rate, led to an increase in the credit loss rate among Moody's-rated issuers to 1.2%, compared to 0.2% in 2007. The average annual credit loss rate since 1982 is 0.9% (see underlying data in Exhibit 29).

Exhibit 10



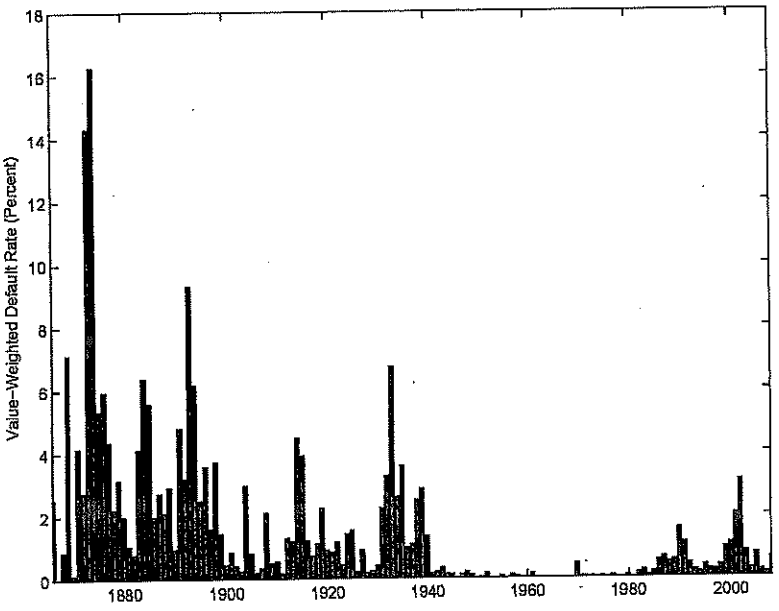


Figure 1. Historical Default Rates. This graph plots the annual value-weighted percentage default rate for bonds issued by domestic nonfinancial firms for the 1866-2008 period.

Table 3

The Most-Severe Three-Year Default Periods. This table lists the dates for the 12 top three-year default periods during the 1866-2008 sample period. Total default is the sum of the annual default rates during each three-year period. Stock return is the sum of the annual stock market returns for each three-year period. NBER Fraction is the proportion of time during each three-year period that the economy was in an NBER-designated business downturn. Default rates are expressed as percentages.

Rank	Period	Total Default	Maximum Default	Stock Return	NBER Fraction
1	1873-1875	35.90	16.25	1.50	0.72
2	1892-1894	18.69	9.32	−5.46	0.47
3	1883-1885	16.06	6.38	5.36	0.81
4	1933-1935	12.88	6.73	35.54	0.08
5	1876-1878	12.51	5.94	−1.29	1.00
6	1869-1871	11.41	4.14	10.06	0.50
7	1914-1916	9.59	4.48	15.98	0.33
8	1896-1898	8.91	3.73	18.74	0.50
9	1887-1889	7.71	2.91	5.17	0.36
10	1938-1940	6.67	2.84	7.61	0.17
11	1879-1881	6.16	3.14	26.14	0.08
12	2000-2002	6.15	3.07	−14.40	0.22

2 Corp FMC

Hit <MENU> for more choices or hit 1 <GO> to view graph.

Fair Market Sector Curves

CURVE # 1: [redacted] # 2: [redacted] # 3: [redacted] # 4: [redacted] # 5: [redacted] # 6: [redacted]

Curve freq: 0/YR (0 for default frequencies)

\+ indicates curve floats intraday with benchmark curve

LIST FOR: US DOLLAR Page 1

US GOVT & AGNCY
79 + USD US Trsy Strips
82 + USD US Tsy Notes/Bds
84 + USD Govt Agency
85 + USD Govt Agency MTN
87 + USD US Treasury Bill
91 + USD REFCO/Agcy Strps
93 + USD Govt Agency DN's
94 + Agy Comp Strps/Zeros
500 + ACTIVE U.S. GOVTS
US $ Domestic
1 + USD Industrial AAA
3 + USD Industrial (AA)
5 + USD Industrial A+
6 + USD Industrial A
7 + USD Industrial A-
8 + USD Industrial BBB+
9 + USD Industrial BBB
10 + USD Industrial BBB-
16 + USD Phones (A)
19 + USD Phones (BBB)
21 + USD Finance AAA
23 + USD Finance (AA)
26 + USD Finance (A)
28 + USD Finance (BBB)
29 + USD Finance (BB)
33 + USD 1st Mtg Utl (AA)
34 + USD 1st Mtg. Utl (A)
36 + USD US Utility (A)
38 + USD US Utility BBB+
39 + USD US Utility BBB
40 + USD US Utility BBB-
41 + USD 1st Mtg Ut (BBB)
42 + Yankee Bank/Fin (AA)
43 + Yankee Bank/Fin (A)
44 + Ynkee World Bk Zeros
45 + Yankee Supranatl AAA
49 + Yankee Indust. (A)
51 + Ykee Sov/Agency (AA)
53 + Yankee Ind (BBB)
60 + USD Canada Prov (AA)
61 + USD Canada Prov (A)

Curves in white have been added. 2<go> for full list of curve actions
Curves in red have been resumed after interruption.
Curves in blue have changed length.
Curves in grey have been discontinued or combined.

<HELP> for explanation, <MENU> for similar functions. P111 n Corp **SND**

91) Structured Notes Overview

1) CMS Floaters
2) Callable Step Coupon Notes
3) Callable Capped and/or Floored Floaters
4) Stepped Cap/Floor Floater Notes
5) Stepped Spread Callable Floater
6) Inverse Floater Notes
7) Deleveraged & Leveraged Floater Notes
8) Dual-Index Notes (Steepeners)
9) Floater with a Curve Cap
10) Flip-Flops (Switch Coupon Bonds)
11) Minimum or Maximum of
12) Range Accrual Notes
13) Spread Range Accrual Notes
14) Dual Range Accruals Notes
15) Multi-Range Accrual Notes

Structured Note Definitions

16) Countdown Range Accrual Notes
17) Digital Range Notes
18) Ratchet Floaters
19) Inverse Ratchet Floaters (Snowballs)
20) Snowbear Notes
21) Ratchet Range Accruals
22) Inflation Linked Notes
23) Zero Coupon Accreting as a Structured Coupon
24) Target Redemption Notes (TARN)
25) Volatility/Absolute Value Notes
26) Credit Linked Notes
27) Index Amortization Notes (IAN)
28) Power Reversal Dual Note
29) Variable Principal or Coupon at Redemption
30) Reverse Convertibles

92) STN in Bloomberg: Latest Updates

93) Pricing a Portfolio of STN: an Excel Example

Merton Credit Model

- Assumptions:
  - Balance sheet.
  - Zero-coupon bond, maturity T, notional F.
  - Asset dynamics: $dV = rVdt + \sigma VdZ$.
  - Constant r.
- Valuing equity equivalent to valuing bond.
- Equity payoff at T: $\max(0, V_T - F)$.
- Equity is call option on the firm's assets.

Merton Credit Model Continued

- Black-Scholes model applied to equity:

$$Eq_0 = V_0 N(d) - Fe^{-rT} N(d - \sqrt{\sigma^2 T})$$

$$d = \frac{\ln(V_0/F) + (r + \sigma^2/2)T}{\sqrt{\sigma^2 T}}$$

- Bond value:

$$V_0 - V_0 N(d) + Fe^{-rT} N(d - \sqrt{\sigma^2 T})$$

- Limiting case as $V_0/F \to \infty$.
- Credit spread

$$-\frac{\ln(BondPrice/F)}{T} - r$$

- The term structure of credit spreads.
- Empirical evidence.
- Strengths and weaknesses of the Merton Model.

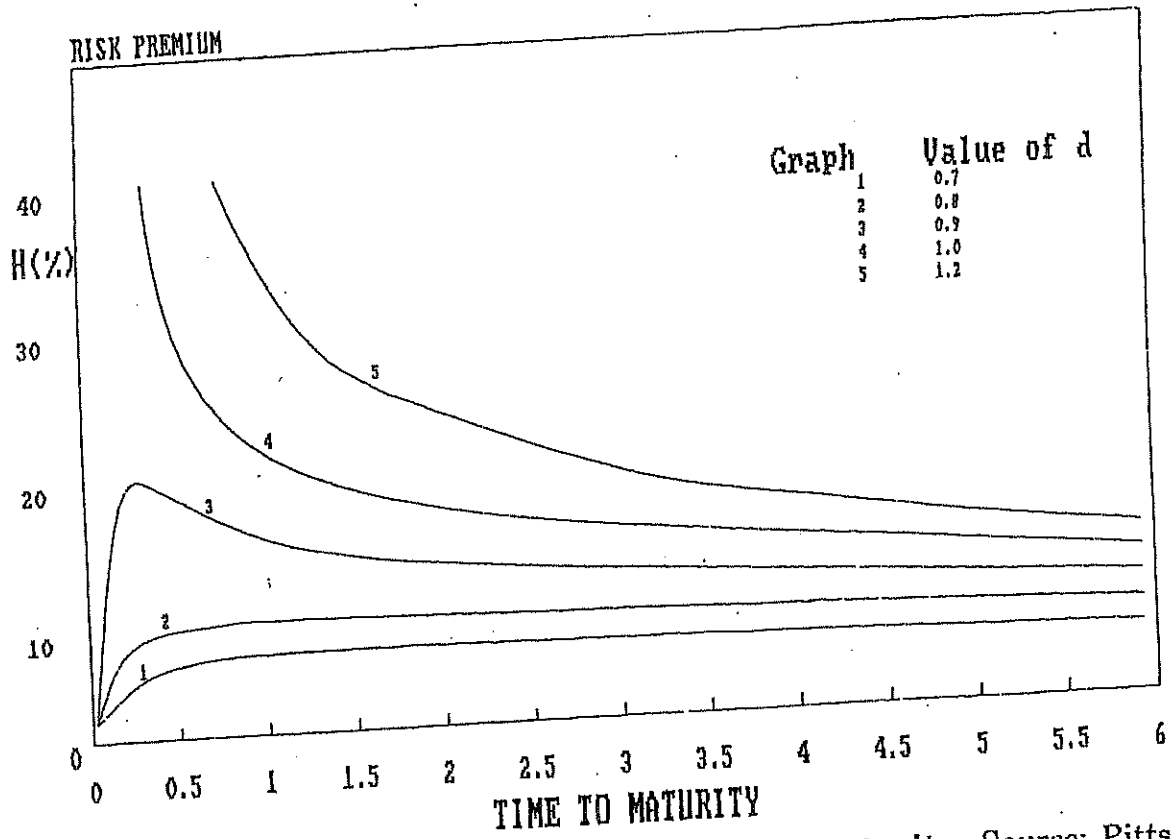


Figure 2. Risk premium (H) as a function of time to maturity. Source: Pitts and Selby (1983). Note that the risk premium is expressed in terms of percent per unit of time. However, the unit of time is arbitrary and need not be one year.

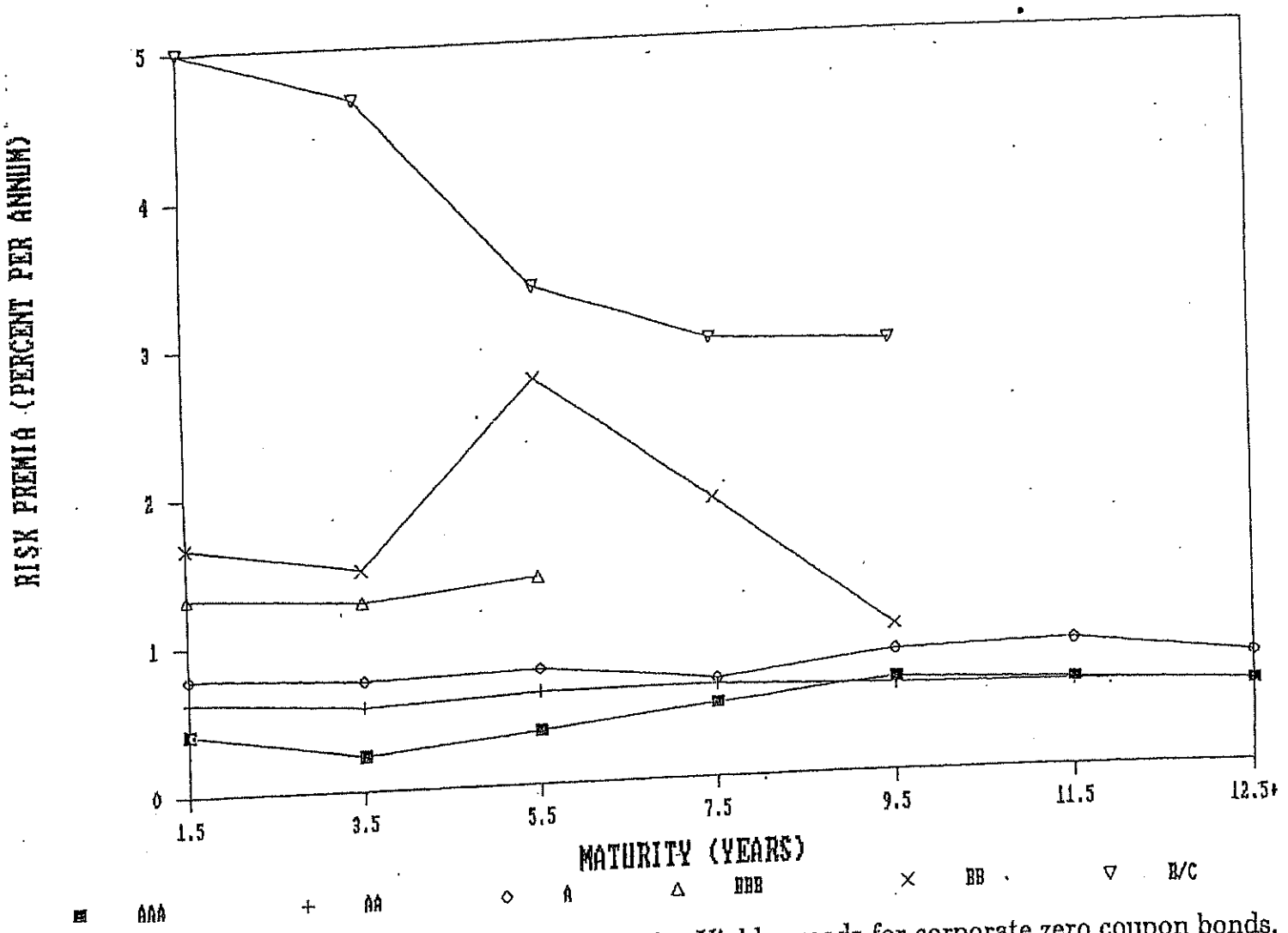


Figure 1. The term structure of risk premia. Yield spreads for corporate zero coupon bonds, February 1985 through September 1987. Maturity numbers (horizontal axis) correspond to the average maturity of each cell in Table I. Average yield spreads are calculated as follows: in each month the yield to an individual corporate bond has subtracted from it the yield to a zero coupon government "strip" with identical maturity. If no government strip with identical maturity existed, the yields on the two "strips" with maturities most closely bounding the corporate bond were

State of the Art Models

- Black-Scholes, Longstaff-Schwartz, KMV.
- No restrictions on liability structure of firm.
- Default occurs first time assets reach threshold K.
  - Consistent with cash-flow-based default.
  - Consistent with covenant-violation-based default.
- Assets of K are then allocated to individual bondholders based on prespecified sharing rule (seniority, coupon rate, secured/unsecured, recovery rate assumptions).

Implementation Approaches

- Assets equal book value debt plus market value equity.
- Default threshold equals short-term debt plus 1/2 long-term debt.
- Volatility of assets equals volatility of equity times option delta.
- Simulate 1,000,000 paths of asset values and determine how frequently default occurs over the next N years.
- The debate: are agency bond ratings better than KMV approach at predicting default?
  - KMV uses historical accounting data.
  - KMV also uses forward looking equity and equity volatility information.
- Horse racing results and resolution of the debate.

Poisson Process

- Stochastic counting process P_t; graph.
- Used as model for rare events:
  - Decay of radioactive atom.
  - Earthquakes.
  - Light bulb burning out.
- Probability of a jump from t to $t + \Delta t$ is $\lambda(t)\Delta t$
- $\lambda(t)$ is intensity at which jumps occur.
- Probability that no jump occur up to time T:

$$= \exp(-Ave\lambda \times T)$$

- Example: $\lambda = 0.02$, $T = 5$. Probability of survival: $e^{-0.10} = 0.9048$.

Credit Case Part I

- We will use information in market prices of corporate bonds to infer probabilities of default and then use these to value credit-sensitive securities.
- Market data:
  - $r = 0.06$.
  - $C(1) = 0.92$.
  - $C(2) = 0.85$.
  - $C(3) = 0.78$.
  - Recovery rate $= 50$ percent.

Credit Case Part I Continued

- Present value of one-year corporate zero-coupon bond:

$$C(1) = e^{-0.06} \times P_1 + 0.50e^{-0.06} \times (1 - P_1)$$

- Solve for one-year probability of survival P_1

$$P_1 = \frac{0.92 - 0.50e^{-0.06}}{0.50e^{-0.06}} = 0.953779$$

Credit Case Part I Continued

- Present value of two-year corporate zero-coupon bond:

$$C(2) = e^{-0.12} \times P_2 + 0.50e^{-0.12} \times (1 - P_2)$$

- Solve for two-year probability of survival P_2

$$P_2 = \frac{0.85 - 0.50e^{-0.12}}{0.50e^{-0.12}} = 0.916745$$

Credit Case Part I Continued

- Present value of three-year corporate zero-coupon bond:

$$C(3) = e^{-0.18} \times P_3 + 0.50e^{-0.18} \times (1 - P_3)$$

- Solve for three-year probability of survival P_3

$$P_3 = \frac{0.78 - 0.50e^{-0.18}}{0.50e^{-0.18}} = 0.867659$$

Credit Default Swaps

- Think of CDS contracts like auto insurance.
- You pay a premium periodically.
- If you have an accident, insurance company makes you whole.
- Bond default is essentially a "crash" of your bond.
- Single-Name Credit Default Swaps — A Users Guide.
- Examples of CDS spread term structures.
- Counterparty credit risk mitigated by marking to market and collateralization.

SALOMON SMITH BARNEY

GLOBAL
CREDIT DERIVATIVES
RESEARCH

FEBRUARY 1, 2002

Credit Derivative Products

UNITED STATES

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New York

Single-Name Credit Default Swaps — A Users Guide

- A basic, single-name credit default swap is described and the mechanics of the swap are highlighted.
- We illustrate the use of single-name credit default swaps as an alternative to cash instruments with an example.
- A credit default swap term sheet is explained in lay terms.

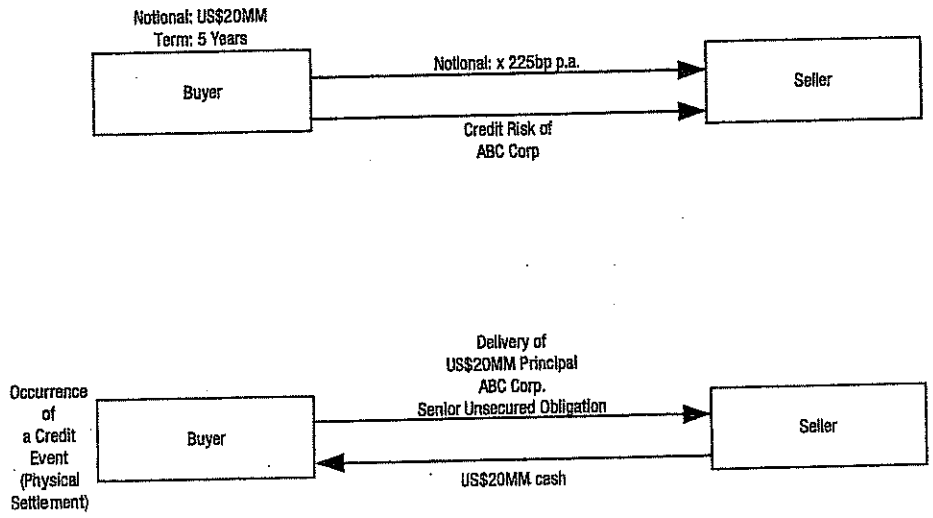
Contents

Figures

What is a Credit Default Swap?

Credit default swaps are contracts that transfer credit risk and allow investors to manage credit exposures by separating their credit views from other market variables. The market for default swaps originated with banks looking to hedge credit risk in their loan portfolios. This market has grown rapidly in recent years as more players seeking credit hedges or yield (pickup over conventional cash instruments) have begun to participate. Banks, insurance companies, corporations, and hedge funds actively trade in the default swap market, which is expected to grow substantially in coming years. The intent of this report is to provide a basic understanding of the single-name credit default swap product and its practical implementation in the credit derivatives marketplace.

Figure 1. A Credit Default Swap



Source: Salomon Smith Barney.

A simple credit default swap is described in Figure 1. The "buyer" is the party that **seeks credit protection** and is willing to pay a credit spread. This creates a short credit risk position for the buyer. The "seller" is the party that **sells credit protection** and receives a credit spread from the protection buyer. This creates a long credit risk position for the seller.

Because the default swap is an instrument for the purchase and sale of protection (the opposite of risk), it is quoted "backwards" from bond market convention. That is, the bid is the price that the bidder would pay to buy protection (sell the risk), and the offer is the fixed rate that the protection seller would require to provide protection (take the risk); thus, the bid is a lower number than the offer.

Setting Up a Credit Default Swap Transaction

In this section, we describe the basics of a credit default swap transaction. The terms discussed in this section are taken from an actual credit default swap confirmation, which is a legal document. The explanations of these terms have been simplified for illustrative purposes and should not be construed as their legal meanings. Consequently they should not be used as the basis on which to negotiate an actual contract.

A single-name credit default swap is a contract between a buyer and a seller of protection. The terms of the swap are flexible and are negotiated between the buyer and seller. The conditions under which the protection is valid are also negotiated at the outset. In addition, the following items must be determined before entering into the contract:

What information do you need?

- "The reference entity" is the obligor on which protection is either being bought or sold, e.g., ABC Corporation.
- "Reference obligation" is an obligation of the reference entity that is referred to in the default swap contract. The characteristics of the reference obligation often provide a basis on which to compare any obligation that may be delivered to the protection seller (a "deliverable obligation") if a credit event occurs. These characteristics typically require that any deliverable obligation be pari passu with the reference obligation in the priority of payments of the debt of the reference entity.
- "Floating-rate payer calculation amount" or the "notional amount" of the default swap is the amount of exposure to a particular credit (the "reference entity") for which protection is either being bought or sold for a particular period of time.
- "Tenor for which risk is being transferred" is the period for which the protection under the default swap will remain effective (typically five years)
- "Credit events" are the circumstances that must occur for the protection buyer (or seller) to require the buyer to exercise its right to exchange a deliverable obligation with the seller for a payment of par. These events typically include failure to pay, bankruptcy, obligation acceleration, restructuring, and moratorium/repudiation and are described later in more detail.
- "Default swap premium" is the premium (fixed rate) that the buyer agrees to pay the seller in exchange for the transfer of credit risk. The market convention is to pay quarterly on an A/360 basis.

If a credit event on the underlying reference entity should occur, the credit default swap is designed to unwind in an orderly manner. We next describe the series of events that unfold upon a credit event.

What Happens in Case of a Credit Event?

Establish the Occurrence of a Credit Event

A credit event is often documented in local newspapers, business magazines, or other publications that are publicly available. The recording of such an event allows the buyer to exercise the right to put the deliverable obligation to the seller at par.

The Buyer (or Seller) Delivers a Credit Event Notice to the Seller (Buyer)

The notice informs the seller (or buyer) as to which credit event has occurred within a specified interval of time called the "notice delivery period." In most cases a "notice of publicly available information" concerning the credit event must also be delivered (either as part of the credit event notice, or delivered separately). This notice cites the sources of information confirming the occurrence of the credit event.

The Buyer Delivers a Notice of Intended Physical Settlement to the Seller

This notice is an expression of the buyer's intent to physically settle the credit default swap contract. The notice also contains a detailed description of the type of deliverable obligations that the buyer reasonably expects to deliver to the seller.

The Buyer Delivers a Deliverable Obligation to the Seller

These obligations are obligations of the reference entity that may be delivered in connection with physical settlement. A deliverable obligation must typically be either a bond or a loan and must meet certain characteristics. Investors should see the International Swaps and Derivatives Association (ISDA) credit derivatives definition documents for details, but in general, the deliverable obligation must be pari passu with senior unsecured obligations of the reference entity.

Seller Pays Par to the Buyer

If the contract is physically settled, the seller pays par to the buyer in exchange for the deliverable obligation. In some special cases delivery cannot be completed. In such cases, a market value is determined for the reference obligation and a cash payment is made to the protection buyer for the implied loss on that obligation (the difference between par and the market value). If market conditions prohibit the successful delivery of the obligations to the seller, the transaction terminates unexercised.

If no credit events occur during the term of the default swap the swap expires unexercised. Furthermore, market conditions may prompt an investor to terminate the swap prior to the final maturity of the default swap, for example, when the investor wants to book a profit. In such a situation, the investor will, in most situations, unwind the default swap contract with the dealer with whom he entered into the transaction at the current market value of the swap.

How is the Default Swap Contract Documented?

Early credit derivative contracts suffered from the ambiguity surrounding the documentation of the agreements. Since 1999, ISDA has provided a standard template to document a default swap transaction between the two parties. These contracts are governed by a set of common rules and definitions published by ISDA. Before entering into a transaction, both parties in the default swap usually have "a signed ISDA" in place. This is an agreement that sets forth the rights and duties of the two parties under all swap contracts.

Other Requirements

In addition to a signed ISDA, credit lines between the counterparties must be in place because each party is taking on credit exposure to the other. These credit lines are the last component of the process necessary to close the credit default swap transaction.

The cash flows of a (funded) cash instrument can be replicated using a credit default swap. In this sense a default swap is a synthetic bond and provide investors alternatives to investing in cash instruments at a potentially higher return for essentially the same risk.

Example: Buy Note Versus Sell Default Protection

A trade in which an investor is faced with the choice of buying the cash instrument or selling protection is described in Figure 2. We use the example of WorldCom (WCOM) where the customer chooses the form of WCOM exposure, i.e., either buy WCOM notes or sell WCOM protection.

Figure 2. WCOM Inc. (A3/BBB+) — Cash or Derivative Exposure?

Buy 8% WCOM Notes 5/15/06	Sell Five-Year WCOM Protection
Indicative bid/offer spread of 240bp/230bp to five-year T 3½% 11/15/06.	Indicative bid/offer of 200bp/215bp in default swaps.
At +240bp, with mid-market swap spreads of 58bp, the notes asset swap to LIBOR+182bp.	Unfunded position, so seller receives 215bp per annum.
If financing cost is LIBOR flat, net spread on the 4.5-year trade is 182bp per annum.	Market price assumes that counterparty funds at LIBOR flat.

Source: Salomon Smith Barney.

Selling WCOM protection results in a spread pickup of 33bp per annum. Some considerations in analyzing this trade are summarized in Figure 4.

Figure 3. Investor Considerations in the Cash Versus Default Trade

Buy WCOM Cash Bond	Sell WCOM Protection
Investor holds a specific bond	If a credit event occurs, the protection seller will purchase the cheapest WCOM bond or loan (within certain parameters) at par.
LIBOR + funding costs results in lower spread pickup	Larger benefit for investors who fund at LIBOR +

Source: Salomon Smith Barney.

Default swap premiums are quoted as a spread to LIBOR, while corporate bonds are typically quoted as a spread to Treasuries. Because most cash bonds are issued as fixed-rate instruments and because most investors fund on a LIBOR basis, it is necessary to convert the Treasury spread to a spread to LIBOR so that a comparison between default swap spreads and the spreads on the corresponding-maturity cash instruments is possible.

In practical terms, we **compare the (par) bond asset swap level for the cash bond and the default swap premium** so as to determine relative value between the cash and default swap market. The asset swap is used to convert a fixed-rate instrument to an equivalent floating-rate instrument. Many calculators are available to do this:

Yield Book™
Yield Book™ has an asset swap calculator that transforms fixed-rate corporate bond spreads into an equivalent asset swap level.

Bloomberg
Bloomberg has two simple calculators for converting a corporate bond price or spread to Treasuries to an equivalent asset swap level.

- Simply pull up the corporate bond and type **ASW <GO>**. In the lower half of the pasge, you can enter the bond price or yield, hit <GO> and the calculator will return the equivalent asset swap spread in the red box on the right side of the page. You can adjust the underlying curves (bid/mid/offer, country, basis) in the upper right hand corner of the page. Most dealers will use the midpoint of curve 23 (US semi bond).
- Alternatively, you can use **YAS <GO>** and enter the bond price, yield, or spread to a particular benchmark. This screen will also return an asset swap level.

The difference between the default swap spread and the corresponding asset swap spread is called the "cash default basis."

Default swap spreads will typically be wider than corresponding levels for asset swaps. In this case, the basis is said to be positive. Conversely, when default swaps trade inside cash, the basis is negative.

The basis is usually positive because a credit default swaps have slightly greater risk than bonds or loans for a particular reference entity. An investor who buys a bond or loan knows exactly what obligation they hold in the event of a credit downturn. The protection seller on the other hand knows broadly that he will hold a senior unsecured bond or loan that meets the criteria of a deliverable obligation. He will not know the specific bond or loan he will receive until there is a credit event, although he will know that it will be the cheapest bond or loan that meets the criteria. (If the buyer were long a different obligation other then the cheapest), he will sell that obligation, buy the cheapest one, and deliver it).

In the next section, we describe an actual credit default swap term sheet in lay terms.

A Credit Default Swap Term Sheet Explained

A typical credit default swap term sheet that explains the nature of the agreement between a protection buyer and protection seller is described in Figure 4. The left column contains the actual terms from a standard term sheet, followed by typical values. The right hand column contains a description/definition of these terms. Please note that actual term sheets are legal documents and the descriptions of the terms in Figure 4 are indicative meanings for explanatory purposes only. These descriptions should not be construed as their true legal meaning.

Figure 4. A Sample Credit Default Swap Term Sheet with Explanations

Item	Typical Value	Description/Definition
Trade Date	November 5, 2001	The date upon which the parties agree to the terms of the Credit Derivative transaction.
Effective Date	November 8, 2001	The date upon which the credit protection commences and the date upon which the Fixed Amount begins to accrue.
Scheduled Termination Date	November 8, 2006	The date upon which the transaction will terminate if any of the specified Credit Events do not occur on or prior to the termination date. If a Credit Event does occur, the transaction may terminate prior to the Scheduled Termination Date or, in certain limited circumstances, after the scheduled termination date.
Seller/Floating Rate Payer	Protection Seller (e.g., Citibank N.A.)	The party from whom credit protection is being purchased; equivalently, the party taking the credit risk.
Buyer/Fixed Rate Payer	Protection Buyer [Customer]	The party purchasing credit protection. The Buyer or Fixed Rate Payer pays the spread for the life of the contract in exchange for being taken out of the credit exposure.
Calculation Agent:	Seller	The party specified as such, typically the seller/dealer. If no party is specified then the Seller will be assumed to be the Calculation Agent. The Calculation Agent is responsible for making certain calculations and determinations with respect to the terms of the credit default swap contract. These are set forth in the Credit Derivatives Definitions.
Business Days	New York	A day on which commercial banks and foreign exchange markets are generally open to settle payments in the place or places and on the days specified for the purpose in the relevant confirmation and if a place or places are not so specified, in the jurisdiction of the currency of the Floating Rate Payer Calculation Amount.
Business Day Convention	Modified Following	The convention for adjusting a relevant date if it otherwise falls on a date that is not a Business Day.
Calculation Agent City	New York	The city in which the Calculation Agent is operating.
Calculation Amount	10 million US dollars	The notional amount of the trade. The amount of credit exposure being transferred.
Reference Entity	International Paper Co.	The entity upon which the credit protection is being bought or sold.
Reference Obligation	IP 7 5/8% of 1/15/07 CUSIP: 460146AM5	A Reference Obligation is selected based on its relationship to the Reference Entity. Most trades specify a senior unsecured obligation issued by the Reference Entity. If no Reference Obligation is specified, it is assumed to be a senior unsecured obligation of the Reference Entity. A Reference Obligation is automatically a Deliverable Obligation
Reference Price	100%	The value assigned by the parties to the Reference Obligation on the Trade Date, typically 100%. In cash-settled transactions, the Cash Settlement Amount will be the difference between the Reference Price and the Final Price multiplied by the Floating Rate Payer Calculation Amount. In physically settled transactions, the Reference Price is multiplied by the Floating Rate Payer Calculation Amount to determine the Physical Settlement Amount.

35

Figure 4. A Sample Credit Default Swap Term Sheet with Explanations (Continued)

Term			Example
Fixed-Rate Payer Payment Dates	February 8, May 8, August 8, and November 8 in each year with the first payment commencing on February 8, 2001.		The dates upon which the Fixed Rate Payer delivers the Fixed Rate Payments. The Fixed Rate Payments are generally paid quarterly in arrears. The final payment occurs on the Termination Date; however, Fixed Rate Payments cease accruing on the earlier of the scheduled Termination Date or the date on which the Credit Event notice or notice of publicly available information is delivered.
Fixed Rate	1.35% p.a. (Actual/360 basis on the Calculation Amount)		The premium to be paid per annum for the protection.
Conditions to Payment	Credit Event Notice (Notifying Party: Buyer or Seller) Notice of Intended Physical Settlement Notice of Publicly Available Information Applicable		Upon the occurrence of a Credit Event, the Conditions To Payment must be met before the parties settle the swap (exchange the deliverable obligation for par). First, the Notifying Party must deliver a Credit Event notice once the Credit Event has occurred. The Notice of Intended Physical Settlement lets the Seller know which obligation the Buyer intends to use to settle the swap.
Credit Events	Bankruptcy Failure to Pay Obligation Acceleration Restructuring/Modified Restructuring (US) Restructuring (Europe) Repudiation/Moratorium (Europe) Limitation Applicable		**Credit Events** are events that must occur before the Conditions To Payment may be met and the swap may be settled. • **Bankruptcy.** The Reference Entity files for bankruptcy protection (or its creditors do). • **Failure to Pay.** Failure of the Reference Entity to make a payment when due, after the Grace Period, in an amount not less than the Payment Requirement (generally US$1 million). • **Obligation Acceleration.** An obligation of the Reference Entity has become due and payable before it otherwise should. • **Restructuring.** A change in an Obligation with respect to the interest rate, principal amount, payment date of the interest or principal, priority of ranking, or currency of interest or principal. A Restructuring Event must occur for obligations greater than the default requirement (generally US$10 million). If restructuring is included as a Credit Event, you may choose either "Restructuring" or "Modified Restructuring" (restructuring maturity limitation applicable). Most new deals in the US use Modified Restructuring. Modified Restructuring means that in a Restructuring Event, the maturity date of the deliverable obligation is limited to the earlier of no more than 30 months from the date of the Restructuring Event and the final maturity date of the restructured bond or loan unless the swap termination date is longer than both of these. In this case deliverable obligations must mature before the termination date of the swap. • **Repudiation/Moratorium.** When a Reference Entity or government authority disclaims or rejects or challenges the validity of one or more obligations in an aggregate amount that totals at least the Payment Requirement.
Obligations (with Respect to Credit Events)	Obligations: Borrowed Money	Obligation Characteristics: None	For a Credit Event to trigger a default swap, it must have occurred on one of these types of obligations with these characteristics.

Figure 4. A Sample Credit Default Swap Term Sheet with Explanations (Continued)

Term		Explanation
Deliverable Obligations	Deliverable Obligation/Deliverable Obligation Category: Characteristics: • Bond or Loan • Pari Passu Ranking • Standard Specified Currencies • Assignable Loan • Consent Required Loan • Transferable • Not Contingent • Max. Maturity: 30 years • Not Bearer	Most deals accept either a Bond or a Loan. Convertible, zeros, and accreting bonds are now considered deliverable. The Deliverable Obligation must fit all the criteria specified in the Deliverable Obligation Characteristics. • **Pari Passu Ranking.** Deliverable must rank Pari Passu to the Reference Obligation listed in the confirmation or senior unsecured debt unless otherwise specified. • **Standard Specified Currencies.** Deliverable Obligation must be denominated in a G7 currency or the Euro. • **Assignable Loan.** A loan that is capable of being assigned to a third party. • **Consent Required Loan.** A loan that is capable of being assigned with the consent of the Reference Entity. • **Transferable.** An obligation that is transferable to institutional investors without any restrictions. • **Not Contingent.** A bond whose repayment of principal does not reference a formula or index, and whose interest payment is computed off a benchmark rate, either fixed or floating. • **Max Maturity.** An obligation, which has a remaining maturity of not greater than the term specified. • **Not Bearer.** An obligation that is not a bearer instrument.
Partial Cash Settlement of Loan	Not Applicable	If Loans are Deliverable Obligations but the Buyer of protection is not able to obtain enough of a loan to deliver, this provision provides for the ability to Cash Settle the portion that is unattainable. Not Applicable means that Partial Cash Settlement is not allowed and the Buyer must deliver a different obligation for that portion of his protection or forfeit the protection.
Partial Cash Settlement of Assignable Loans	Not Applicable	If Assignable Loans are a Deliverable Obligation but the Buyer of protection is not able to obtain enough of a loan to deliver, this provision provides for the ability to Cash Settle the portion that is unattainable. Not Applicable means that Partial Cash Settlement of Assignable Loans is not allowed.
Escrow	Applicable	Either party may request that Physical Settlement take place through an independent third party. Any costs will be borne by the party requesting this arrangement.
Documentation	Confirmation to be prepared by the Seller and agreed to by the Buyer. The 1999 ISDA Credit Derivatives Definitions as supplemented by the Restructuring Supplement, the Successor Supplement, and the ISDA Convertibles Restructuring Supplement (2001) shall apply and shall be incorporated by reference.	The seller generally prepares the confirmation. This section makes reference to the standard ISDA definitions and any applicable supplements.

<HELP> for explanation.

Corp GC

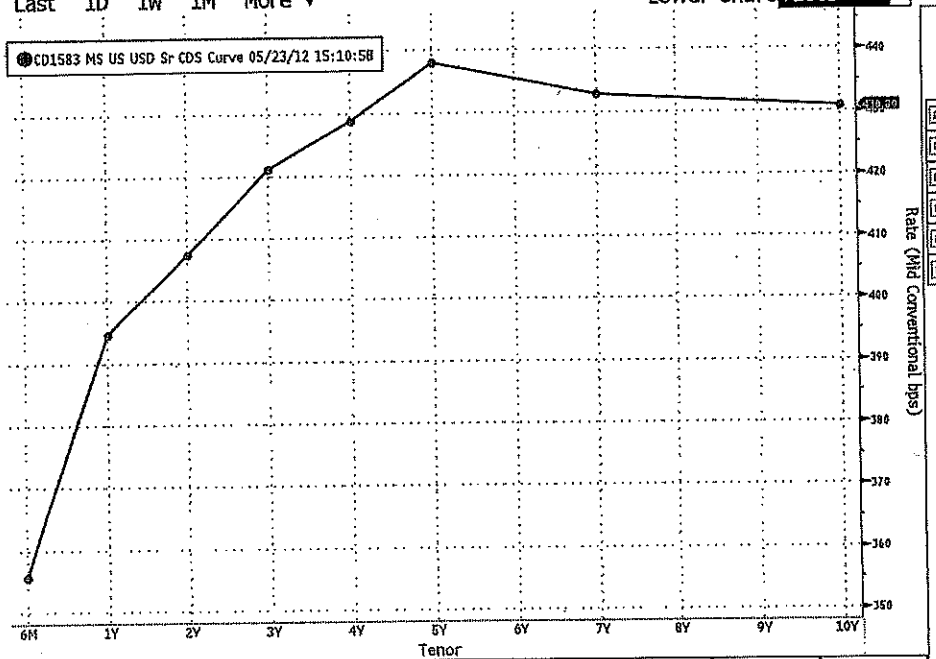
Reference Curve Selected: AUD Australia Sovereign Curve

MS US USD Sr CDS Curve | 97) Actions | 98) Table | 99) Feedback

Graph Curves

Last 1D 1W 1M More ▼

Lower Chart Table » Curve List Related Curves



1) Add Curve 2) Browse...

Select Reference Curve ↓

- MS US USD Sr CDS Curve
- AUD Australia Sovereign Curve
- US Treasury Actives Curve
- CAD Canada Sovereign Curve
- USD Brazil Sovereign Curve
- GBP United Kingdom Sovereign

Curve ID	6M	1Y	2Y	3Y	5Y	7Y	10Y
CD1583	355.8	394.6	407.5	421.1	438.1	432.8	430.8

3) Show All Tenors >

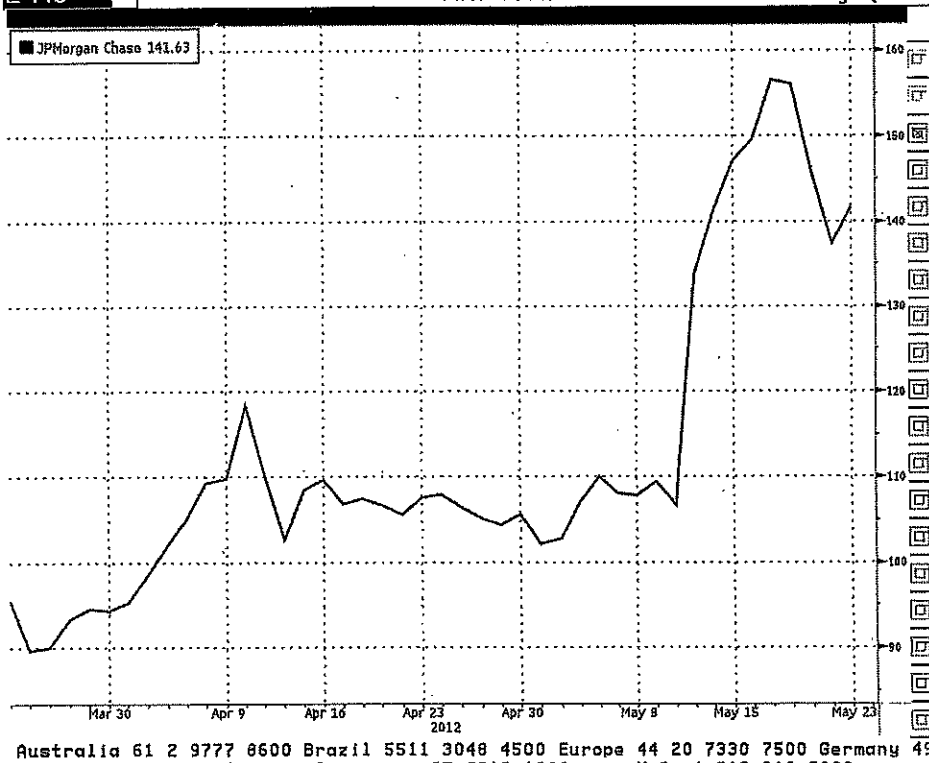
<HELP> for explanation. CurncyCDS

At 13:30 Op 259.1 Hi 259.1 Lo 259.1 Prev 254.6

90) Actions | 91) View | CDS Sector Graph : Price View

Issuer | Region | America | Banks | All Grades | 5Y CDS | Price

2 Mo | America Banks 5Y CDS History (CMAN) | CMAN

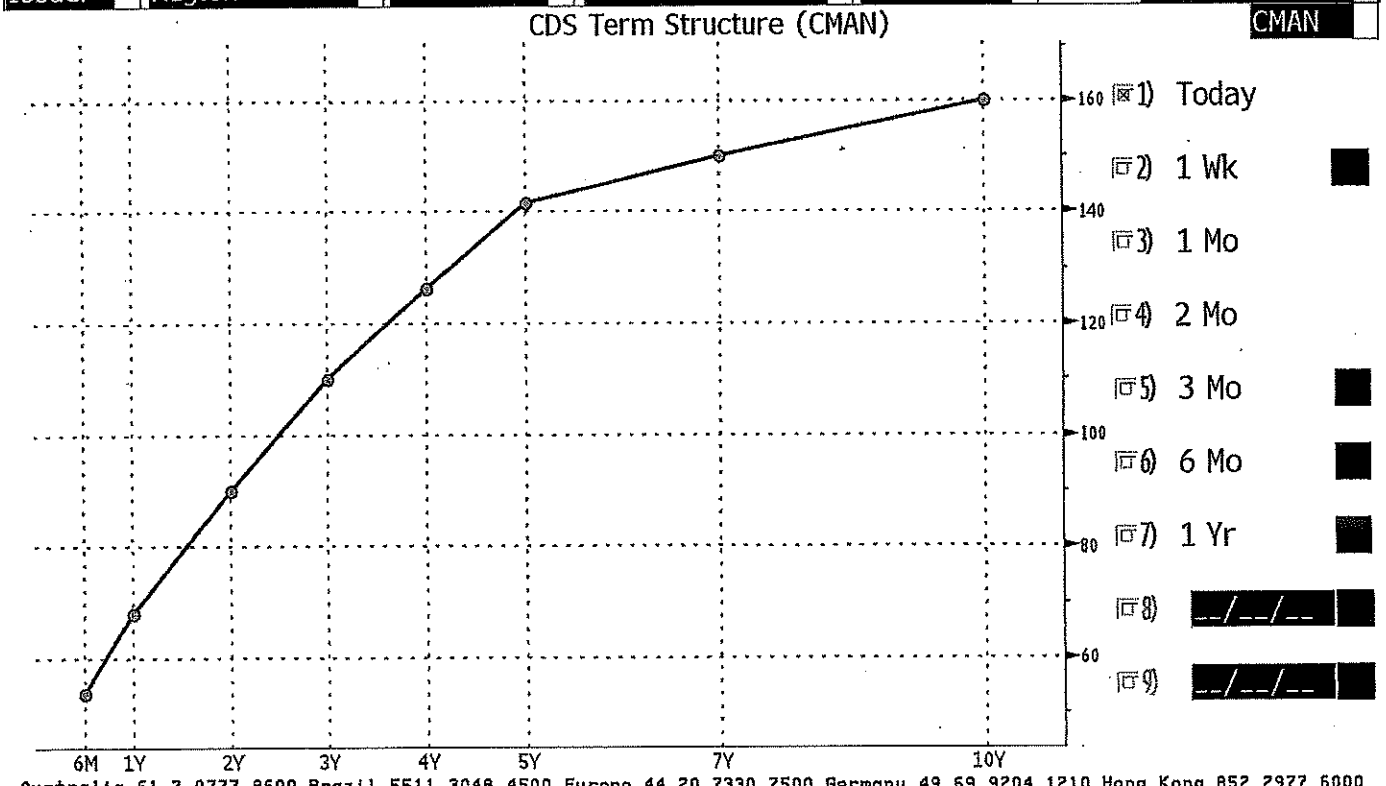


Reference Name	Price
Average of all(35)	227.61
Average of selected(	141.63
JPMorgan Chase	141.63
Bank of America	296.52
Wells Fargo	119.48
Citigroup Inc	259.06
Morgan Stanley	435.73
Goldman	331.48
Northern Trust	N.A.
BB&T	N.A.
M&T Bank	N.A.
Keycorp	N.A.
SunTrust	N.A.
Fifth Third	N.A.
Huntington Bancshar	N.A.
State Street	N.A.
Zions Bancorp	N.A.
Regions Fin'l	N.A.
PNC Fin'l Services	N.A.

<HELP> for explanation. Corp CDHT

90) Actions | 91) View | CDS Sector Graph : CDS Historical Term Structure

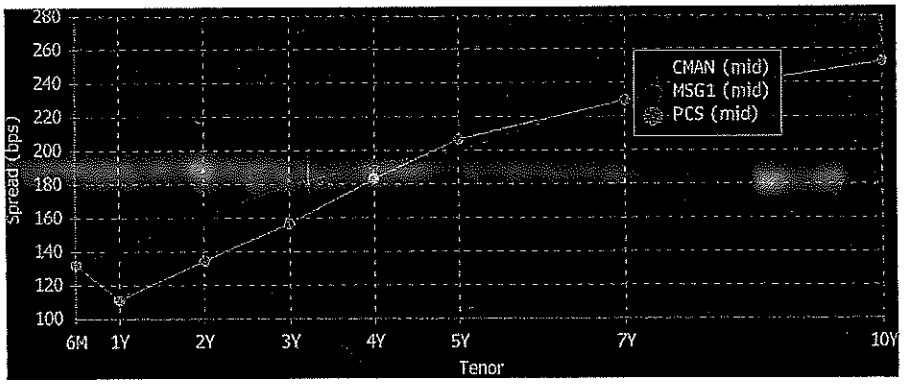
Issuer | Region | America | Banks | All Grades | Name | JPMorgan Chase | CMAN



<HELP> for explanation, <MENU> for similar functions. Corp CDSV
Hit # <Go> to select security

State of California - STCALI CDS USD SR

		MSG Quotes			CMAN			My PCS (Pricing Sources)			
Tenor	Ticker	Bid	Ask	Time	Bid	Ask	Time	Bid	Ask	Time	Source
1) Curve	STCALI CDS USD SR CRV										
2) 6 Mo	STCALI CDS USD SR 6M	N.A.	N.A.	N.A.	124.4	139.5	13:30:00	124.4	139.5	13:30:00	CMAN
3) 1 Yr	STCALI CDS USD SR 1Y	N.A.	N.A.	N.A.	134.7	148.7	13:30:00	106.7	115.4	05/23/12	CBGL
4) 2 Yr	STCALI CDS USD SR 2Y	N.A.	N.A.	N.A.	154.9	167.1	13:30:00	130.2	138.9	05/23/12	CBGL
5) 3 Yr	STCALI CDS USD SR 3Y	N.A.	N.A.	N.A.	174.1	184.7	13:30:00	152.2	161.3	05/23/12	CBGL
6) 4 Yr	STCALI CDS USD SR 4Y	N.A.	N.A.	N.A.	187.4	196.7	13:30:00	178.4	188.1	05/23/12	CBGL
7) 5 Yr	STCALI CDS USD SR 5Y	N.A.	N.A.	N.A.	195.3	203.9	13:30:00	201.4	211.7	05/23/12	CBGL
8) 7 Yr	STCALI CDS USD SR 7Y	N.A.	N.A.	N.A.	227.5	237.3	13:30:00	223.9	235.3	05/23/12	CBGL
9) 10 Yr	STCALI CDS USD SR 10Y	N.A.	N.A.	N.A.	255.0	265.0	13:30:00	246.4	258.6	05/23/12	CBGL



Credit Case Part II

- Simplified CDS contract: You pay me a fixed amount A each year for three years or until default occurs.
- If a default occurs, I pay you 0.50 in 3 years, and contract ends.
- What is the fair price for credit protection?

Credit Case Part II Continued

- Present value of fixed leg:

$$A\, e^{-0.06}\, P_1 + A\, e^{-0.12}\, P_2 + A\, e^{-0.18}\, P_3 = 2.436045\, A$$

- Present value of protection leg:

$$0.50\, e^{-0.18}\, (1 - P_3) = 0.05527$$

- Set both legs equal to each other and solve for A:

$$2.436045\, A = 0.05527 \implies A = 0.0226$$

- In theory, a corporate bond with CDS protection should be a synthetic Treasury bond.

Introduction to CDOs

- Imagine you start a fund. You raise \$100 from investors, and invest funds in a portfolio of 100 corporate bonds, each yielding 50 basis points over Treasuries.
- If no default, investors earn extra 50 bps.
- If one default, then fund value declines by 1, and investors have a -1 percent return. If two defaults, investors have a -2 percent returns, etc.
- Standard fixed-income mutual fund situation.

Introduction to CDOs Continued

- Now imagine that instead, you raise \$100 from two classes of investors. You raise \$3 from an equity class, and \$ 97 from a debt class. You invest in the same \$100 portfolio of bonds.
- The equity class absorbs the first 3 percent of any losses from default.
  - If one default, equity value goes from 3 to 2 (no change in the value of debt class.).
  - If a second default, equity value goes from 3 to 1 no change in the value of the debt class).
  - If a third defaults, equity class is wiped out, and equity investors have lost 100 percent.
- Equity class is leveraged about 33 to 1.
- Equity class needs to earn close to 33 times the usual spread of 50 bps, or about 1500 bps.
- Equity class is similar to bank stock; similar PE ratios.

Introduction to CDOs Continued

- A CDO is just an extension of this to multiple classes of different seniorities. For example:
  - 0-3 Equity tranche.
  - 3-7 Junior mezzanine tranche..
  - 7-10 mezzanine tranche.
  - 10-15 mezzanine tranche.
  - 15-30 senior mezzanine tranche.
  - 30-100 super senior tranche.

CDX IG Spreads

- The CDX Index is a weighted average of the CDS spreads for 125 liquid CDS contracts for US investment grade firms and is widely followed.
- Examples of historical spreads for CDX IG Index tranches:
  - 0-3 Tranche: 42 pts up front, 500 bps
  - 3-7 Tranche: 175.7 bps
  - 7-10 Tranche: 43.97 bps
  - 10-15 Tranche: 24.43 bps
  - 15-30 Tranche: 9.77 bps

CDO Features

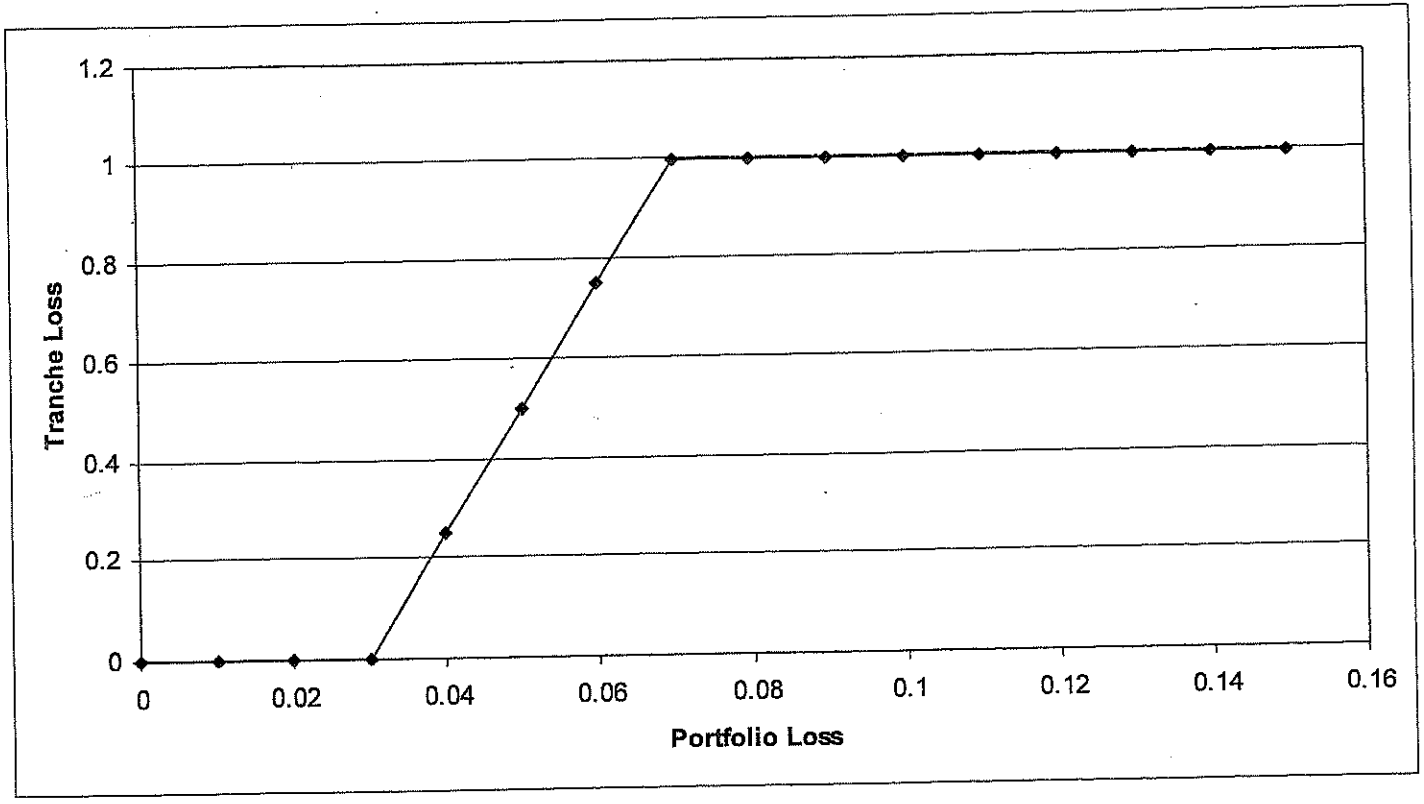
- Each tranche is similar to a debt investment and can have its own unique credit rating.
- Each tranche can be viewed as an investment in same part of the capital structure.
- CDOs can be viewed as "synthetic" banks or hedge funds.
- A CDO manager is effectively an asset manager.

Valuation of CDOs

- Graph of losses on 3-7 tranche.
- Losses on 3-7 tranche are the same as the cash flows from a long position of 25 calls struck at 0.03, and a short position of 25 call struck at 0.07.
- The key to understanding tranche values and spreads is by thinking of them as portfolios of options.

Credit Default Swaps and CDOs

Losses on 3-7 Tranche

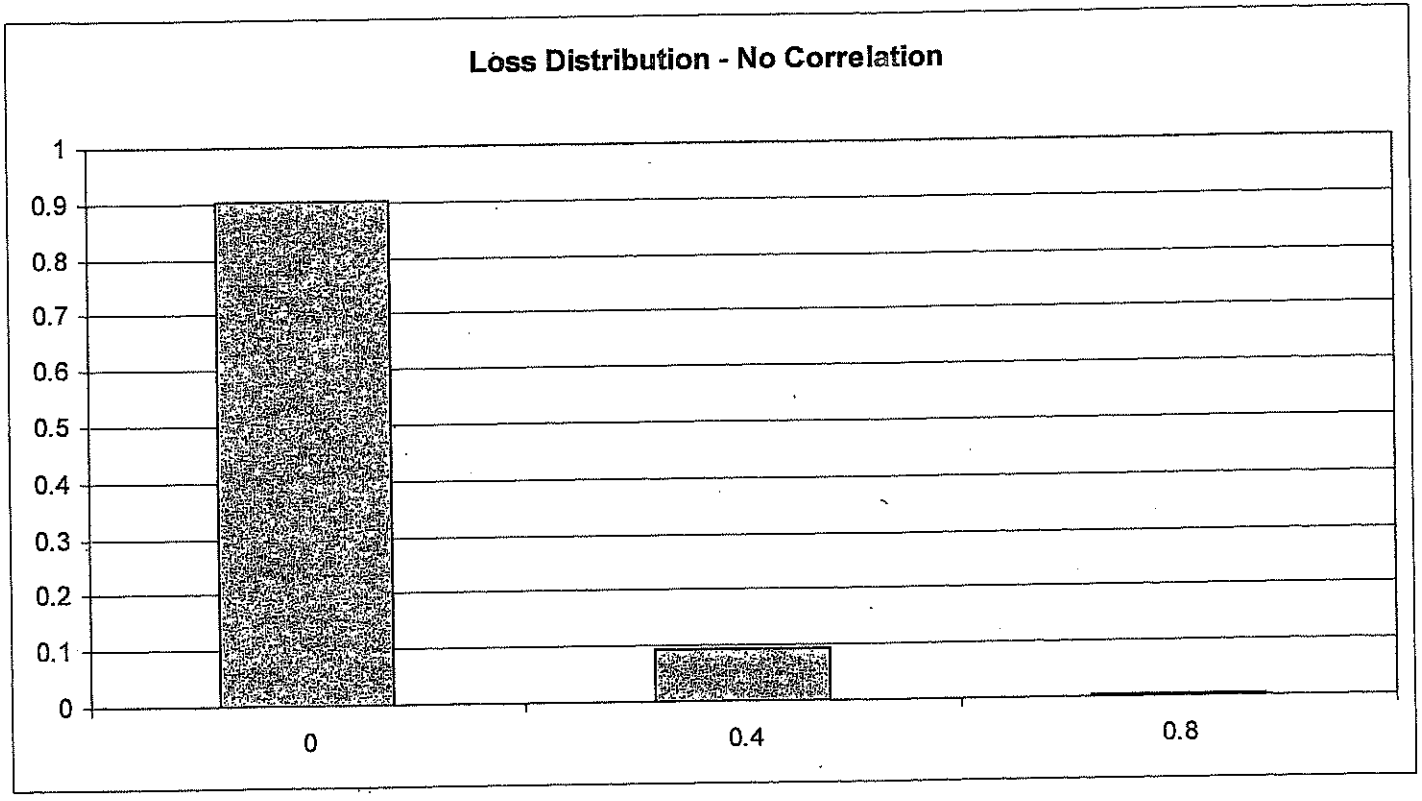


CDO Correlation Example

- Two bonds, each with 5 percent prob of default.
- If default, lose 8 percent of value of bond.
- Assume uncorrelated defaults.
- Prob of no defaults: $0.95 \times 0.95, L = 0.00$
- Prob of A but not B: $0.05 \times 0.95, L = 0.40$
- Prob of B but not A: $0.95 \times 0.05, L = 0.40$
- Prob of both defaulting: $0.05 \times 0.05, L = 0.80$

Credit Default Swaps and CDOs

CDO Correlation Example



CDO Correlation Example Continued

- Graph of loss distribution.
- Expected loss:

$$0.9025 \times 0.00 + 0.095 \times 0.40 + 0.0025 \times 0.80 = 0.04$$

- Standard deviation of loss: 0.1233.

CDO Correlation Example Continued

- Now assume that defaults are correlated.
- How could this occur?
- Prob of no defaults: 0.94, $L = 0.00$
- Prob of A but not B: 0.01, $L = 0.40$
- Prob of B but not A: 0.01, $L = 0.40$
- Prob of both defaulting: 0.04, $L = 0.80$

CDO Correlation Example Continued

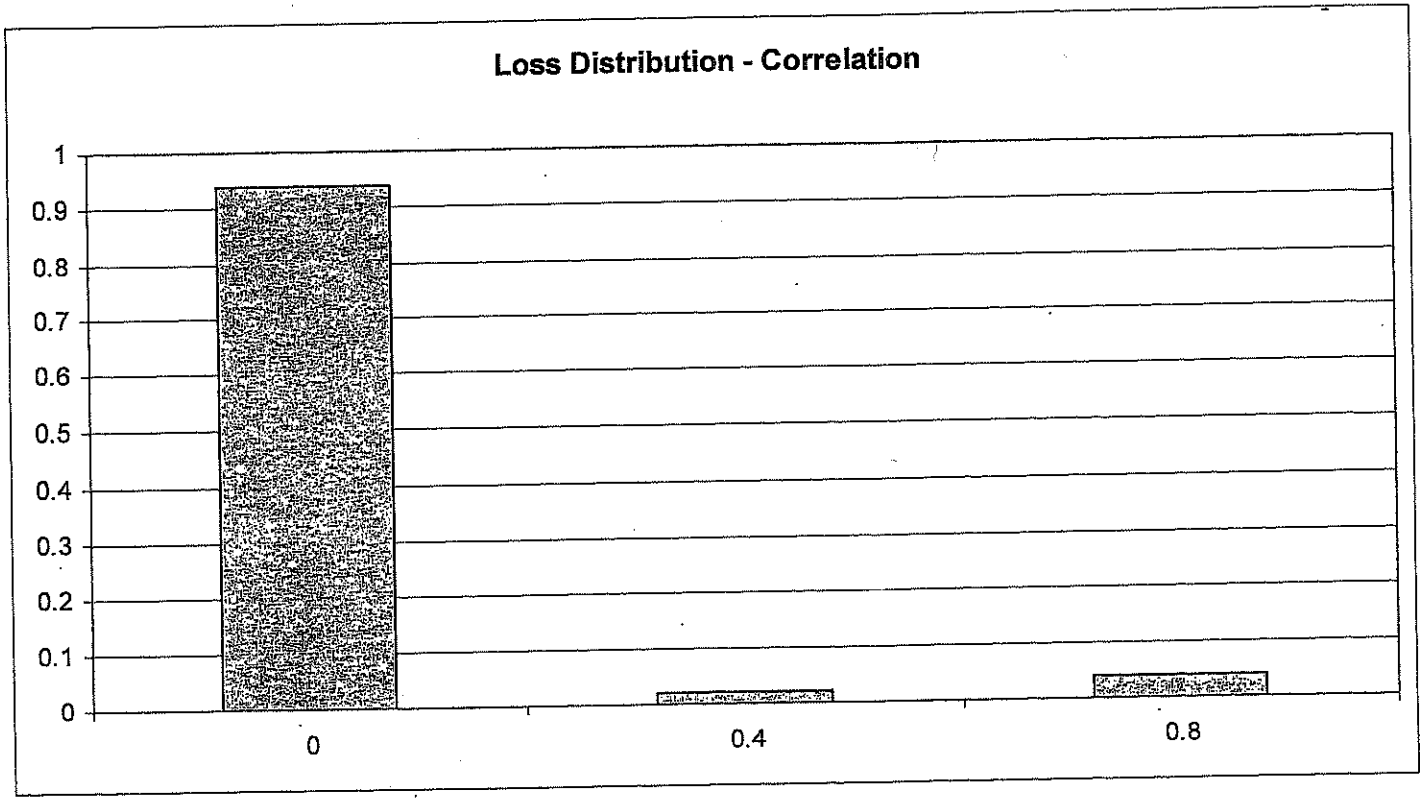
- Graph of loss distribution.
- Expected loss:

$$0.94 \times 0.00 + 0.02 \times 0.40 + 0.04 \times 0.80 = 0.04$$

- Standard deviation of loss: 0.1649.
- Correlation increases volatility of loss distribution without changing expected loss. Affects value of the implicit options.

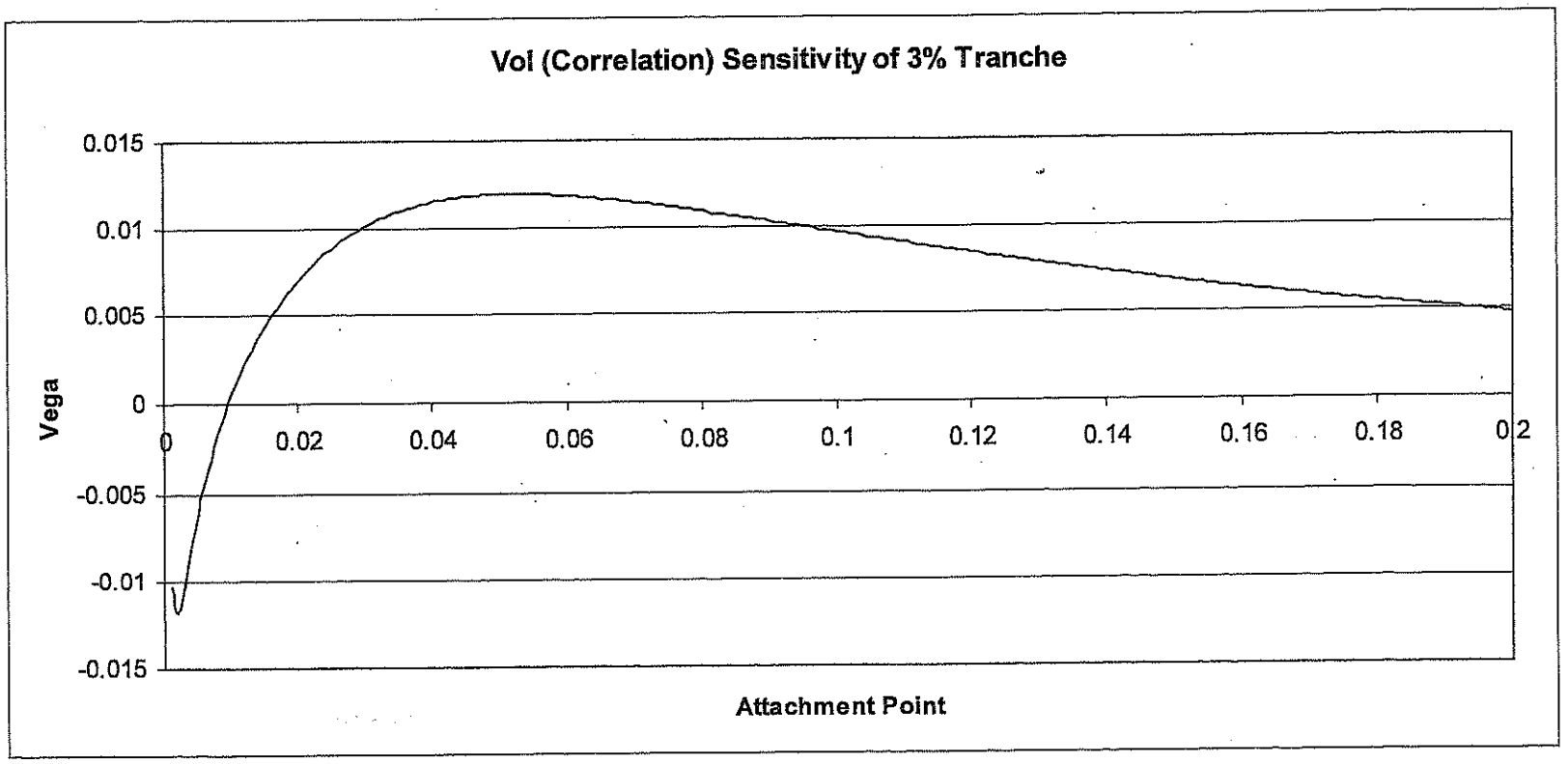
Credit Default Swaps and CDOs

CDO Correlation Example



Credit Default Swaps and CDOs

Vega of Call Spreads



Subprime CDO Example

- Countrywide Subprime ABS CDO Structure CWABS 2006-1 Structure.
- Subordination.
- Were the high credit ratings justified?

Table 1

Countrywide Subprime ABS CDO Structure CWABS 2006-1. This table reports some of the contractual terms listed in the prospectus for this asset-backed CDO structure. The L in the initial pass-thru rate represents one-month Libor. The seniority ranking n/m means that the tranches seniority is n-th out of m tranches.

Tranche	Notional Amount	Price to Public	Under-Writer Fee	Initial Pass-thru Rate	Maturity	Initial Moody's Rating	Initial S&P Rating	Seniority Ranking
AF-1	147,232,000	100.0000	0.0521	L+ 0.130%	Nov 2025	Aaa	AAA	1/7
AF-2	22,857,000	99.9995	0.1042	5.281%	May 2027	Aaa	AAA	1/7
AF-3	90,995,000	99.9998	0.1563	5.384%	Jul 2033	Aaa	AAA	1/7
AF-4	21,633,000	99.9985	0.2500	5.714%	Sep 2034	Aaa	AAA	1/7
AF-5	38,617,000	99.9987	0.3333	5.884%	Jul 2036	Aaa	AAA	1/7
AF-6	44,200,000	99.9980	0.4167	5.526%	May 2036	Aaa	AAA	1/7
MF-1	13,260,000	99.9981	0.4167	5.917%	May 2036	Aa1	AA+	2/7
MF-2	12,155,000	99.9972	0.5000	6.016%	May 2036	Aa2	AA+	3/7
MF-3	7,293,000	99.9965	0.5833	6.115%	Apr 2036	Aa3	AA	4/7
MF-4	6,409,000	99.4627	0.8333	6.200%	Apr 2036	A1	AA-	5/7
MF-5	6,188,000	98.9985	1.0000	6.200%	Mar 2036	A2	A+	6/7
MF-6	5,525,000	98.5371	1.2500	6.200%	Feb 2036	A3	A	7/7
AV-1	139,560,000	100.0000	0.0522	L+0.080%	Jul 2028	Aaa	AAA	1/8
AV-2	115,712,000	100.0000	0.1033	L+0.190%	May 2035	Aaa	AAA	1/8
AV-3	25,042,000	100.0000	0.1033	L+0.300%	Jun 2036	Aaa	AAA	1/8
MV-1	14,320,000	100.0000	0.4167	L+0.390%	May 2036	Aa1	AA+	2/8
MV-2	13,067,000	100.0000	0.5000	L+0.410%	May 2036	Aa2	AA+	3/8
MV-3	7,518,000	100.0000	0.8333	L+0.440%	May 2036	Aa3	AA	4/8
MV-4	6,802,000	100.0000	0.9167	L+0.560%	Apr 2036	A1	AA-	5/8
MV-5	6,802,000	100.0000	0.9667	L+0.600%	Apr 2036	A2	A+	6/8
MV-6	5,907,000	100.0000	1.0000	L+0.660%	Mar 2036	A3	A	7/8
MV-7	5,549,000	100.0000	1.0833	L+1.300%	Mar 2036	Baa1	A	8/8