

Investment-Grade CDOs

GLEN M. McDERMOTT, TERRY L. BENZSCHAWEL, AND SOHAIL KHAN

GLEN McDERMOTT
is a director at Salomon
Smith Barney Inc. in
New York.
glen.mcdermott@citigroup.com

TERRY L. BENZSCHAWEL
is a director in Quantitative
Credit Modeling and Ana-
lytics at Salomon Smith
Barney Inc. in New York.
terry.l.benzschawel@citigroup.com

SOHAIL KHAN
is a vice president at
Salomon Smith Barney Inc.
in New York.
sohail.khan@citigroup.com

A lively debate is taking place in the marketplace on the merits and risks of investment-grade average CDOs. The debate focuses on the high leverage of investment-grade CDOs compared to high-yield CDOs; event risk associated with investment-grade issuers, given recent rating volatility; credit rating arbitrage resulting from buying the cheapest issues in a particular rating category; and credit distributions in these transactions.

We consider each of these criticisms, and show that the risk-adjusted returns for investment-grade CDO equity are comparable to those of the best of traditional and alternative asset classes. To do so, we use traditional analyses, as well as a novel simulation-based methodology that projects future equity cash flows. This approach complements current market convention, but has the advantages of being free of default timing assumptions and providing estimates of the volatility of expected returns. Using this method, we calculate risk/reward measures to compare returns on investment-grade CDO equity and on other asset classes.

Under traditional assumptions of a 0.25% annual default rate, 50.0% recovery, and a standard investment-grade CDO structure, we find an expected investment-grade CDO equity return of 19.0%. Our simulations project an average return of 16.5%, a Sharpe ratio of 2.3, and an implicit default rate of 0.33% per year. Investment-grade equity moreover is robust enough to withstand as much as three times historical defaults without loss of principal.

Our simulations also reveal that increasing the number of firms in the collateral pool improves risk-adjusted returns through reduction in return volatility. That is, increasing the number of firms in the pool from 50 to 100 improves the risk-adjusted return by more than 35%. This effect tapers off at about 100 obligors.

The liquidity and diversity of the investment-grade market, coupled with the gradual credit migration of investment-grade CDO collateral, presents ample trading opportunities for the manager to minimize loss of par. This considerable obligor and industry diversity allows for a minimal ramp-up period (if any) after closing, reducing the risk that credit spreads will tighten significantly during the collateral accumulation process.

Finally, we develop a framework to evaluate investment-grade CDO equity relative to alternative investments. Including investment-grade CDOs to diversify an investment portfolio can lower its overall volatility, while delivering superior risk-adjusted returns.

I. CRITICISMS

Critics of investment-grade CDOs (IG CDOs) argue that:

- Investment-grade CDOs are too highly levered. The typical investment-grade CDO is levered 20–25 times, which is twice the leverage of a standard high-yield CDO. This leverage, critics argue, leaves

little room for defaults (i.e., mistakes are magnified).

- Investment-grade credits experience rapid credit deterioration. Citing events of 2000 and 2001 as historical proof, IG CDO critics claim that IG credits may fail quickly. This track record, coupled with the high leverage in these structures, spells trouble for CDO note holders.
- Investment-grade CDO managers pick the highest-yielding credits for any given rating category. Some argue that IG CDO managers are tempted to pick the highest-yielding credits for any given rating category (i.e., engage in rating agency arbitrage). In this search for yield, the argument goes, these managers pick up a disproportionate amount of credit risk, all other things equal.
- Investment-grade CDOs are credit “barbells.” The typical IG CDO can invest a certain portion of the portfolio in Ba-rated credits, which has drawn the criticism that investment-grade *average* CDOs are really investment-grade/high-yield barbells, with resulting higher default rates.

We disagree with all four points. We believe that the credit tranches (i.e., equity and second loss tranches) issued by investment-grade CDOs offer significant unrealized value, a view that we demonstrate in this report. In short, we consider IG CDO equity and Baa tranches cheap.

In this report, we confront these criticisms directly and dispel some widely held myths. We argue that the low historical default rates and default rate volatility of investment-grade average collateral pools of assets far outweigh the higher leverage in IG CDOs. This point gains strength as the number of obligor positions rises above 100 and as long as the vast majority of positions do not exceed 1.25%. Our simulations indicate that obligor diversity is crucial.

Results in our corporate bond database show that, on average, the deterioration of investment-grade-rated companies is much slower than the demise of high-yield companies. In fact, since 1980, only a handful of companies have gone from investment-grade to default within one month. This slow decline gives IG CDO managers ample opportunity to analyze any changes in a company's credit fundamentals, and either continue to hold or sell a security. When managers choose to sell, they do so in a market that is vastly more liquid and deep than the high-yield market.

With respect to moving down the credit spectrum for yield, we think the criticism goes too far. The same argument can be leveled against high-yield CDOs and

the entire arbitrage CDO market. If a CDO manager focuses primarily on yield, to the exclusion of fundamental credit analysis, this will spell doom for a CDO (history has proven this to be the case). Only an irresponsible, inexperienced, or incompetent manager would focus on yield in a vacuum. In our opinion, the key drivers of the performance of a CDO have always been the skill of the manager in picking the initial portfolio and the trading decisions made over the life of the transaction.

As for the credit barbell criticism, the myriad of investment guidelines (including the twin constraints of a minimum average Moody's rating factor and the need to generate a minimum return to equityholders) make it difficult, if not impossible, to barbell the portfolio. We find that widening the credit distribution within current CDO investment guidelines has little negative effect on expected returns.

We discuss cash flow corporate investment-grade CDOs, not investment-grade asset-backed securities, multisector, or synthetic transactions. While there are a few variations on the corporate investment-grade CDO structure in the marketplace, we deal with the most prevalent investment-grade CDO structure.

A brief description of the CDO equity structure appears in Appendix A. For a more detailed discussion of CDO equity, see McDermott [2000].

II. MARKET AND CAPITAL STRUCTURES

The market for corporate CDOs, which dates back to 1988, has grown explosively since 1996. Every year since 1996, the CDO market has set a new issuance record. In 2000, Moody's rated 189 transactions (about \$120 billion), easily exceeding the 166 transactions (\$92 billion) that it rated in 1999.

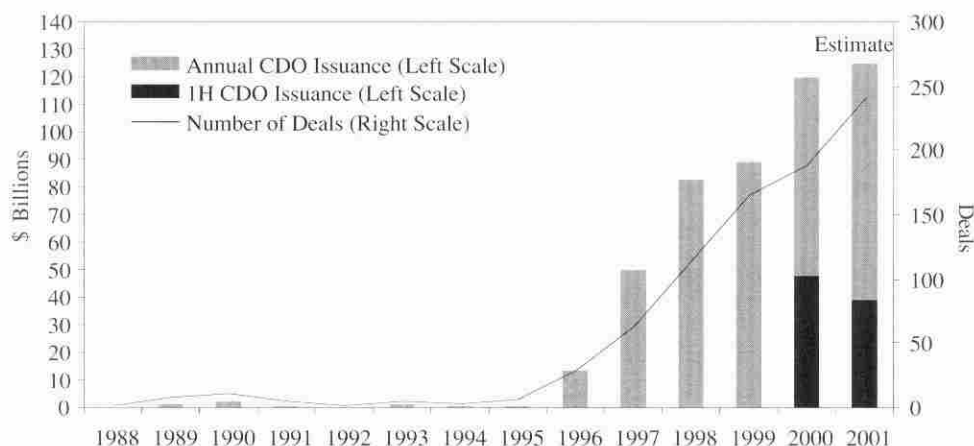
Exhibit 1 provides historical perspective on the growth of the CDO market in terms of number of deals and total dollar amount of issuance.

The investor base for CDOs continues to grow globally, as many investors gain approval to invest more deeply in the CDO capital structure. New CDO buyers are in the United States, Asia, Europe, and the Middle East, and CDO buyers now include banks, insurance companies, high net worth individuals, hedge funds, pension funds, structured investment vehicles, and commercial paper conduits.

As a CDO subcategory, investment-grade average arbitrage CDOs had their strongest year of issuance on record in 2000. The growth of the IG CDO market is not surprising, given the high average credit quality of the assets

EXHIBIT 1

CDO Market Growth, 1988-2001E



E: Moody's estimate.

Note: Excludes equity or other unrated tranches. Includes rated debt and swaps issued in connection with synthetic CDOs (not including super-senior tranches).

Source: Moody's Investors Service.

in these deals and the continued credit deterioration in the high-yield market. We expect this flight to quality from high-yield assets to continue, causing investment-grade average issuance to double to more than \$11 billion.

Exhibit 2 shows the IG CDOs that have been closed since their introduction in 1998 through June 2001.

Although some investors have expressed concern with the rapid credit deterioration that some investment-grade companies have experienced, others point to the long-term low default rates and low default rate volatility associated with these portfolios. Since the first deal was done in 1998, investment-grade average CDOs as a class have performed very well, and most have maintained stable asset bases.

A typical capital structure for an IG CDO appears in Exhibit 3. By definition, the default rate and default rate volatility of an investment-grade average CDO should be much lower than those of conventional high-yield CDOs. As Exhibit 3 illustrates, this allows for a more highly levered deal, with equity constituting 4%-5% of the capital structure (as opposed to the standard high-yield CDO, which has around 10% equity).

Additional collateral parameters may include:

- Ratings. The average rating of IG CDO pools is Baa3. There may be a maximum of 30% Ba-rated

credits, with the minimum rating on any collateral debt security of Ba3 (Ba3 can be no more than 10%). Most high-yield CDOs have historically carried an average rating of B2.

- Obligor concentrations. These are usually tiered based on rating. A typical tiering is a maximum of 2% for each investment-grade credit and 1% for each Ba-rated credit. Actual obligor concentrations typically range from 1.00% to 1.25%. The additional diversity inherent in investment-grade CDOs helps mitigate catastrophic risk. In a high-yield CDO, by contrast, maximum obligor concentrations can be as high as 3% with actual concentrations around 2%.
- Diversity score. The minimum Moody's diversity score is usually 45 or higher. Actual diversity scores have historically ranged from the high 40s to the 60s. High-yield CDOs often have diversity scores that are at least five points lower. As we discuss later in this report, the breadth and depth of the investment-grade market as compared with that of the high-yield market makes a higher diversity score achievable.
- Classes of collateral. Classes are generally senior unsecured bonds with a small allowance for loans (5%-10%)—almost always just corporate credit exposures.

EXHIBIT 2

Investment-Grade Average CDO Issuance—1998-June 30, 2001

Issuer	Manager	Rated Volume (MM)	Rating Agency
1998			
Travelers Funding, Ltd.	Travelers Asset Mgmt. Int'l Corp.	\$397	Moody's
Conseco Funding Ltd.	Conseco Capital Management, Inc.	596	Moody's and S&P
		\$993	
1999			
Emerald Investment Grade CBO Ltd.	American General Investment Management, L.P.	\$513	Moody's and S&P
Knight Funding, Ltd.	MBIA Capital Management	482	Moody's and S&P
		\$995	
2000			
Emerald Investment Grade II CBO Ltd.	American General Investment Management, L.P.	\$507	Moody's and S&P
Coliseum Funding CBO Ltd.	Travelers Asset Mgmt. Int'l Corp.	562	Moody's and S&P
Solar Investment Grade CBO I Ltd.	Sun Capital Advisors	442	Moody's and S&P
Strong CDO III	Strong Capital Management, Inc.	245	Moody's and S&P
Diamond Investment Grade CDO Ltd.	American General Investment Mgmt. L.P.	500	Moody's and S&P
Knight II Funding, Ltd.	MBIA Capital Management	485	Moody's and S&P
Diamond Investment Grade CDO II Ltd	American General Investment Mgmt., L.P.	481	Moody's and S&P
Lone Star CBO Funding, Ltd.	Sage Advisory Services, Ltd.	279	Moody's and S&P
PPM America High Grade CBO I Ltd.	PPM America, Inc.	988	Moody's and S&P
		\$4,489	
2001			
Valeo Investment Grade CDO Ltd.	Deerfield Capital Management LLC	\$495	Moody's and S&P
FMA IG Funding IV Ltd.	Financial Management Advisors, Inc.	406	Moody's and S&P
Phoenix Funding Ltd.	D. L. Babson (MassMutual)	589	Moody's and S&P
Madison Avenue CDO II Ltd.	Metropolitan Life Insurance Co.	481	Moody's and S&P
GIA Investment Grade 2001, Ltd.	Global Investment Advisors	412	Moody's and S&P
Hampden CBO, Ltd.	D. L. Babson (MassMutual)	480	Moody's and S&P
Valeo Investment Grade CDO II Ltd.	Deerfield Capital Management LLC	485	Moody's and S&P
Balboa CDO I Ltd	Pacific Investment Management Co.	297	Moody's and S&P
Palmyra Funding, Ltd. CLN	D. L. Babson (MassMutual)	90	Moody's and S&P
Panther CDO I B.V.	M&G Investment Management Ltd.	444	Moody's and S&P
		First-Half 2001	\$3,903
		Full-Year 2001 Estimated Volume	11,500

Sources: Moody's and Standard & Poor's.

EXHIBIT 3

Typical Investment-Grade CDO—Capital Structure

Assets				
Average Moody's Rating	610			
Principal Amount (MM)	\$500.0			
Liabilities and Equity	Class A-1 Notes	Class A-2 Notes	Class B Notes	Preferred Shares
Moody's Rating	Aaa	Aa2	Baa2	NR
S&P Rating	AAA	NR	NR	NR
Principal (MM)	\$407.5	\$39.0	\$33.5	\$22.1
Percent of Capital Structure	81.2%	7.8%	6.7%	4.4%
Stated Final Maturity (Years)	12.0	12.0	12.0	12.0
Average Life (Years)	8.3	10.7	11.1	—
Expected Yield*	6mL + 40bp- 45bp	6mL + 65bp-70bp	6mL + 215bp-225 bp	15%-18 %

*Assumes a 0.25% annual default rate with a 50% recovery rate. NR: Not rated.

Source: Salomon Smith Barney.

EXHIBIT 4

Various Asset Classes—Historical Returns December 31, 1990-December 2000^a

	Average IRR	Ex-Ante Sharpe Ratio				
CDO Equity ^b	16.5%	2.33				
	Ten-Year			Five-Year		
	Average Return	Standard Deviation	Sharpe Ratio	Average Return	Standard Deviation ^c	Sharpe Ratio ^d
Fixed Income						
BIG	8.27%	3.68%	0.91	7.62%	3.17%	0.79
SSB Brady	15.54	15.08	0.70	13.11	15.92	0.50
Corporate Bond Index	8.71	4.41	0.86	7.65	4.05	0.63
Intermediate-Term Treasury	8.62	5.55	0.66	7.82	5.13	0.53
Mortgage Bond Index	8.23	2.99	1.10	7.75	2.47	1.07
AAA Corporate	8.25	3.50	0.95	7.57	3.32	0.74
High-Yield Index	9.66	6.77	0.70	4.75	6.78	-0.05
Equities ^e						
Nasdaq	17.28%	25.91%	0.48	12.76%	34.05%	0.22
S&P 500	12.53	12.43	0.58	12.79	17.26	0.45
Dow Jones	12.62	13.45	0.60	13.18	17.77	0.45

^aSharpe ratios are computed on actual returns, not percentage returns, and all returns, except for CDO equity, are compounded monthly returns expressed annually.

^bFor CDO equity, average IRRs and ex ante Sharpe ratios are calculated using a Monte Carlo simulation technique described in the "Return Analysis" section.

^cAnnualized based on monthly returns.

^dMeasured using the three-month T-bill as the benchmark.

^eEquity returns are compounded annually excluding dividends.

Sources: Yield BookTM and Salomon Smith Barney.

III. MERITS

Investors should consider adding investment-grade CDOs to a well-diversified portfolio for a number of reasons. Chief among them are: stable risk-adjusted mezzanine and equity tranche returns; lack of correlation of

returns with those of other asset classes; low default rate and default rate volatility; manageable transitions of collateral to default; greater liquidity and obligor/industry diversity; no ramp-up risk; non-call for life features; and the maturity profiles of investment-grade bonds.

EXHIBIT 5

Various Asset Classes—Correlations of Monthly Returns 1990-2000

	Corporate Index	3-Mo. Treasury BIG	Brady Bond Index	Treasury 7- to 10-Yr	AAA- Rated Corporates	Mortgage Index	High- Yield Index	DJIA	S&P 500	Nasdaq	Hedge Fund	
SSB BIG	0.99											
3-Month Treasury Bill	0.18	0.21										
Brady Bond Index	0.51	0.49	0.10									
Treasury 7- to 10-Year	0.95	0.97	0.11	0.46								
AAA-Rated Corporates	0.98	0.99	0.21	0.47	0.97							
Mortgage Index	0.93	0.96	0.31	0.51	0.88	0.93						
High-Yield Market Index	0.52	0.41	-0.01	0.38	0.33	0.41	0.41					
DJIA	0.03	-0.02	0.00	0.24	-0.09	-0.05	0.04	0.47				
S&P 500	0.05	0.02	0.01	0.14	-0.02	-0.02	0.07	0.44	0.87			
Nasdaq	-0.01	-0.02	-0.10	0.11	-0.01	-0.07	0.00	0.25	0.54	0.81		
Hedge Fund	-0.16	-0.17	-0.21	0.12	-0.19	-0.24	-0.12	0.27	0.26	0.36	0.59	
Private Equity	-0.24	-0.22	-0.13	0.17	-0.21	-0.29	-0.16	-0.09	0.11	0.19	0.49	0.64

Sources: IHR Hedge Funds, Venture Economics, Yield Book™, and Salomon Smith Barney.

Stable Risk-Adjusted CDO Equity and Mezzanine Returns

As we explore in depth later, lower default rate volatility leads to more stable risk-adjusted returns on investment-grade average CDO equity. For perspective, Exhibit 4 shows historical returns for popular asset classes and ex ante Sharpe ratios for CDO equity projected from our simulations.

According to our simulations, the ex ante Sharpe ratios that we calculate for investment-grade CDO equity returns compare very favorably with those of other asset classes. The average internal rate of return (IRR) for investment-grade CDO equity through 2000 was 16.5% (ranging from 14.1% to 18.6%). The average Sharpe ratio was 2.3 (ranging from 1.4 to 2.9), and the average standard deviation of returns was 5.1%.

Lack of Correlation with Other Asset Classes

Although there is no established CDO performance index, the performance of the typical investment-grade CDO is inextricably linked to the behavior of the U.S. high-grade bond market. We use the Salomon Smith Barney Corporate Index as a proxy for the performance of corporate bonds.¹

As Exhibit 5 illustrates, the SSB Corporate Index is virtually uncorrelated with traditional equity indexes and negatively correlated with alternative investments such as hedge funds and private equity. From an asset allocation perspective, this suggests that investing in IG CDO equity is an

excellent way to diversify within the traditional and the alternative investment portions of a well-balanced portfolio.

Nonetheless, one must be cautious when engaging in correlation analysis across illiquid asset classes that by definition are difficult to mark to market.

Low Default Rates and Low Default Rate Volatility

According to Moody's, the average annual default rate for Baa3 credits from 1983 through 2000 was 0.46% (standard deviation 1.16%) versus an average default rate for B2 credits (typical of high-yield CDOs) during the same period of 7.41% (standard deviation 6.08%) (see Exhibit 6).

Exhibit 7 shows that default rate volatility increases dramatically at the lower end of the credit spectrum. In fact, the volatility of B2 default rates is more than ten times higher than the volatility of Baa defaults.²

Moody's makes the same point in a 2001 report: "As one moves down the ratings scale . . . default risk increases, and the risk that the default rate will differ from the historical average also increases."³

Default rate volatility is extremely important in analysis of CDOs, given the granular nature of the typical CDO portfolio—most CDOs include between 80 and 120 names.

Although it is not surprising that Baa default rates are lower than Ba default rates, investment-grade CDOs are more highly levered than high-yield CDOs.⁴ Thus, the critical question for investment-grade CDO note holders is whether there is value, given the greater leverage in

EXHIBIT 6

Baa3, Baa3 Average Blend, and B2 Annual Default Rates 1983-2000

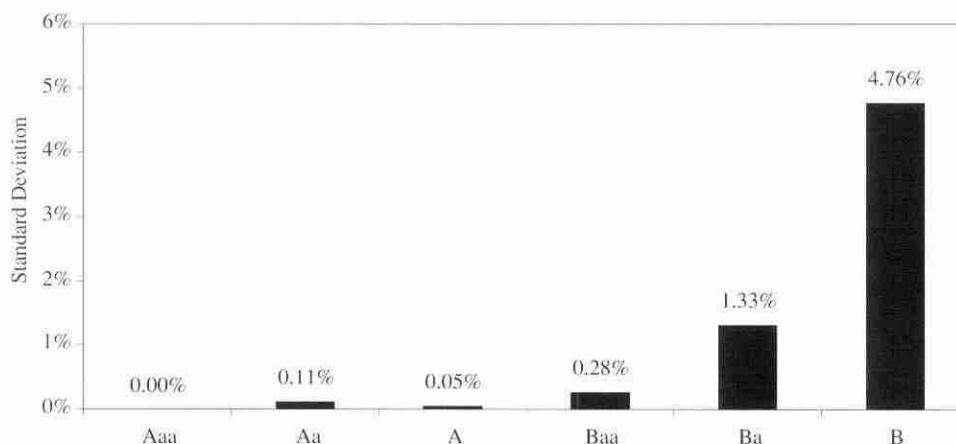
Year	Baa3	Baa3 Avg. Blend	B2
1983	0.00%	0.08%	10.00%
1984	1.06	0.69	18.75
1985	0.00	0.19	7.41
1986	4.82	2.63	16.67
1987	0.00	0.40	4.30
1988	0.00	0.08	6.90
1989	1.07	0.94	8.28
1990	0.00	0.45	22.09
1991	0.00	0.47	12.74
1992	0.00	0.02	1.54
1993	0.00	0.08	4.96
1994	0.00	0.02	3.66
1995	0.00	0.05	6.36
1996	0.00	0.00	0.00
1997	0.00	0.01	1.50
1998	0.00	0.11	7.57
1999	0.34	0.27	6.68
2000	0.98	0.67	3.89
Average	0.46	0.40	7.41
Standard Deviation	1.16	0.62	6.08

Note: The Baa3 Blend uses the tight distribution (see Exhibit 21). Moody's did not track default data by modifier (e.g., Baa1, Baa2, and Baa3) before 1983.

Sources: Moody's Investors Service and Salomon Smith Barney.

EXHIBIT 7

Various Rating Categories—One-Year Rate Volatilities 1970-2000



Source: "Default and Recovery Rates of Corporate Bond Issuers: 2000" [2001].

the typical investment-grade CDO. Our answer is a resounding "yes."

Transition, not Cliff

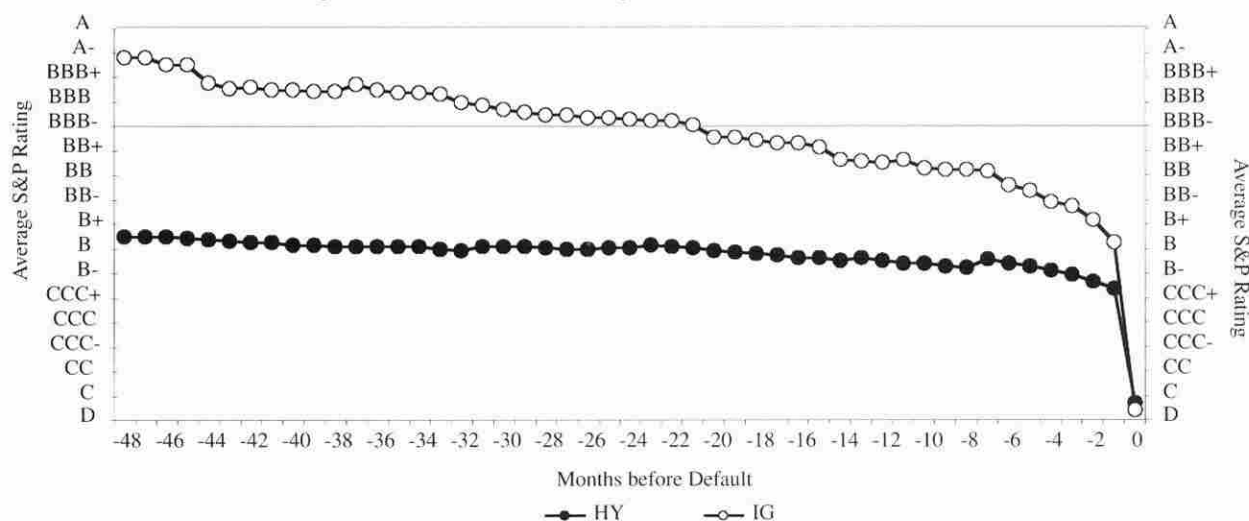
The vast majority of investment-grade firms do not default, and unlike high-yield companies, those that do

default generally do not fall off a cliff from investment-grade directly to default. Credit problems for investment-grade companies have historically tended to develop much more gradually.

For example, the open circles in Exhibit 8 show the average progression to default of bonds that were initially rated investment-grade, and the solid circles illustrate the

EXHIBIT 8

Investment-Grade Versus High-Yield Credits—Average Path to Default



Source: Salomon Smith Barney.

EXHIBIT 9

Firms Going Directly from Investment-Grade to Default in One Month Since 1980

Firm	Country	Date of Original Rating	Original Rating	Default Date	Rating Before Default
Mercury Finance Corp.	U.S.	9/16/93	BBB+	1/30/97	BBB+
Johns Manville Corp.	U.S.	1/1/81	A+	8/26/82	BBB
Confederation Life Insurance Co.	Canada	12/30/86	AAA	8/11/94	BBB
Documation Inc.	U.S.	1/1/81	B-	11/1/84	BBB
Guangdong International Trust & Investment Corp.	China	11/3/93	BBB	10/7/98	BBB-
General American Life Insurance Co.	U.S.	6/20/90	AA	8/10/99	BBB-
Heileman (G.) Brewing Co., Inc.	U.S.	1/1/81	A	11/20/91	NR

NR: Not rated.

Source: Salomon Smith Barney (courtesy of Edward I. Altman).

same trend line for high-yield bonds. Four years prior to default, the average investment-grade bond was rated A-, and just prior to default it was rated B. During the intervening 48 months, the average rating slid eight rating subcategories. By contrast, four years prior to default, the average high-yield bond was rated B+, and just prior to default it was rated CCC+. The average rating on these bonds declined only three rating subcategories before default.

This gradual decline in credit quality, coupled with the deep, liquid investment-grade bond market, often gives investment-grade average CDO managers ample opportunity to trade out of credit-impaired names. The same cannot always be said of the high-yield market.

As Exhibit 9 illustrates, since 1980 only seven firms have dropped from investment-grade to default within a month.

Greater Liquidity and Diversity

If a single security constitutes a great percentage of the asset base of a CDO, its default early in the life of a deal can significantly impair CDO equity returns. Thus, a high degree of industry and obligor diversity is crucial to the success of any CDO. This diversity is much easier to achieve in the investment-grade market than it is in the high-yield market. In addition, trading after the close occurs in a much deeper and more liquid market. As a result, selling becomes a much more realistic exit strategy for an investment-grade CDO than for a high-yield CDO (i.e., there is less price volatility).

The breadth and depth of the investment-grade market dwarfs that of the high-yield market. As Exhibit 10 illustrates, the investment-grade market includes 1,227

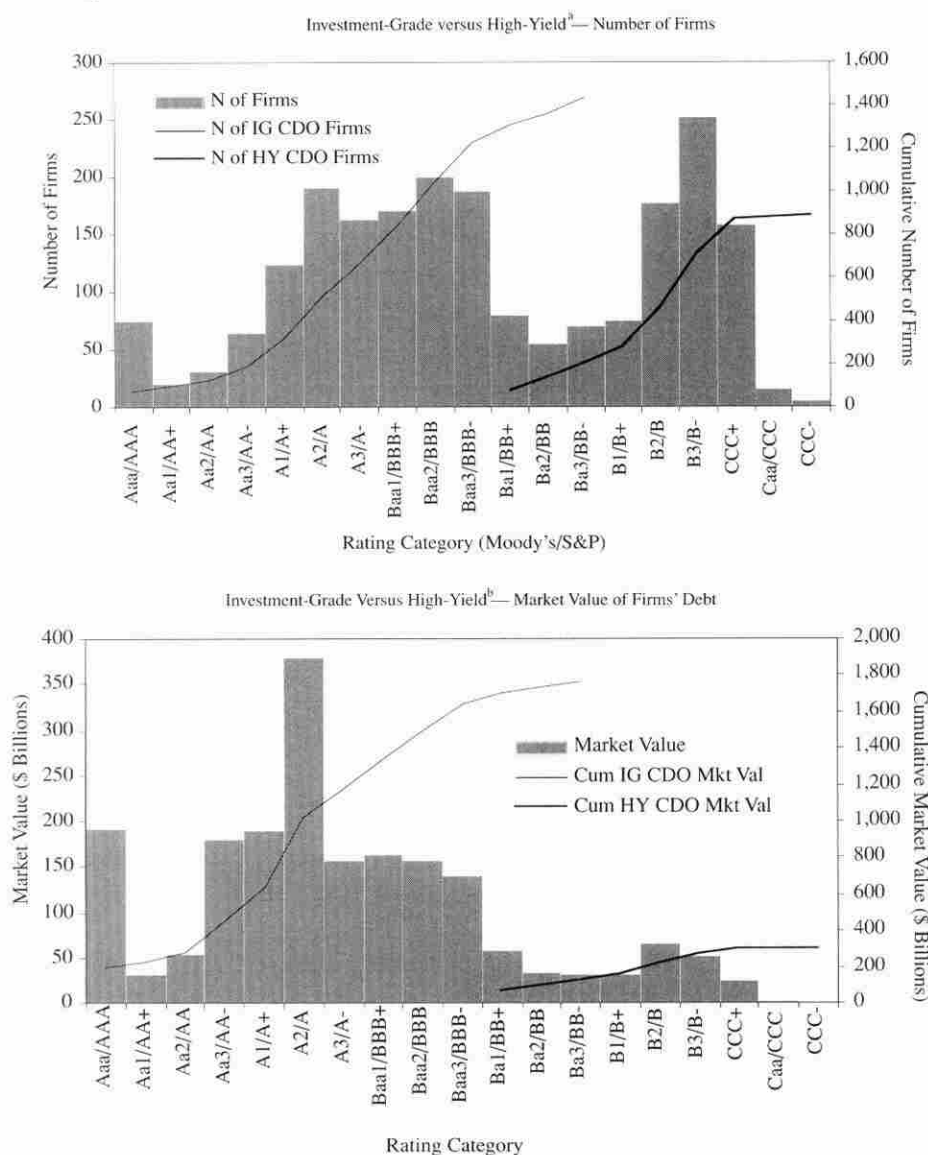
EXHIBIT 10

Investment-Grade and High-Yield Sectors—Number of Firms and Market Value of Debt

	IG	HY
Number of Firms	1,227	883
Market Value (billions)	\$1,689	\$258
	IG CDOs	HY CDOs
Number of Firms	1,431	883
Market Value (billions)	\$1,761	\$298

Note: By IG CDOs we mean the range of assets that could be present in an IG CDO (AAA to BB-) and by HY CDO we mean the range of assets that could be present in a HY CDO (BB+ to CCC-).

Source: Salomon Smith Barney.



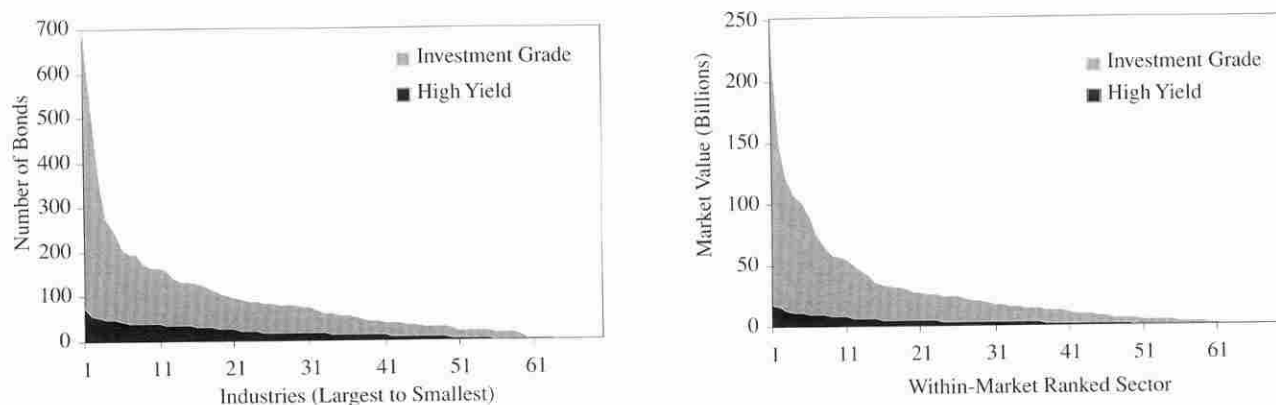
^aNumber of firms with face value greater than \$100 million by rating category (bars) and cumulative number of eligible firms for investment-grade and high-yield CDOs by rating category, as of February 28, 2001 (U.S. firms only).

^bMarket value of firms with face value greater than \$100 million by rating category (bars) and cumulative market value of eligible firms for investment-grade and high-yield CDOs by rating category, as of February 28, 2001 (U.S. firms only).

Source: Salomon Smith Barney.

EXHIBIT 11

Investment-Grade Versus High-Yield*—Industry Diversity



*Market value of bonds with face value greater than \$100 million ranked by amount outstanding per industry sector for investment-grade and high-yield sectors, as of February 28, 2001.

Source: Salomon Smith Barney.

firms with an aggregate market value of \$1,689 billion. The high-yield market has 25% fewer firms (883), with an aggregate market value that is less than one-fifth (\$258 billion) the market value of the investment-grade market. The investment-grade market also has more industry diversity.

Exhibit 11 ranks the number and market value of bonds from largest industry to smallest (see Appendix B for the detailed table used to create Exhibits 10 and 11). The left panel shows that the number of firms per industry in the investment-grade universe greatly eclipses the number of firms per industry in the high-yield market.

The largest industry in the investment-grade market (banking—628 firms) has almost nine times the firms in the largest sector of the high-yield market (service/other—74 firms). There are more than five times the number of firms in the top ten investment-grade industries (2,549) than in the top ten high-yield industries (490).

Finally, the investment-grade market has 20 industries with fewer than 20 firms versus the high-yield market, which has 46 industries with fewer than 20 firms. The high-yield market has only 61 industries in total. That is, more than two-thirds of high-yield industries consist of fewer than 20 firms.

No Ramp-Up Risk

Because of the depth of the investment-grade market, most investment-grade average CDOs are fully “ramped up” at closing, an advantage that can benefit

both rated note holders and CDO equityholders. That is, the absence of a ramp-up period reduces the risk that credit spreads will tighten during the collateral accumulation process.⁵

Because other markets are not nearly as deep and liquid, the same cannot be said for high-yield CDOs, leveraged loan CLOs, or multisector CDOs. A CDO that accumulates assets after closing is exposed to the risk that credit spreads will tighten, and the CDO manager will be forced down the credit spectrum to meet minimum average coupon and margin requirements and generate sufficient returns to CDO equityholders. In this chase for yield, some managers will take on a disproportionate amount of credit risk, which has the potential to affect all note holders in the capital structure.

Investment-Grade Bonds are Non-Call for Life

Many arbitrage CDOs have five-year reinvestment periods during which note holders are paid only interest. During this period, the collateral manager reinvests all principal collections in new bonds and loans, and it must do so while complying with minimum ratings, coupon, margin, and tenor restrictions.

In a declining interest rate environment, or when credit spreads are tightening, there is a risk that the arbitrage projected at closing will deteriorate. This reinvestment risk is exacerbated in high-yield CDOs because the typical ten-year high-yield bond is callable after five years.

EXHIBIT 12

Investment-Grade CDO Equity Returns—Sensitivity to Annual Default Rates and Recoveries

Recovery Rate	Annual Default Rate						
	0.00%	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%
60%	20.6	19.3	17.9	16.3	14.3	11.9	8.4
50	20.6	19.0	17.2	15.0	12.1	7.6	1.3
40	20.6	18.7	16.4	13.5	8.8	1.6	(13.1)
30	20.6	18.4	15.6	11.6	4.6	(9.5)	(20.3)
20	20.6	18.0	14.7	9.1	(1.1)	(19.7)	(28.7)
10	20.6	17.7	13.7	6.0	(12.8)	(25.5)	(37.3)
0	20.6	17.3	12.5	2.4	(19.6)	(28.9)	(40.8)

Source: Salomon Smith Barney.

In general, investment-grade CDOs have far less of this uncontrollable portfolio turnover because most investment-grade bonds are non-call for life.

Maturity Profile

A majority of high-yield bonds are issued with either a 10NC5 or a 7NC3 structure. Where the issuer performs well, issues are generally called prior to maturity. From a CDO manager's perspective, this call feature, coupled with the scarcity of short-term high-yield investment alternatives, makes it difficult to rebalance the portfolio toward the end of the reinvestment period.

Investment-grade bonds by contrast are not callable generally, and investment-grade issuers have access to more funding sources (e.g., bonds, medium-term notes, commercial paper). This makes it easier for the manager of an investment-grade CDO to manage the portfolio up to and past the end of the reinvestment period.

IV. RETURN ANALYSIS

CDO Pricing— Current Market Convention

To evaluate cash flow CDO equity, the typical investor will run multiple default and recovery rate scenarios to compute a risk-adjusted internal rate of return on its initial capital outlay. The standard approach assumes a constant default rate (CDR) of 2% per year for high-yield CDOs and 0.25% for investment-grade CDOs.⁶

In addition, various default "spike" scenarios are run. Default rate spikes are assumed to occur at the beginning, middle, and end of the transaction's life. Under each scenario, an IRR is calculated from the resulting cash flows, and this is used as the expected value of the return.

Exhibit 12 shows a typical IRR table used in the marketing of investment-grade CDO equity. The columns indicate the assumed annual default rates, and along the vertical axis are the assumed recovery rates.

The average annual default rate for Baa3 bonds is 0.46% (see Exhibit 6), but IG CDO equity has typically been marketed at a 0.25% per year rate under the assumption that an experienced manager should be able to outperform the market average over time. Average recovery rates are nearing the low point of the cycle, and the long-run average recovery rate for corporate bonds is around 44%.⁷

From Exhibit 12, we can see that if an investment-grade CDO manager has proven that it can outperform the market (i.e., 0.25% per year default rate and 50.0% recovery rate), the resulting IRR is 19.0%. Alternatively, if a manager's default and recovery experience matches the historical average (i.e., a 0.50% per year default rate and a 40.0% recovery rate), the resulting IRR in our example is 16.4%.

Even if annual default rates occur at three times the historical average (1.50%) for the life of the deal, the IRR is still positive (1.3%), assuming a 50.0% recovery rate.

Exhibit 13 illustrates break-even annual default rates for recovery rates from 60% to 0%.

Finally, Exhibit 14 illustrates the effect of default spikes on investment-grade CDO equity. This scenario assumes that defaults are high in the first two years of a transaction, and then they revert to either 0%, 0.25%, 0.50%, or 0.75% per year thereafter. The first set of numbers in Exhibit 14 solves for a 0% break-even IRR, and the second set for a 5% break-even IRR, which is an approximation of what an investor could earn at the risk-free rate.

In each of the first two years of this transaction, defaults can exceed seven times the historical average (3.55%) and revert to 0.50% per year thereafter, and an investor's initial capital contribution can still be returned.

EXHIBIT 13

Break-Even Annual Default Rates

	Recovery Rate						
	0%	10%	20%	30%	40%	50%	60%
Break-Even Rates	0.79	0.88	0.98	1.13	1.28	1.53	1.9

Source: Salomon Smith Barney.

EXHIBIT 14

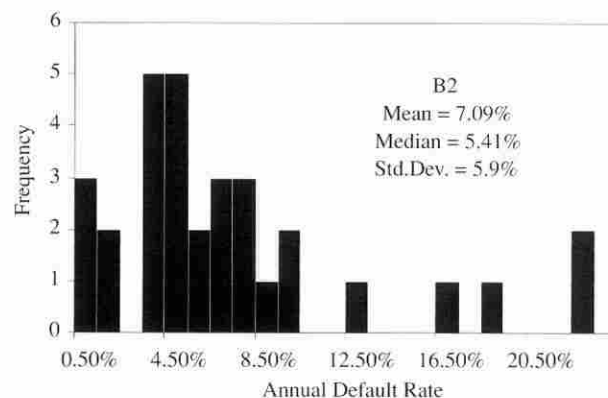
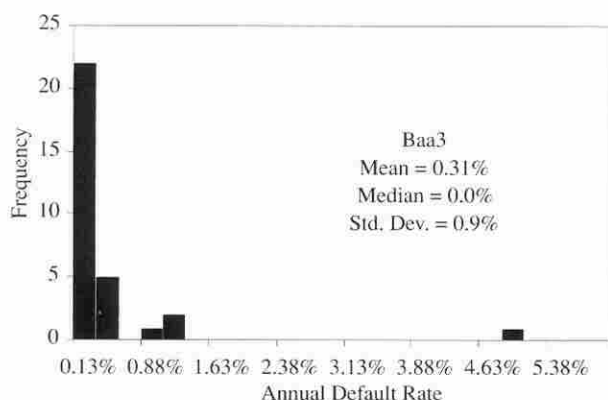
Default Spike Analysis

Default Rate	Approximate IRR							
	0.00%				5.00%			
Years 3-12	0.00%	0.25%	0.50%	0.75%	0.00%	0.25%	0.50%	0.75%
Years 1 and 2	4.73	4.15	3.55	2.98	3.82	3.31	2.81	2.31

Source: Salomon Smith Barney.

EXHIBIT 15

Annual Moody's Default Rates for Bonds Rated Baa3 and B2 1970-2000*



*Default rates prior to 1983 are available by letter category only.

Sources: Moody's Investors Service and Salomon Smith Barney.

Alternatively, the assumed risk-free rate (5.00%) can be earned even if defaults exceed five times the historical average (2.81%) and then revert to 0.50% per year for each subsequent year.

Market convention notwithstanding, there are certain weaknesses in pricing CDO equity (and other CDO tranches) using a constant default rate methodology. First, annual default rates are not uniformly distributed in either investment-grade or high-yield rating categories. To illustrate this point, Exhibit 15 shows frequency distributions of annual default rates for bonds rated Baa3 and B2.⁸

For Baa3 bonds (first graph), the mean is 0.31%, close to the 0.25% constant default rate assumption commonly used to price investment-grade CDOs.⁹ The fre-

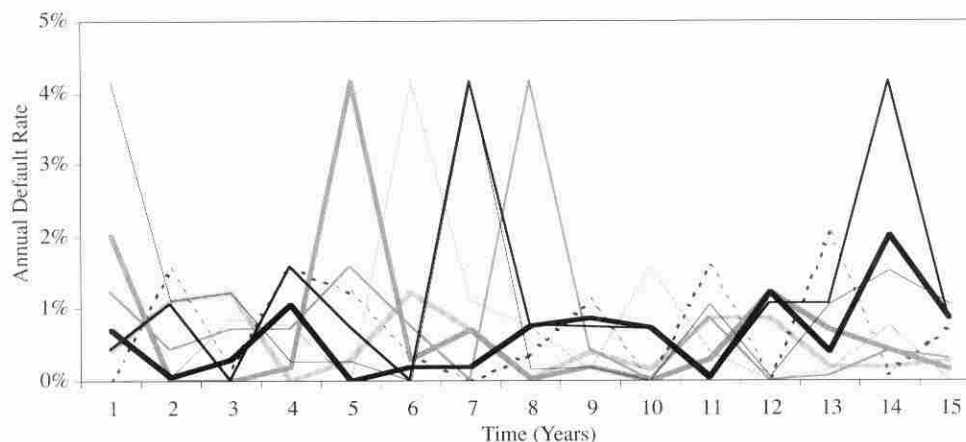
quency distribution of Baa3 default rates is highly skewed, however; the closest approximation is either a Poisson distribution or a negative exponential distribution. Also, notice that the standard deviation of Baa3 credits is 0.9%, but that at minus 1 standard deviation Baa3 credits have an annual default rate of negative 0.59%.

Similarly, for B2 credits (second graph), the distribution is highly skewed, so that the distribution is more Poisson than normal, and the standard deviation is inadequate as a measure of dispersion.

If the mean is not a good measure of central tendency for triple-B minus and single-B credits, can the median value serve as a reliable benchmark for pricing CDO equity? No. The median of the triple-B minus dis-

EXHIBIT 16

Sample of Eight Paths Used to Price a 15-Year Investment-Grade CDO



Sources: Moody's Investors Service and Salomon Smith Barney.

tribution is zero, yet no rational person would argue that there is no default risk for investment-grade CDO equity investors. Even though the mean and median are similar for B2 default rates, large annual default rate spikes occur more than occasionally.

Finally, with respect to the timing of defaults, both investment-grade and high-yield CDO equity returns are critically path-dependent. That is, large defaults that occur early in the life of the CDO have a much greater negative effect on returns than later defaults.

Timing is key. Even one early year with a 10% default rate for the high-yield CDO or an early 5% annual default rate for an investment-grade CDO can impair the return on CDO equity.

Pricing CDOs Using Monte Carlo Simulations

We propose a refinement to the current market convention for pricing CDOs—a refinement grounded in Monte Carlo simulation and actual historical default rates. The fact that the distribution of annual default rates is not normal or described well by traditional non-normal distributions presents difficulties in generating meaningful annual default paths for the simulation. Our approach is to make no parametric assumptions about the underlying distribution, but rather to generate annual default rates for each pricing vector by sampling (with replacement) from the historical default rates published by Moody's since 1970.

Accordingly, we randomly sample from these annual default rates and construct 24 default vectors that are a mix of front-, middle-, and back-loaded curves. Exhibit 16 shows a sample of paths.¹⁰

Recognizing that these are investment-grade *average* CDOs, we construct three sets of 24 default vectors from three different credit distributions, all of which result in an average credit quality of approximately triple-B minus. The distributions are defined as “point,” “tight,” and “wide” (see Appendix C).¹¹

We then take the initial portfolio and capital structure of our nine outstanding investment-grade average CDOs and compute the cash flows from each CDO along the 72 simulated default vectors.¹² From the cash flows we compute an average rate of return for each pricing path, and the average over all paths is the stated IRR in Exhibit 17.

To calculate ex ante Sharpe ratios, cash flows for a given tranche are discounted back to the pricing date, using values obtained from the yield curve on that date (May 21, 2000). For each CDO we calculate the mean, standard deviation, and Sharpe ratio on the equity cash flows, and the second-loss-tranche cash flows (typically rated Baa2).¹³

This simulation method has several advantages over the constant default rate method and the ad hoc spike method. First, to the extent that a reasonable set of variable default paths can be generated, one can estimate not only the average return but also its expected volatility. This enables us to calculate Sharpe ratios for the expected returns by computing the average return over all the paths and dividing by its standard deviation.

EXHIBIT 17

Monte Carlo Simulations—Summary Statistics

Deal	Average Internal Rate of Return	Ex Ante Sharpe Ratio	Internal Rate of Return				
			Min	Quartile 1	Median	Quartile 3	Max
1	18.6%	2.72	16.6%	18.3%	18.6%	19.2%	19.6%
2	17.2	2.60	15.2	16.9	17.2	17.7	18.2
3	18.1	3.23	16.3	17.9	18.2	18.7	19.2
4	15.7	2.42	13.5	15.4	15.8	16.4	16.9
5	16.9	2.89	15.0	16.6	16.9	17.5	17.9
6	16.9	2.76	14.8	16.6	16.9	17.5	17.9
7	14.1	1.58	10.5	13.8	14.3	15.1	15.8
8	15.1	1.36	10.4	14.6	15.3	16.3	17.4
9	15.8	1.41	11.2	15.2	16.0	17.0	18.1
Average	16.5%	2.33	13.7%	16.1%	16.6%	17.3%	17.9%

Source: Salomon Smith Barney.

Second, time-varying default rates let us mimic, in a statistical sense, the effects of different sequences of annual default rates that might be encountered. Finally, one can compare the expected cash flow profile for a typical investment-grade average CDO to the cash flow profiles of other asset classes.

Results

Exhibit 17 displays the results of pricing simulations for the nine SSB-originated investment-grade CDO equity tranches. Each deal was structured with a maximum Moody's average rating factor of 610, and for the purposes of the exhibit we use the tight credit distribution.¹⁴ All results assume a static portfolio with no CDO manager intervention.

The results are impressive. Across the nine transactions, the average IRR is 16.5%, and it ranges from 14.1% to 18.6%. The ex ante Sharpe ratios for the deals range from 1.36 to 3.23, with an average of 2.33. These solid risk-adjusted returns and high Sharpe ratios stack up favorably with those of both traditional and alternative investments.

The rates of return are correlated with the Sharpe ratios, but the relation is not monotonic, indicating the usefulness of that risk/reward measure for assessing relative asset performance. The IRRs in the first quartile are reduced only slightly from the average expected return, indicating a high likelihood of equity-like returns from investment-grade average CDO equity.

Further, examination of the minimum returns for the deals reveals that investment-grade CDO equity returns were greater than those for an equivalent investment in a risk-free asset-class for all 24 paths of all nine deals (i.e., 216 paths).

This bodes well for the mezzanine tranches, whose cash flow may be adversely affected by poor CDO equity performance. We confirm this by simulating the effects of collateral default on mezzanine tranche cash flows. In fact, we stress our 216 default vectors by a factor of 1.5 times, with limited impairment to Baa2 cash flows.

Under such conditions, the simulated returns on the mezzanine tranches are roughly 264 basis points over Treasuries on average, which is approximately the return on a Ba1-rated corporate bond. Yet, the mezzanine tranche is rated Baa, and a Baa-rated corporate bond has an average return of +148 bp (see Benzschawel and Adler [2001]).

The estimates for returns on CDO equity investments shown in Exhibit 17 should not be viewed as the upper bound in that our method assumes that: 1) the manager does not actively trade the portfolio; and 2) the assets in the CDO default at a rate that matches the rate in a simulation based on historical default rates for the entire market. Historically, a number of investment-grade CDO managers have proven that they can significantly outperform the market average default rate. The CDO manager adds value in a number of ways, including the initial selection of credits for the portfolio.

Another CDO manager core competence is to enhance and preserve capital through credit risk and credit-improved sales. Although the role of the manager in investment-grade CDO deals may be more limited than for high-yield deals, there is the potential for judicious portfolio management to enhance returns.

EXHIBIT 18

Knight II Funding Capital Structure

Tranche	Principal Amount	Cumulative Amount of Pari Passu or Senior Debt	Collateral in Excess of Debt	
			Collateral	Ratio
Class A-1	\$402,000,000	\$402,000,000	\$98,000,000	124.4%
Class A-2	37,000,000	439,000,000	61,000,000	113.9
Class B	27,000,000	466,000,000	34,000,000	107.3
Equity	18,000,000	484,000,000	16,000,000	—

Source: Salomon Smith Barney.

Methodology Limitations

Let us note some limitations of the methods employed for this analysis and the extent to which they fail to provide complete assessment of the risks involved in investing in investment-grade CDOs. The main limitations of our pricing method are that we do not assess the cost of lack of liquidity to CDO investors or quantify the effect of active portfolio management on returns. Also, we assume a constant 50% recovery rate and no temporal correlation of annual default rates. The 30-year sample of default rates may not be sufficient to characterize the future distribution of rates. While we assume that the manager maintains a portfolio with an average credit quality of Baa3, there has been no attempt to analyze each deal at the individual asset level.

V. RELATED ISSUES

Subordination Defined

There has been a fair amount of confusion in the market concerning the amount of subordination available to note holders in a cash flow arbitrage CDO. Proper quantification of subordination in investment-grade average CDOs is very important, given that these deals, by definition, are more levered than high-yield CDOs.

Note holders in IG CDOs enjoy two types of protection: principal subordination, and excess spread. Measuring principal subordination is fairly straightforward. For any class, take the aggregate notional amount of the assets, and subtract the notional amount of the class in question plus the notional amount of any classes senior to the class in question.

Exhibit 18 provides a useful example. At closing, Knight II CDO had \$500 million par amount in assets in the capital structure shown in Exhibit 18. The amount of principal subordination available to the Class A-2 would be calculated as follows:

$$(\$500,000,000) - (\$37,000,000 + \$402,000,000) = \$61,000,000$$

The principal amount of collateral subordinated to the Class A-2 notes is 12% of the aggregate collateral balance. If a Class A-2 investor, however, simply sums the notional amount of liabilities subordinate to the Class A-2 and divides it by the aggregate notional amount of the liabilities, this would understate the amount of principal protection available — $(\$27 \text{ million} + \$18 \text{ million})/\$484 \text{ million} = 9.3\%$.

This second way to calculate principal protection understates the level of protection, and is incorrect because the assets were purchased at a discount. Clearly, this faulty method would overstate the amount of principal protection in the unlikely event that the assets were purchased at a premium.

Excess spread, the second type of protection to CDO note holders, is harder to quantify. Excess spread benefits note holders to the extent that it is used to amortize the liabilities rather than being paid out to the CDO equity-holders. This redirection of cash flow occurs when an interest coverage (I/C) or overcollateralization (O/C) test is tripped.

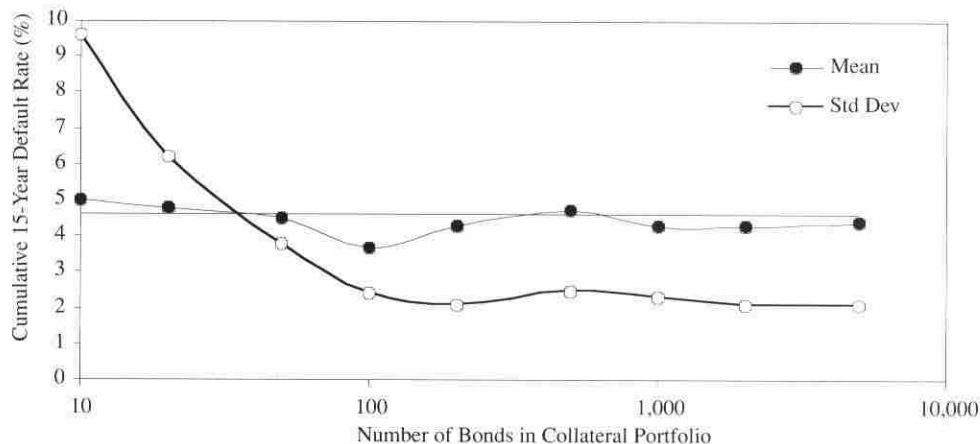
A number of key variables will determine whether these tests are in compliance:

- Size of the buffer above the minimum I/C and O/C tests.
- Trading gains and losses.
- Level and timing of defaults and recoveries.
- Yield on the portfolio.

Because a number of variables will affect the value of excess spread to note holders, the best way to quantify it is to run numerous cash flow scenarios. For example, in a front-loaded default scenario with lagged recoveries, the amount of excess spread available to rated note hold-

EXHIBIT 19

Benefits of Obligor Diversity



Note: Mean cumulative default rates (solid symbols) and standard deviations (open symbols) as a function of number of bonds in the collateral pool.

Source: Salomon Smith Barney.

ers would increase because this would be one way to hit the triggers and redirect cash flow from the CDO equity to the most senior notes then outstanding. Taking the present value of all redirected cash flows would be one way to quantify the benefit.

Obligor Diversity

As McDermott [2000] discusses, rating agency methodologies encourage obligor and industry diversity. Simply put, because CDO asset pools are “lumpy” to begin with, the more names in the pool, the less any single obligor default can hurt note holders. This is especially true with respect to the typical investment-grade average CDO, given its higher leverage than a high-yield CDO.

In our opinion, obligor diversity is even more important than industry diversity, and we typically look for an investment-grade average CDO to have at least 100 different names with maximum position sizes between 1.00% and 1.25%. All other things equal, a larger number of smaller positions are better, but at what point do the benefits of obligor diversity trail off?

This question of obligor diversity is important for CDO investors and managers alike. From an investor’s perspective, there is a minimum number of obligors that a CDO should include (and a maximum size for any one obligor) to keep default rate volatility within acceptable bounds. Yet, a manager has to expand its research staff as it follows more credits—at some point, it realizes a diminishing benefit for each additional credit that it adds to the portfolio.

To determine the effects of obligor diversity (i.e.,

the coarseness or fineness of the collateral pool) on CDO equity returns, we run pricing simulations similar to those used to generate Exhibit 17, but vary the number of underlying bonds in the pool.¹⁵

For the simulations, we use the 24 default paths created for the point distribution in Appendix C over a 15-year period. For each pricing path, we calculate a cumulative 15-year default rate as the sum of the defaults over the 30 semiannual payout periods divided by the number of firms in the pool at the start of the simulation. We then calculate the mean 15-year default rate over the 24 paths and its standard deviation. Simulations are run for collateral pools of 10, 20, 50, 100, 200, 500, 1,000, 2,000, and 5,000 bonds.¹⁶

The results of the simulation are shown in Exhibit 19. The solid horizontal line shows the 15-year historical Baa3 cumulative default rate of 4.6% calculated from Moody’s default tables.¹⁷ The solid circles are the mean cumulative 15-year default rates from the 24 paths of the simulation for a given collateral pool.

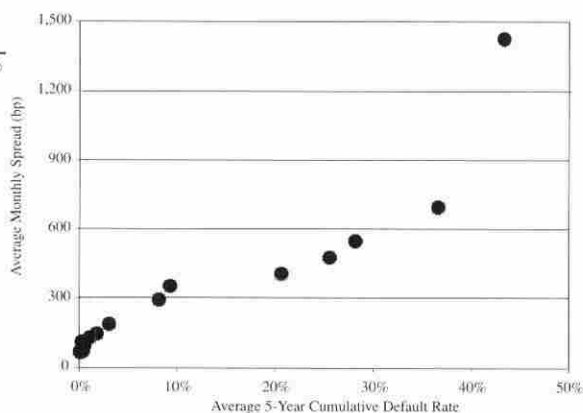
As is evident from the graph, the size of the collateral pool has little effect on the resulting average cumulative default rates obtained in the simulations. The standard deviations about those averages (the open circles), however, are highly dependent on the diversity of the asset base. That is, as the number of bonds drops below 100, the volatility of the cumulative default rates across pricing paths increases dramatically.

For example, default rate volatility in the 50-bond portfolio has a standard deviation of 3.8%, which is almost 60% higher than the default rate volatility in the 100-bond portfolio with a standard deviation of 2.4%. Con-

EXHIBIT 20

Relationships Among Changes in Ratings, Spreads, and Default Probabilities

Credit Rating		Average Spread	Cost of Ratings Decrease	Five-Year Cumulative Default Rate	Diff
S&P	Moody's				
AAA	Aaa	68	-1	0.2%	0.0%
AA+	Aa1	67	6	0.2	0.2
AA	Aa2	73	9	0.4	0.0
AA-	Aa3	82	13	0.4	0.2
A+	A1	95	7	0.6	0.0
A	A2	102	13	0.6	-0.3
A-	A3	115	16	0.4	0.8
BBB+	Baa1	131	17	1.2	0.7
BBB	Baa2	148	43	1.9	1.3
BBB-	Baa3	191	104	3.2	5.0
BB+	Ba1	294	61	8.1	1.2
BB	Ba2	356	51	9.3	11.4
BB-	Ba3	407	74	20.6	5.0
B+	B1	481	68	25.6	2.6
B	B2	549	147	28.2	8.4
B-	B3	696	331	36.7	6.7
C	Caa1-C	1,423	1,009	43.4	



Sources: Moody's Investors Service and Salomon Smith Barney.

versely, the default rate volatility of 2.1% in the 200-bond portfolio is only 14% lower than the default rate volatility in the 100-bond portfolio. Thus, increasing the number of bonds above 100 provides little incremental risk reduction in the form of decreased volatility.

Hence, the sweet spot for optimal collateral diversity seems to be just over 100 obligors. This result supports our view that the leverage inherent in IG CDOs makes it risky for a manager to have fewer than 100 bonds in the portfolio, and that no position should exceed about 1.25% of the portfolio.

Credit Distributions in IG CDOs—Credit Barbell?

As we have mentioned, although the portfolios backing these transactions are investment-grade on average, the typical deal can include up to 30% Ba-rated credits (up to 10% Ba3). Ba-rated names are included in the portfolios primarily to improve returns for CDO equity-holders. Of course, by definition, long-term Baa default rates are lower than Ba default rates, but CDO note holders should be indifferent to this as long as they are adequately compensated for this additional default risk.

Our studies have shown that at certain points along the double-B continuum CDO investors are compensated, and at certain points they are not (see Benzschawel and Adler [2001]).

To examine the relationship between changes in rating category average spreads and changes in default prob-

ability, we compare cumulative five-year default rates from Moody's for various rating categories in Exhibit 20. We also examine the width of the credit distribution of the collateral in an attempt to address the criticism that an investment-grade average CDO is a credit barbell.

The table in Exhibit 20 provides numerical values of five-year cumulative defaults by rating category along with the change in default probability as one declines one notch in credit quality. The progression of increases in default probabilities is roughly monotonic until crossing the investment-grade/high-yield boundary from BBB- to BB+. At that point, the incremental increase in default probability rises from 1.3% to 5.0% going to BB+, and then by only 1.2% going from BB+ to BB.

Analysis of each rating category's cumulative default rate versus average spread indicates that moving from BB+ to BB is one way a CDO manager can maximize yield relative to incremental changes in default risk. Conversely, investing in BB- names represents a poor spread/credit risk trade-off. Going from BB+ to BB, the five-year cumulative default probability (5YCD) increases by only 1.2% with a 61 bp increase in average spread change, while a downgrade from BB to BB- results in a similar 51 bp average spread change, but a steep increase in 5YCD of 11.4% (from 9.3% to 20.6%).

Consequently, because these deals are almost always fully accumulated by pricing, we would recommend that investors review the portfolios and be wary of those that come close to the 10% double-B minus limitation.

EXHIBIT 21

Frequency Distributions of Collateral*

Moody's Rating	S&P Rating	Moody's Weighted-Ave. Credit	Wide		Tight		Point	
			Pct. in Rating Category	Cum Pct.	Pct. in Rating Category	Cum Pct.	Pct. in Rating Category	Cum Pct.
Aaa	AAA	1						
Aa1	AA+	10						
Aa2	AA	20						
Aa3	AA-	40						
A1	A+	70	7.5%	100.0%				
A2	A	120	7.5	92.5	2.5%	100.0%		
A3	A-	180	12.5	85.0	5.0	97.5		
Baa1	BBB+	260	12.5	72.5	12.5	92.5		
Baa2	BBB	360	15.0	60.0	15.0	80.0		
Baa3	BBB-	610	15.0	45.0	50.0	65.0	100.0%	100.0%
Ba1	BB+	940	15.0	30.0	7.0	15.0		
Ba2	BB	1,350	7.5	15.0	5.0	8.0		
Ba3	BB-	1,780	7.5	7.5	3.0	3.0		
B1	B+	2,220						
B2	B	2,720						
B3	B-	3,490						

*By rating category for investment-grade CDOs with similar Moody's average credit quality weightings for wide (rating = 590.5), tight (rating = 590.2), and point (rating = 610) distributions.

Source: Salomon Smith Barney.

EXHIBIT 22

Sharpe Ratios for IG CDOs with Wide, Tight, and Point Distributions of Collateral Credit

Deal	Distribution		
	Wide	Tight	Point
1	2.45	2.72	1.04
2	2.42	2.60	1.01
3	2.95	3.23	1.24
4	2.15	2.42	0.92
5	2.61	2.89	1.10
6	2.38	2.76	1.03
7	1.35	1.58	0.61
8	1.28	1.36	0.57
9	1.36	1.41	0.61
Average	2.11	2.33	0.90

Source: Salomon Smith Barney.

CDO deals have been criticized as credit barbell deals in that the manager buys high- and low-yielding credits to enhance yield over a narrower distribution, which exposes investors to poor credits. In our opinion, the myriad of investment guidelines (including the twin constraints of a minimum average Moody's rating factor and the need to generate a minimum return to equity-

holders) make it difficult, if not impossible, to barbell the portfolio. We find that widening the credit distribution within existing CDO investment guidelines has little negative effect on expected returns.

Having said this, many different credit distributions can be constructed to meet the minimum average credit rating constraint. For example, Exhibit 21 shows a set of

frequency distributions that satisfy a Moody's average credit quality (MACQ) of 610 for an investment-grade CDO.¹⁸ The point distribution at the right in Exhibit 21 shows 100% of BBB minus-rated collateral, and by definition it meets the 610 MACQ hurdle.¹⁹ The wide and tight distributions in Exhibit 21 have collateral that is more widely distributed over the rating categories, but that has similar MACQs of about 590.²⁰

The rating composition of an IG CDO is critical; the manager must strike a balance between highly rated, lower-yielding credits and more risky, high-yield assets with higher downgrade and default probabilities.

To examine the question of optimal distribution width, we perform our default rate simulations on the wide and point distributions of Exhibit 21, and compare results with those reported for the tight distribution in Exhibit 17. Average default rates for the wide, tight, and point distributions are 0.37%, 0.31%, and 0.32%, respectively. Thus, wide distributions of credit do produce slightly higher average default rates, but not by much (0.31% versus 0.37%). There is no barbell.

In fact, the investment guidelines within a typical investment-grade CDO are designed to ensure this. Furthermore, Sharpe ratios for the various distributions shown in Exhibit 22 confirm that risk-adjusted CDO equity returns decline minimally as the distribution of credits widens. Finally, the reason that the Sharpe ratio for the point distribution is lowest (despite its low average default rate) is because it has the greatest variation of average default rates across pricing paths.

Equivalent Constant Default Rate

The Sharpe ratios and IRRs that result from our simulations should aid investors in making relative-value judgments among various IG CDO equity investments. In addition, one may wish to express the value of a deal in terms of the constant default rate level that would produce an identical IRR.

For example, after an IRR is calculated for a given default path for CDO equity, one can, using approximation methods, solve for the equivalent constant default rate (ECDR) that would produce that same IRR.²¹ The ECDRs for all our deals fall within a narrow range from 0.33% to 0.36%, and the average IRR across all our deals is 16.5%.

One advantage of the ECDR is that it allows us to express the effects of the default simulations using a single number that can serve as a benchmark for IG CDO equity pricing. For example, assume that an investor runs a new

transaction at a constant annual default rate of 0.34% (the average ECDR in our simulations), and the resulting IRR is less than 16.5%. All other things equal, the CDO equity in the new deal would not be as robust as the average CDO investment resulting from our simulations. Of course, this method, while simple, does not provide investors with a measure of the volatility of expected returns.

VI. RELATIVE VALUE

We conclude with a brief discussion that places IG CDO equity in the context of other alternative investments. Insurance companies, banks, pension plans, endowments, and high net worth individuals are increasingly looking at alternative investments as a way to diversify traditional fixed-income and equity portfolios. A strategy of diversifying into alternative investments is one way that these investors can reduce portfolio volatility while retaining robust risk-adjusted returns.

Exhibit 23 compares alternative investments to CDO equity on a number of dimensions, including returns.

The average return on CDO equity compares favorably to returns on alternative asset classes. In addition, CDO equity provides diversification regarding investment guidelines, obligors, cash flow structure, management depth, and performance transparency.

Returns

Exhibit 24 presents a more detailed comparison of returns on CDO equity with other higher-return asset classes at a finer level of detail than shown in Exhibit 23. The first row gives the average IRR (annualized) for the given asset class for 1990 through 2000. As before, the rate of return from CDO equity is estimated from our simulations.

Exhibit 24 shows that CDO equity returns are about average for the class of alternative investments, as is the estimated Sharpe ratio for CDO equity.

Lack of Correlation

The profile of CDO equity returns in Exhibit 24 appears similar to those of more aggressive strategies as pursued by hedge funds, REITs, private equity funds, and market-neutral investment firms. Yet remember that Exhibit 5 shows the relative lack of correlation between investment-grade bond returns and those of hedge funds ($r = -0.16$) and private equity ($r = -0.24$).

EXHIBIT 23

IG CDO Equity and Alternative Investments

Parameter	Growth Private Equity	Value Hedge Funds	Income		
			REITs ^a	Mezzanine Fund	CDO Equity ^b
Average Return (1980–2000)	16.4%	17.7%	10.95%	14.7%	16.5%
Market Size (Billions)	\$400	\$400	\$100	\$50	\$350 ^c
Median Return (1920–2000)	1.9%	19.4%	17.2%	2.6%	16.6%
Standard Deviation	17.9	6.2	16.6	16.6	5.1
Investment Objective	Return enhancer	Return enhancer or diversifier	Diversifier	Diversifier	Return enhancer and diversifier
Manager Core Competence	Focus on long-term value creation	Trading focused	Acquisition and redeployment	Hybrid equity play	Focus on minimizing portfolio defaults
Ability to Monitor Performance	None	Indexes	Indexes	None	Projected cash flows plus rating agency tests
Investment Guidelines	None	None	None	None	Extensive
Equity Market Exposure	Yes	Yes	No	Yes	No
Diversity—Obligor (#)	15–25	—	15–25	15–25	80–125
Diversity—Industry (#)	2–5	—	1	3–6	20–30
Cash Flows	Back-loaded	Periodic	Periodic	Back-loaded	Front-loaded
Manager Co-Investment	0%–5%	0%–5%	Limited	0%–5%	0%–49%
Manager Compensation (Mgmt Fee + Carried Interest)	2.5% p.a. + [20–30]%	[1–2] p.a. + [10–30]%	1% p.a. + [10–20]%	1% p.a. + [15–20]%	0.30% p.a.
Maturity	12 years	—	8–12 years	6–10 years	12 years, 3- to 5-year duration
Management Depth	Shallow	Shallow	Shallow	Shallow	Increasingly institutionalized
Callable	No	Yes: redeem at market value	No	No	Yes: after 3 years at market value, conditions apply
Leverage	No	Yes	Yes	Yes	Yes
Nature of Leverage	—	Short-term	Short-term	Short-term	Long-term
Liquidity	None	Moderate	None	None	None
Interest Rate Sensitivity	Limited	Limited	Significant	Significant	Limited
Can Manager Be Changed?	No	No	No	No	Yes: Conditions apply
Tax Treatment—U.S. Investors	Capital	Ordinary	Ordinary	Ordinary + Capital	Ordinary
Transparency	Low	Low/Moderate	Low	Low	Moderate

^aFor purposes of this analysis, we assume private REITs. ^bOwing to the private nature of the CDO market and the resulting paucity of information, the average return and standard deviation are simulated using our methodology. ^cSize of total CDO market.

Sources: Venture Economics, IHR Hedge Funds, National Association of Real Estate Investment Trusts, and Salomon Smith Barney.

EXHIBIT 24

Performance Statistics for Alternative Asset Classes and Simulations of IG CDO Equity 1990–2000

Summary Statistics	Value Strategies					Growth Strategies		Income Strategies		
	Distressed Securities	Convertible Arbitrage	Equity Mkt-Neutral	Fixed-Income	Fund Composite	Private Equity	Venture Capital	REITs	Mezzanine	CDO Equity
Average	15.98%	12.23%	12.11%	11.99%	17.66%	12.07%	17.18%	10.95%	9.81%	16.5%
StDev	6.16	3.82	3.27	3.79	6.20	4.72	7.87	8.47	5.53	5.05
Min	–3.79	–3.71	2.64	–1.90	3.23	0.50	2.30	–19.67	–0.50	14.1
Max	31.09	18.26	15.24	24.61	28.34	18.90	34.60	31.51	18.70	18.6
Median	15.89	13.57	12.86	11.29	19.43	12.50	14.30	17.20	8.25	16.9
75% Percentile	21.02	14.76	14.12	14.72	23.49	16.70	17.75	21.05	14.25	17.6
25% Percentile	5.22	9.86	8.26	6.85	5.63	9.10	8.75	–2.26	7.70	15.4
Sharpe Ratio	1.79	1.91	2.19	1.86	2.05	1.51	1.56	0.71	0.88	2.33

Note: Active strategies indexes are weighted according to HFR's best estimate of the total hedge fund industry assets in the strategy as a percentage of HFR's best estimate of the total hedge fund industry assets across all active strategies. Active strategies include, e.g., convertible arbitrage, equity market-neutral, distressed securities, event-driven, emerging markets.

Sources: Venture Economics, IFR Hedge Funds, National Association of Real Estate Investment Trusts, and Salomon Smith Barney.

The absence of correlations among returns in these sectors suggests that inclusion of IG CDOs in a diversified aggressive portfolio might, by reducing variability of returns, serve to increase that portfolio's risk/reward ratio. Again, we stress caution when engaging in correlation analysis across illiquid asset classes that are difficult to mark to market.

Investment Objective

An assessment of alternative investment strategies must include identifying the ultimate investment objective. Alternative investments may either diversify away the risk associated with traditional markets (diversifier) or offer a return enhancement strategy (enhancer), while offering relatively little by way of diversification.

CDO equity is one of the few alternative asset classes that can deliver both: high absolute returns and relatively low correlation with traditional asset classes.

Performance Benchmarking and Transparency

One of the prime criticisms of many alternative investments is that their lack of transparency defies performance benchmarking. That is, investors have difficulty assessing how their investments are faring, and often until close to maturity. CDO equity investors, however, receive a cash flow statement from inception, detailing what the projected periodic cash flows should be over the life of the investment, given certain key assumptions including the absolute level and timing of defaults and recoveries.

While realized cash flows will not exactly match projections, significant deviations should prompt investors to initiate a dialogue with the CDO manager. Early warning signs let a CDO manager address issues as they arise, and allow an investor to constantly assess the manager's performance.

Although many other alternative investment managers see a lack of transparency as the cornerstone of their ability to generate above-market returns, CDO managers provide monthly disclosure through trustee reports. The trustee report provides trading details (credits bought and sold, prices), while also listing the CDO manager's compliance/non-compliance with numerous investment guidelines.

Investment Guidelines

CDOs, unlike most other alternative investments, have stringent guidelines governing the quality, diversity, and tenor of assets in which they can invest. These guide-

lines, formulated through consultation with the credit rating agencies, include limitations on the ratings of bonds, minimum number of credits, maximum exposure per credit, and industry diversification.

While these parameters are designed to secure the highest possible ratings for the notes, the higher credit rating reflects the fact that a diverse pool of assets benefits CDO equityholders as well.

Diversification

While many other alternative investments seek to diversify exposure across a few industries and a handful of investments, CDO managers often invest across 20 to 30 industries through 80 to 125 investments. This ability of CDO managers to follow many sectors of the economy concurrently allows for a wider variety of portfolio rebalancing options.

Hence, IG CDO equity returns rely less upon the performance of one or two industries than other focused alternative investment strategies.

Manager Equity Coinvestment and Compensation

A CDO manager closely aligns its economic interest with the interests of third-party equity investors in two important ways. First, historically, the typical CDO manager has purchased anywhere up to 49% of the equity of each of its CDOs. Second, about half of the annual management fee is subordinated, and paid only if the deal is in compliance with asset and liquidity triggers, and the notes senior to the equity have been paid their interest entitlement.

The reward system for the CDO manager is different from the standard incentive fees paid to hedge fund and private equity investors. While the objective of alternative investment managers is to maximize returns, CDO managers are paid to maximize returns by minimizing credit loss (i.e., maintain the arbitrage that the CDO has locked into from the onset).

Nature of Cash Flows

Although the cash flows from a CDO equity position are similar to those for a simple coupon bond, the periodic cash flows are higher on average. This satisfies a need for higher-than-bond-like periodic cash management, reduces duration relative to an average bond of

comparable face value, and, subject to call provisions/market conditions, provides an excellent, high-return tool for intermediate-term liability management.

Because CDO equity cash flows are typically front-loaded, the dollar value at risk to the CDO equity investor declines with time, unlike private equity whose dollar value at risk tends to increase in the beginning years of the investment. Also, the front-loaded nature of CDO equity cash flow can act as a nice complement to the back-loaded flows associated with many alternative investments.

Management Depth and Key Person Risk

A majority of alternative investment boutiques rely heavily upon the experience and ability of a handful of professionals to access, interpret, and act upon information. For the most part, this entails gaining an intimate understanding of a handful of companies or markets. By contrast, a large percentage of the CDO management universe is institutionalized.

Investment-grade CDOs require an extensive understanding of the fundamentals of 80 to 120 credits, and this often requires large and dedicated research teams. Decision-making is often more diffuse and less prone to key person risk.

Interest Rate Sensitivity

Unlike other income-generating alternative investments (e.g., REITs), whose returns are closely linked to market factors (e.g., credit spreads, market volatility, interest rates, liquidity), investment-grade CDO equity returns, by and large, are much less sensitive to such factors. Hence, while volatility breeds risk (and opportunity) for investors in these alternatives, CDO equity returns remain relatively immune.

Leverage

One of the key differences between CDOs and other leveraged alternatives (like hedge funds and mezzanine funds) is the nature of the leverage. While CDOs finance themselves through long-term financing, many other alternatives frequently roll over short-term borrowings.

Rollover risk leaves other alternative strategies open to the risk of financing costs increasing, or, even more important, financing being pulled altogether. Many hedge funds realized huge losses in the fall of 1998 during the Asian financial crisis for this very reason.

VII. SUMMARY AND CONCLUSIONS

Our review of the investment-grade collateralized debt obligation market highlights the features, criticisms, rewards, and risks associated with investing in the asset class. We have evaluated CDO equity returns using traditional metrics and Monte Carlo simulation methods.

Our analysis shows that IG CDO equity provides either comparable risk-adjusted returns or better risk-adjusted returns than returns of traditional and alternative asset classes. Moreover, the low correlations of returns on IG CDO collateral with traditional asset classes suggest that IG CDOs are a powerful portfolio management tool.

APPENDIX A

The ABCs of CDO Equity²²

A CDO is created when a trust is established to acquire a pool of high-yield corporate bonds, bank loans, or other debt obligations (see Exhibit A-1). To fund the acquisition of the debt obligations, the trust issues rated and unrated liabilities. Because the majority of the liabilities are highly rated, the CDO can raise most of its capital cheaply in the investment-grade market, and invest it more profitably in other markets including the high-yield market.

In a typical cash flow CDO, the rated liabilities are tranching into multiple classes. The most senior class receives a triple-A or double-A rating, and the most subordinated class above the CDO equity receives a double-B or single-B. The ratings on the classes are a function of subordination and how cash flow and defaults are allocated among classes.

Principal and interest cash flow are paid sequentially from the highest-rated class to the lowest, but if the cash flow is insufficient to meet senior costs or certain asset maintenance tests are not met, most or all cash flow is paid to the most senior class.

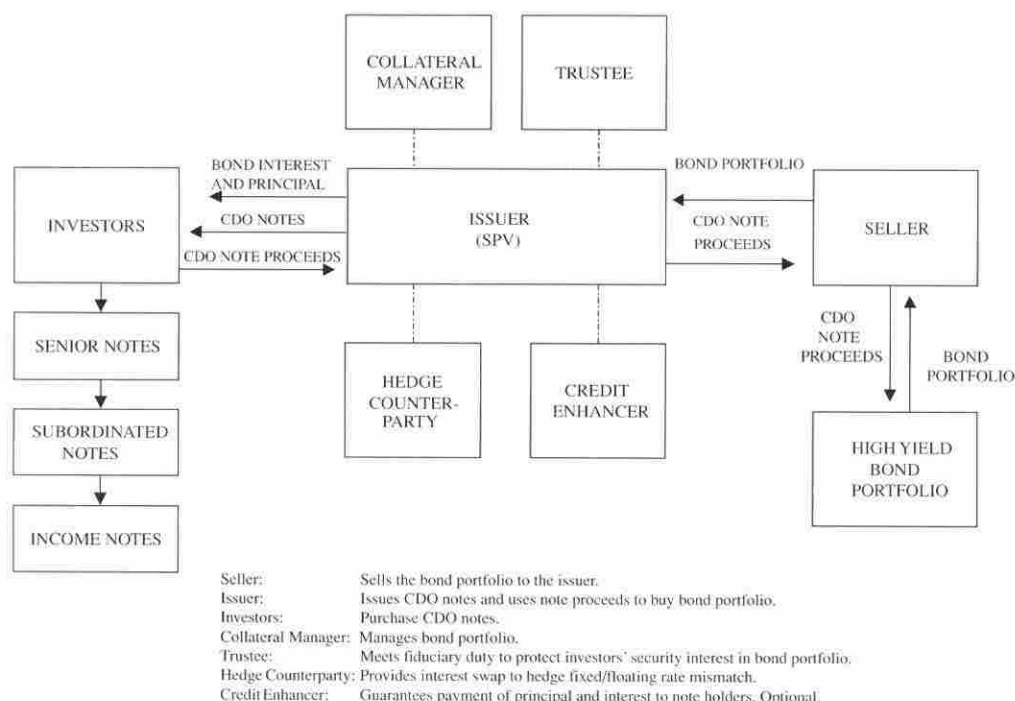
CDO equity is typically unrated and represents the most subordinated part of the CDO capital structure.²³ These notes will receive the residual interest cash flow remaining after payment of fees, rated note holder coupon, and the satisfaction of any asset maintenance tests.

Factors that will affect the residual interest cash flow include the level and timing of defaults, the level and timing of recoveries, and the movement of interest rates. Equity returns are generated by capturing the spread differential between the yield on the pool of fixed-income assets (the majority of which are high-yield bonds and bank loans) and the lower borrowing cost of the investment-grade and the non-investment-grade debt issued by the trust. This positive spread relationship can produce risk-adjusted returns to CDO equityholders in the range of 15% to 20%.

Once a cash flow CDO is issued, the collateral manager will manage the portfolio according to the investment guide-

EXHIBIT A-1

Typical CDO Structure



Source: Salomon Smith Barney.

lines set forth in the bond indenture and within parameters necessary to satisfy the rating agencies. Pursuant to these guidelines, the manager will sell and buy assets, and during the reinvestment period will reinvest collateral principal cash flows into new bonds. The investment guidelines typically require that the CDO manager maintain a minimum average rating and portfolio diversity so that any trading will have a minimal impact on the senior CDO bondholders.

The primary responsibility of the cash flow CDO collateral manager is to manage the portfolio in a way that minimizes losses to note holders resulting from defaults and discounted sales. To this end, all note holders rely on the manager's ability to identify and retain creditworthy investments.

A manager's trading decisions can have a substantial impact on the returns paid to CDO equityholders; the initial asset selection and its trading activity throughout the reinvestment period are critical to achieving high returns. A manager with a deep understanding of the underlying credit fundamentals of each of its investments can make informed, credit-based trading decisions, not trading decisions based on price movements.

Favorable Characteristics

Cash flow CDO equity has many favorable characteristics.

Healthy returns. The risk-adjusted internal rate of return (IRR) to CDO equityholders can range from 15% to 20%. This return rate compares favorably with that of other investment opportunities (see Exhibit A-2).

Lack of correlation with other asset classes. Although there is no established index for CDO equity returns, the performance of traditional cash flow CDO equity is directly linked to the behavior of a pool of U.S. high-yield bonds. U.S. high-yield bonds have not shown a strong correlation with other asset classes (see Exhibit A-3).

Top-tier fund managers. A CDO equity investment allows an investor to gain exposure to an experienced CDO manager and the healthy returns it can generate, with a smaller initial investment than might otherwise be required.

Access to esoteric assets. A CDO equity investment can be an efficient way for an investor to gain exposure to a variety of esoteric asset classes. Certain asset types, such as leveraged loans, mezzanine loans, and project finance loans, are asset classes to which relatively few investors have access.

EXHIBIT A - 2

Various Asset Classes — Historical Returns 1990–2000

Index	Ten-Year			Five-Year		
	Average Return (%)	Standard Deviation	Sharpe Ratio	Average Return (%)	Standard Deviation	Sharpe Ratio
Fixed-Income*						
SSB Brady Bond Index	17.52	15.98	0.78	17.52	17.88	0.69
SSB HY Market Index	10.94	6.39	0.92	9.71	5.25	0.86
Corporate Bond Index	8.27	4.58	0.70	8.15	4.66	0.63
Intermediate-Term Treasury Index	7.89	5.79	0.49	7.95	5.78	0.47
Mortgage Bond Index	7.84	3.17	0.88	7.93	2.87	0.95
SSB Broad Investment-Grade (BIG) Index	7.75	3.88	0.69	7.74	3.74	0.68
AAA-Rated Corporate Bond Index	7.65	3.70	0.70	7.46	3.68	0.61
Equities						
Nasdaq Composite	24.50	20.62	0.94	40.17	22.82	1.53
S&P 500	18.27	13.42	0.98	28.72	14.07	1.67
DJIA	16.17	14.26	0.78	24.56	15.65	1.24

*For more information, see "April 2000 Performance" [2000].

Source: Salomon Smith Barney.

EXHIBIT A - 3

Various Asset Classes — Correlations 1990–2000

	SSB HY Mkt Index	3-Month Tsy. Bill	Brady Bond Index	Corporate	Treasury 7-10 Year	BIG	AAA Rated Corporates	Mortgage Index	Nasdaq Composite	DJIA
3-Month Treasury Bill	-0.08									
SSB Brady Bond Index	0.47	0.11								
Corporate Bond Index	0.53	0.10	0.34							
Intermediate-Term Treasury Index	0.30	0.09	0.19	0.94						
SSB Broad Investment-Grade (BIG) Index	0.41	0.14	0.26	0.98	0.98					
AAA-Rated Corporate Bond Index	0.45	0.11	0.28	0.98	0.97	0.99				
Mortgage Bond Index	0.43	0.22	0.29	0.90	0.87	0.94	0.91			
Nasdaq Composite	0.51	-0.05	0.43	0.29	0.16	0.21	0.25	0.21		
DJIA	0.53	0.00	0.59	0.38	0.25	0.32	0.33	0.35	0.71	
S&P 500	0.54	0.00	0.56	0.47	0.35	0.40	0.42	0.42	0.82	0.92

Source: Salomon Smith Barney.

Cash flow-based returns. Returns on cash flow CDO equity are driven by the cash flow generated from the assets, not the market value or the price of those assets. This characteristic enables the investor to mitigate market risk and allows focus on the underlying credit fundamentals of the high-yield collateral.

An investment is especially attractive when there is a dislocation in the high-yield market due to technical, not credit, factors (e.g., in fourth-quarter 1998). This stands in stark contrast to high-yield mutual fund returns, which are sensitive to market value fluctuations.

Diversification. A relatively small investment in a cash flow CDO equity can confer substantial diversification benefits. An investor can gain exposure to 50 to 120 obligors across 15 to 25 industry sectors.

Structural protections. CDO equityholders benefit from a variety of structural features present in cash flow CDOs. Chief among them is an ability to remove the portfolio manager and a right to call the deal after the end of the non-call period.

Front-loaded cash flows. Unlike other alternative investments (e.g., private equity), an investment in cash flow CDO equity will typically generate cash flow within six months of the initial investment.

Transparency. CDO equity investments are more transparent than many alternative investments. Every month, the trustee reports, among other things, trading activity, obligor names and exposure amounts, industry concentrations, and compliance or non-compliance with liquidity and asset maintenance tests.

Imbedded interest rate hedges. Many CDOs are floating-rate obligations backed by pools of fixed-rate bonds. To hedge the mismatch between the fixed-rate assets and the LIBOR-indexed liabilities, most CDOs purchase a combination of interest rate swaps and/or caps. Although these hedges are bought for the benefit of the rated note holders, they also benefit the CDO equity as the residual interest beneficiary.

Taxation. Non-U.S. investors are not subject to U.S. withholding tax on dividends and gains from sale, exchange, or redemption of the investment. Tax-exempt entities are not subject to unrelated business income tax.

Risks

Although CDO equity has many favorable characteristics, prospective note holders should consider the risks associated with ownership.

Subordination of the CDO equity. CDO equity is the most subordinated class in the CDO capital structure. It receives interest cash flow only after fees and rated coupon interest are paid, and asset and cash flow coverage tests are satisfied. No principal of the CDO equity is paid until all other notes are retired, and, to the extent that any losses are suffered by note holders, such losses are borne first by the CDO equityholders.

Since CDO equity is subordinated, prospective investors should consider and assess for themselves, given a manager's track record, the likely level and timing of defaults, recoveries, and interest rate movements. The text describes examples that will help investors understand how these variables impact CDO equity returns.

Limited liquidity and restrictions on transfer. Potential CDO equity buyers should not rely on a secondary market for CDO equity. The investment trades on a best efforts basis, and

in a typical transaction, the CDO equity will be owned by a relatively small number of investors. Also, before selling CDO equity in the secondary market, the seller must comply with various regulations that restrict the transferability of certain types of securities.

Mandatory principal repayment of senior notes. If the aggregate asset balance is insufficient to meet the minimum overcollateralization test, or the aggregate asset yield is insufficient to meet the minimum interest coverage test, cash flow that would have been distributed to the CDO equity will be diverted to amortize the most senior notes. If this occurs, the capital structure will de-lever until the test is brought back into compliance. A de-levering structure will have a negative impact on CDO equity returns.

Reinvestment risk. During the reinvestment period, the collateral manager will reinvest principal collections in additional bonds and loans. Depending on market conditions and the CDO's investment guidelines, the manager may purchase loans and bonds with a lower yield than the initial collateral (i.e., spread compression), resulting in less cash flow for all note holders.

APPENDIX B

Sector Analysis of Investment-Grade and High-Yield Corporate Bonds

Exhibit B provides a breakdown by sector (for both investment-grade and high-yield) of number of bonds, market values, and percentages. The values are computed on bonds in the Salomon Smith Barney proprietary corporate bond database that had face values greater than \$100 million on March 31, 2001. This exhibit demonstrates the greater obligor diversity and liquidity in the investment-grade market over the high-yield sector.

First, there are nearly four times as many investment-grade bonds with face value of at least \$100 million as there are high-yield bonds. Further, the investment-grade bonds have more than 6.5 times the market value of the high-yield sector bonds. This translates to an average issue size in the investment-grade market of \$336 million compared to \$202 million for high-yield bonds.

EXHIBIT B

Number of Firms, Market Values, and Percentages by Sector for Investment-Grade and High-Yield Bonds

Sector	Investment-Grade				High-Yield			
	Number of Bonds	Pct	Market Value (\$MM)	Pct	Number of Bonds	Pct	Market Value (\$MM)	Pct
Banking	628	12.5	216,614	12.8	16	1.3	3,798	1.5
Electric Utilities	465	9.3	96,713	5.7	50	3.9	16,474	6.4
Diversified Telecom	298	5.9	130,310	7.7	7	0.5	917	0.4
Independent Finance	226	4.5	90,853	5.4	28	2.2	3,956	1.5
Securities	199	4.0	79,442	4.7	2	0.2	392	0.2
Retail Stores — Other	163	3.3	43,855	2.6	41	3.2	5,026	1.9
Gas Pipelines	156	3.1	35,582	2.1	0	0.0	0	0.0
Real Estate Inv. Trust	153	3.1	26,515	1.6	19	1.5	2,474	1.0
Cable	135	2.7	55,742	3.3	58	4.5	17,494	6.8
Chemicals	126	2.5	29,759	1.8	41	3.2	8,668	3.4
Paper/Forest Products	125	2.5	25,939	1.5	33	2.6	7,320	2.8
Automotive Manufacturing	124	2.5	109,052	6.5	3	0.2	420	0.2
Integrated Oil	105	2.1	38,986	2.3	0	0.0	0	0.0
Property & Casualty Ins.	98	2.0	22,635	1.3	5	0.4	1,028	0.4
Railroads	97	1.9	28,833	1.7	2	0.2	346	0.1
Secondary Oil & Gas Prod.	95	1.9	20,201	1.2	53	4.2	8,743	3.4
Regional Government	94	1.9	47,457	2.8	0	0.0	0	0.0
Airlines	83	1.7	21,876	1.3	13	1.0	2,077	0.8
Credit Cards	78	1.6	47,485	2.8	0	0.0	0	0.0
Food Processors	77	1.5	19,629	1.2	18	1.4	2,096	0.8
Life Insurance	72	1.4	16,497	1.0	9	0.7	2,719	1.1
Aerospace	71	1.4	27,739	1.6	17	1.3	2,832	1.1
Beverage/Bottling	69	1.4	18,698	1.1	7	0.5	1,012	0.4
Conglomerate/Divers. Mfg.	66	1.3	20,871	1.2	11	0.9	1,539	0.6
Metals/Mining	64	1.3	14,295	0.8	46	3.6	6,386	2.5
Foreign Sovereign	63	1.3	65,800	3.9	0	0.0	0	0.0
Electronics	62	1.2	22,623	1.3	15	1.2	2,863	1.1
Supranational	61	1.2	48,600	2.9	0	0.0	0	0.0
Service — Other	60	1.2	13,756	0.8	74	5.8	10,862	4.2
Consumer Products	59	1.2	19,845	1.2	40	3.1	5,095	2.0
Information/ Data Tech.	58	1.2	18,010	1.1	19	1.5	3,078	1.2

EXHIBIT B — continued

Sector	Investment-Grade				High-Yield			
	Number of Bonds	Pct	Market Value (\$MM)	Pct	Number of Bonds	Pct	Market Value (\$MM)	Pct
Vehicle Parts	48	1.0	12,158	0.7	40	3.1	6,197	2.4
Machinery	47	0.9	10,916	0.6	17	1.3	1,669	0.6
Retail Stores — Food/Drugs	47	0.9	15,964	0.9	13	1.0	2,322	0.9
Finance — Other	45	0.9	10,639	0.6	7	0.5	1,015	0.4
Health Care Supply	45	0.9	8,246	0.5	32	2.5	5,003	1.9
Publishing	39	0.8	7,520	0.4	19	1.5	3,955	1.5
Pharmaceuticals	35	0.7	11,513	0.7	4	0.3	800	0.3
Gas Utilities — Local Distrib.	33	0.7	7,528	0.4	1	0.1	120	0.0
Stranded Assets	33	0.7	13,949	0.8	0	0.0	0	0.0
Tobacco	29	0.6	10,660	0.6	3	0.2	306	0.1
Utilities — Other	29	0.6	9,081	0.5	2	0.2	447	0.2
Oil Refining & Marketing	28	0.6	6,440	0.4	12	0.9	1,601	0.6
Leasing	27	0.5	4,621	0.3	12	0.9	1,573	0.6
Building Products	26	0.5	6,550	0.4	25	2.0	3,698	1.4
Oil Service	23	0.5	5,132	0.3	3	0.2	540	0.2
Agency	22	0.4	12,676	0.8	0	0.0	0	0.0
Leisure	22	0.4	3,819	0.2	21	1.6	3,683	1.4
Wireless	22	0.4	11,644	0.7	25	2.0	10,459	4.1
Oil Equipment	20	0.4	5,025	0.3	17	1.3	4,760	1.8
Industrials — Other	18	0.4	3,336	0.2	35	2.7	3,749	1.5
Transportation — Other	18	0.4	3,705	0.2	13	1.0	1,502	0.6
Broadcast/Outdoor	17	0.3	5,977	0.4	30	2.3	6,138	2.4
Environmental Services	17	0.3	5,591	0.3	9	0.7	4,591	1.8
Lodging	17	0.3	5,590	0.3	14	1.1	4,316	1.7
Restaurants	16	0.3	2,440	0.1	19	1.5	2,704	1.0
Textiles/Apparel/Shoes	15	0.3	2,435	0.1	21	1.6	3,516	1.4
Mortgage Banking	14	0.3	3,605	0.2	1	0.1	66	0.0
Gaming	11	0.2	3,564	0.2	47	3.7	13,611	5.3
Health Care Facilities	5	0.1	1,080	0.1	35	2.7	10,577	4.1
Home Builders	5	0.1	669	0.0	39	3.1	5,550	2.2
Containers	4	0.1	960	0.1	34	2.7	5,899	2.3
Satellite	4	0.1	703	0.0	11	0.9	4,571	1.8
Retail Propane Distributors	2	0.0	214	0.0	4	0.3	613	0.2
Broad Band	1	0.0	153	0.0	24	1.9	10,214	4.0
Cars	1	0.0	606	0.0	0	0.0	0	0.0
CLEC	0	0.0	0	0.0	37	2.9	10,152	3.9
ISP/Data	0	0.0	0	0.0	14	1.1	3,344	1.3
Paging	0	0.0	0	0.0	8	0.6	517	0.2
Water	0	0.0	0	0.0	2	0.2	450	0.2
Total	5,015	100.0	1,688,922	100.0	1,277	100.0	257,843	100.0

Source: Salomon Smith Barney.

APPENDIX C

Default Path Simulations

The paths of annual default rates for tight, point, and wide distributions of obligor credit in Exhibits C-1 through C-6 were used for pricing the IG CDOs.

EXHIBIT C-1

Annual Default Rates for Tight Credit Distribution, Paths 1 through 12

Year	1	2	3	4	5	6	7	8	9	10	11	12
1	0.19%	0.00%	0.01%	0.30%	0.00%	0.30%	0.69%	0.08%	0.00%	0.00%	0.08%	0.06%
2	0.67	0.35	0.83	0.00	0.00	0.15	0.08	0.44	0.00	0.47	0.08	0.00
3	0.15	0.01	0.35	0.44	0.35	0.08	0.01	0.00	0.08	0.05	0.02	0.27
4	0.15	0.07	0.00	0.27	0.69	0.35	0.47	0.30	2.64	0.40	0.19	0.15
5	0.08	0.11	0.05	0.00	0.00	0.47	0.00	0.19	0.47	0.83	0.08	0.15
6	0.30	0.35	0.15	0.83	0.00	0.94	0.08	0.69	0.15	0.00	0.27	0.05
7	0.06	0.00	0.35	0.00	0.30	0.00	0.00	0.69	0.02	0.27	0.15	0.67
8	0.15	0.02	0.00	0.47	0.08	0.15	2.64	0.02	0.67	0.08	0.94	0.47
9	0.08	0.19	0.44	0.08	0.47	0.05	0.67	0.83	2.64	0.27	0.69	0.00
10	0.94	0.02	0.07	0.05	0.40	0.94	0.15	0.83	0.35	0.94	0.15	0.83
11	0.15	0.02	0.15	0.15	0.02	0.01	0.01	0.67	0.08	0.27	0.19	0.94
12	0.83	0.08	0.00	0.00	0.30	0.08	0.16	2.64	0.00	0.00	0.67	0.00
13	0.08	0.30	0.08	0.07	0.07	0.15	0.02	0.07	0.19	0.67	2.64	0.44
14	0.00	0.83	0.00	0.05	0.16	0.00	0.01	0.67	0.06	0.08	0.01	0.40
15	0.16	0.94	0.16	0.08	0.08	0.19	0.11	0.00	0.00	0.94	0.15	2.64
Avg.	0.27%	0.22%	0.18%	0.19%	0.19%	0.26%	0.34%	0.54%	0.49%	0.35%	0.42%	0.47%
Std. Dev.	0.29	0.30	0.23	0.24	0.21	0.31	0.68	0.66	0.89	0.34	0.67	0.67

Source: Salomon Smith Barney.

EXHIBIT C-2

Annual Default Rates for Tight Credit Distribution, Paths 13 through 24

Year	13	14	15	16	17	18	19	20	21	22	23	24
1	0.06%	0.69%	0.67%	0.69%	0.05%	0.67%	0.16%	0.08%	0.01%	0.30%	0.69%	0.69%
2	0.08	0.02	0.69	0.01	0.08	0.06	0.27	0.15	0.00	0.27	0.27	0.00
3	0.40	0.00	0.15	0.15	0.00	0.15	0.02	0.08	0.00	0.06	0.05	0.08
4	0.00	0.27	0.19	0.35	0.83	0.08	0.00	0.15	0.00	0.02	0.15	0.67
5	0.94	0.15	0.35	0.35	0.02	0.11	0.44	0.15	0.05	0.00	0.27	0.69
6	0.83	0.15	0.00	0.40	0.06	0.69	0.35	0.00	0.44	0.44	0.08	0.00
7	0.00	2.64	0.00	0.15	0.00	2.64	0.00	0.19	0.08	0.94	0.16	0.02
8	0.00	0.02	0.00	0.16	0.06	0.44	0.69	0.07	0.11	0.35	0.11	0.35
9	0.08	0.01	0.67	0.35	0.27	0.08	0.02	0.40	2.64	0.08	0.44	0.00
10	0.30	0.01	0.40	0.00	0.02	0.00	0.19	0.83	0.08	2.64	0.67	0.01
11	0.30	0.47	0.08	0.06	0.67	0.40	0.67	0.67	0.40	0.02	0.00	0.67
12	0.08	0.05	0.11	0.07	0.00	0.08	0.35	0.08	0.15	0.44	0.27	0.19
13	0.00	2.64	0.00	0.35	0.02	0.05	2.64	0.00	0.08	0.02	0.47	0.69
14	0.19	0.15	0.05	0.00	0.40	0.00	2.64	0.07	0.00	0.08	0.02	0.27
15	0.08	0.30	2.64	0.00	0.08	0.06	0.40	0.19	0.94	2.64	0.40	0.00
Avg.	0.22%	0.50%	0.40%	0.21%	0.17%	0.37%	0.59%	0.21%	0.33%	0.55%	0.27%	0.29%
Std. Dev.	0.30	0.89	0.67	0.20	0.26	0.67	0.86	0.24	0.69	0.88	0.22	0.31

Source: Salomon Smith Barney.

EXHIBIT C - 3

Annual Default Rates for Point Credit Distribution, Paths 1 through 12

Year	1	2	3	4	5	6	7	8	9	10	11	12
1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.31%	0.34%	0.00%	0.31%	0.00%
2	0.27	0.00	0.00	0.34	0.98	0.00	0.45	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.45	0.00	0.00	1.06	0.98	0.00	0.00	0.00
4	1.06	0.27	1.06	0.00	0.00	0.28	0.98	0.00	0.00	0.00	0.00	0.00
5	0.31	1.06	0.45	0.27	0.45	0.98	0.00	0.00	0.00	0.00	0.45	0.00
6	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00
7	4.82	4.82	0.31	0.34	0.00	0.98	0.00	0.00	0.00	0.00	0.00	1.06
8	1.06	0.00	0.34	0.31	0.00	0.31	0.00	0.31	1.06	0.00	0.00	0.00
9	4.82	0.00	1.06	1.06	0.00	0.00	0.00	0.28	0.98	0.00	0.00	0.98
10	0.00	0.31	0.00	0.00	0.00	0.00	0.27	0.27	0.31	0.00	0.00	0.00
11	0.00	0.28	0.34	1.06	0.00	0.31	0.98	0.00	0.00	0.00	0.28	0.00
12	0.00	0.00	1.06	0.00	1.06	0.00	0.00	0.00	0.34	0.00	0.00	4.82
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.06	0.00
14	0.28	4.82	4.82	0.00	1.06	1.06	0.00	0.00	0.00	0.00	0.00	0.27
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.31	0.00	4.82	0.00
Avg.	0.84%	0.79%	0.63%	0.23%	0.27%	0.26%	0.18%	0.20%	0.29%	0.00%	0.46%	0.48%
Std. Dev.	1.65	1.66	1.23	0.37	0.43	0.40	0.35	0.29	0.40	0.00	1.24	1.25

Source: Salomon Smith Barney.

EXHIBIT C - 4

Annual Default Rates for Point Credit Distribution, Paths 13 through 24

Year	13	14	15	16	17	18	19	20	21	22	23	24
1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.06%	0.00%	0.31%	0.00%	0.00%	0.00%
2	0.28	4.82	0.98	0.00	0.00	0.00	4.82	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.45	0.00	0.00	0.31	0.00	0.00	0.00	0.31	0.00
5	0.45	0.00	0.00	0.00	0.27	0.00	0.98	0.00	4.82	0.00	0.00	0.00
6	1.06	0.00	1.06	0.00	0.00	0.31	0.00	0.00	0.00	4.82	0.00	0.34
7	0.00	0.00	0.00	0.00	1.06	0.00	0.00	0.00	0.00	0.00	0.45	0.00
8	0.00	0.00	0.27	0.00	0.45	0.28	0.00	0.00	0.00	0.00	0.00	0.45
9	0.00	0.00	0.00	0.00	1.06	0.00	0.00	0.00	0.00	0.00	0.00	0.45
10	0.00	1.06	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00
11	0.00	0.00	0.28	0.00	0.00	0.00	0.27	0.00	0.27	0.28	0.00	0.00
12	0.00	1.06	0.00	0.00	0.00	1.06	0.00	0.00	0.00	0.31	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.31	0.00	1.06	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00
15	0.98	0.00	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00	0.27	4.82
Avg.	0.18%	0.48%	0.17%	0.10%	0.19%	0.20%	0.50%	0.02%	0.38%	0.36%	0.07%	0.40%
Std. Dev.	0.36	1.26	0.36	0.29	0.38	0.36	1.25	0.07	1.23	1.24	0.15	1.23

Source: Salomon Smith Barney.

ENDNOTES

The authors thank Dennis Adler and Timothy Beaulac for their guidance, support, and analytical contributions. They also thank James Beck, Florian Bitz, Jungmin Lee, Raphi Lesser, Kathy Liu, Adrian Lui, Shalabh Mehrish, Joshua Nahas, Aaron Palmer, Donald Quintin, Ratul Roy, Joshua Siegel, and Seth Vance for their analytical and technical contributions to this work. Thanks also to Cecilia Brion-Sarmas, Charles Earle, Norma Lana, and Peg Pisani for editorial assistance.

Copyright 2002, Salomon Smith Barney Inc. This article was written by Glen M. McDermott with Terry L. Benzschawel and Sohail Khan, employees of Salomon. Although the information in this article was obtained from sources that Salomon believes to be reliable, Salomon does not guarantee its accuracy, and such information may be incomplete or condensed. All exhibits included in this report constitute our judgement as of the original publication date.

¹The optimal solution would be to correlate these asset classes with the historical performance of investment-grade CDO equity,

EXHIBIT C-5

Annual Default Rates for Wide Credit Distribution, Paths 1 through 12

Year	1	2	3	4	5	6	7	8	9	10	11	12
1	0.04%	1.35%	0.19%	0.13%	0.00%	0.18%	0.00%	0.28%	0.04%	0.19%	0.04%	0.18%
2	0.04	0.04	0.90	0.18	1.35	0.13	1.02	0.13	0.29	0.13	0.00	0.00
3	1.00	0.00	0.29	0.15	0.19	0.31	0.18	0.85	0.45	0.00	0.00	0.29
4	0.18	0.85	0.00	0.13	0.19	0.00	0.45	0.32	0.04	0.00	0.04	0.00
5	0.00	0.85	0.04	0.04	0.19	0.85	1.20	0.20	0.31	0.48	0.31	0.29
6	0.29	0.30	0.04	1.02	0.19	0.00	0.48	0.13	0.13	0.32	0.45	0.20
7	0.00	0.00	0.32	0.29	1.35	0.19	0.29	1.20	0.18	0.32	0.28	0.89
8	0.32	0.18	0.20	0.85	0.00	0.00	0.20	0.00	0.04	0.00	0.04	0.89
9	0.13	0.90	0.41	0.45	0.04	0.20	0.06	0.48	1.35	0.13	0.18	0.48
10	0.04	0.48	1.35	0.28	0.30	0.20	0.90	0.19	0.41	0.19	0.41	0.13
11	0.20	0.30	0.90	1.20	0.00	0.19	0.89	0.32	1.02	0.29	0.90	0.30
12	1.20	0.19	0.04	0.28	0.06	1.20	0.32	0.48	0.19	0.00	0.89	1.02
13	0.04	0.29	0.31	0.06	0.18	0.30	0.41	1.20	0.90	0.18	0.45	0.18
14	0.13	0.00	0.45	0.20	0.18	0.13	0.18	0.29	0.00	0.06	0.04	0.90
15	1.20	0.18	0.48	0.31	0.06	0.85	1.35	0.15	0.18	0.19	0.41	0.20
Avg.	0.32%	0.39%	0.39%	0.37%	0.29%	0.31%	0.53%	0.42%	0.37%	0.17%	0.29%	0.40%
Std. Dev.	0.43	0.41	0.39	0.36	0.44	0.36	0.43	0.38	0.41	0.14	0.30	0.35

Source: Salomon Smith Barney.

EXHIBIT C-6

Annual Default Rates for Wide Credit Distribution, Paths 13 through 24

Year	13	14	15	16	17	18	19	20	21	22	23	24
1	1.35%	0.13%	0.29%	0.19%	0.00%	0.18%	0.45%	0.41%	0.00%	0.00%	0.31%	1.02%
2	0.00	0.18	0.18	0.00	0.00	0.06	0.19	0.31	0.90	1.35	0.15	0.00
3	0.19	0.89	0.18	1.20	0.28	0.30	0.20	1.35	0.04	0.18	1.20	1.02
4	0.00	0.00	0.31	0.18	0.18	0.48	0.89	0.13	0.15	1.35	0.29	0.19
5	0.32	0.18	0.04	1.35	1.00	0.89	0.04	0.41	0.41	0.04	0.90	0.18
6	0.19	0.00	1.02	0.13	0.00	1.20	0.18	0.31	0.28	0.29	1.02	0.00
7	0.06	0.45	0.00	0.06	1.35	0.90	0.00	0.00	0.28	0.30	0.48	0.41
8	0.04	0.04	0.15	0.00	0.48	0.04	0.19	1.20	0.32	0.15	0.41	0.28
9	0.15	0.41	1.20	1.35	0.89	0.19	0.00	0.20	0.13	0.04	0.00	0.28
10	1.35	0.32	1.35	0.89	0.13	0.13	0.85	0.06	0.19	0.45	0.19	0.06
11	0.89	0.45	0.15	0.28	1.00	0.00	0.41	0.00	0.18	0.89	0.00	0.06
12	0.48	0.18	1.00	0.18	0.18	0.19	0.45	0.41	0.00	0.06	0.06	0.00
13	0.29	0.41	0.19	0.13	0.13	0.90	0.13	0.04	0.00	1.35	0.04	0.19
14	0.06	0.04	0.41	0.89	1.02	0.48	0.13	0.90	0.19	1.00	1.00	0.41
15	0.00	0.48	0.19	0.30	1.02	0.00	0.30	1.00	1.35	0.04	1.35	0.29
Avg.	0.36%	0.28%	0.44%	0.47%	0.51%	0.40%	0.29%	0.45%	0.29%	0.50%	0.49%	0.29%
Std. Dev.	0.47	0.24	0.45	0.51	0.48	0.40	0.28	0.45	0.37	0.53	0.47	0.33

Source: Salomon Smith Barney.

but the lack of historical data concerning investment-grade CDO equity prevents us from doing so. The Corporate Index is a rough proxy at best for the performance of IG CDO equity. In general, the performance of CDO equity is more closely correlated with default behavior and loss of par than it is with total return data.

²The Baa3 blend actually reduces the standard deviation of default, because the standard deviation of Ba default rates as a percentage of the mean Ba default rate is lower than that of investment-grade categories.

³See "Default and Recovery Rates" [2001, p. 22].

⁴In fact, during the early 1990s' recession, the Baa3 default rate was 0% in 1990 and in 1991, while the B2 default rate skyrocketed to 22.09% and 12.74%, respectively.

⁵Ramp-up will take longer with investment-grade CDOs representing European collateral.

⁶This target scenario usually assumes a recovery rate of 50%.

⁷See "Altman High Yield Bond and Default Study" [2001].

which reports an average recovery rate of 25.67% for the first half of 2001, well below the 23-year average of 43.8%.

⁸The average rating of an investment-grade CDO portfolio is Baa3, and the average rating of a high-yield portfolio is B2.

⁹See "Default and Recovery Rates" [2001, Exhibits 39 and 40]. Because Moody's does not report ratings data by modifier before 1983 (e.g., Baa1, Baa2, or Baa3), Baa2 one-year default rates are used for the 13 years from 1970 through 1982. From 1983 through 2000, the average one-year default rate for Baa3 credits is 0.46%.

¹⁰We feel that 24 paths gives us a good mix of front-, middle-, and back-loaded default paths. In fact, even the subset of eight default paths in Exhibit 16 is fairly diverse.

¹¹The point distribution assumes all assets are rated triple-B minus. The tight distribution assumes a tight distribution of credits around the triple-B minus mean, and the wide distribution assumes the maximum allowable in the double-B category (i.e., 30%). In the distributions other than point, we take the annual default rate for each portion of the credit spectrum and weight that default rate by the percentage of assets in that rating category. For example, let's assume a portfolio that comprises 70% Baa-rated credits and 30% Ba-rated credits. According to "Default and Recovery Rates" [2001], the one-year rate for these categories in 2000 was 0.38% (Baa) and 1.05% (Ba). This would result in an assumed weighted-average one-year default rate of 0.58% for 2000. The same weightings would be applied to one-year default rates going back to 1970. The random sampling would then be performed on these 30 data points (1970–2000).

¹²The nine deals represent all investment-grade average CDOs originated by SSB at the time of the study. The deals are: Coliseum Funding, Conseco Funding, FMA IG Funding IV, Hampden CBO, Knight Funding, Knight II Funding, Lone Star CBO Funding, Madison Avenue CDO II, and Travelers Funding.

¹³The Sharpe ratio is calculated as the incremental return on an investment over that of a risk-free asset for a given regular sampling divided by the standard deviation of the returns over the sample period. It is customary to express the Sharpe ratio as an annualized number. For example, Sharpe states that typical estimates of annual excess return on the stock market of a developed country would be about 0.4 (Sharpe [1994]). For this particular case, the risk/reward ratio is called the *ex ante* Sharpe ratio to indicate that it is an expected value.

¹⁴All these deals were structured to an average ratings factor below 610 to build in some buffer portfolio credit deterioration.

¹⁵We assume each bond is of equal size.

¹⁶To calculate the number of bonds that default over a given six-month payout period in the simulations, we first generate a series of numbers at random from a uniform distribution between 0 and 1. For the first six-month time step, we apply a random number to each bond and compare its value with the default rate over that interval. If the bond's value is less than or equal to the default rate, the bond is assumed to have defaulted and is eliminated from the sample. The process is repeated for the next time step on all surviving bonds and so forth, until maturity at 15 years. The cumulative 15-year default rate is calculated as the number of defaulted bonds divided by the total number of bonds in the collateral pool.

¹⁷We choose 15 years because this is the approximate length of our longest simulated CDO equity cash flows. We use Moody's triple-B minus cumulative default rates (1970–2000) to arrive at the solid horizontal line, by computing the 30-year cumulative default rate and dividing that number by two.

¹⁸The Moody's average weighted credit quality is calculated for a given portfolio as the sum over all rating categories of the products of each rating category's weight times the percentage of the portfolio in that rating category. The value of 610 corresponds to a portfolio with an average rating of BBB–.

¹⁹The wide and tight portfolios have a lower MACQ than the point distribution and are therefore higher-quality portfolios. This is typical of an investment-grade CDO collateral structure, which generally builds in a credit buffer over the required level to allow for manager flexibility in managing the collateral pool in changing market conditions.

²⁰For the wide distribution, 30% of the collateral is rated below investment-grade, typically the maximum amount permissible for IG CDOs. The point and wide distributions represent extremes, while the tight distribution is similar to the average investment-grade CDO. It is for this reason that we use it in our pricing simulations reported in Exhibit 17.

²¹Recall that for the nine deals shown in Exhibit 17 we assume the same composition of credits as appears for the tight distribution in Exhibit 21.

²²This is a slightly modified excerpt from McDermott [2000]. The return and correlation exhibits do not match those in the body of the article, because they were computed at a different time.

²³Duff & Phelps Credit Rating Co. has now developed criteria for rating CDO equity. See "DCR's Criteria" [2000].

REFERENCES

- "Altman High Yield Bond and Default Study." Salomon Smith Barney, July 19, 2001.
- "April 2000 Performance—Total Rate-of-Return Indexes." Salomon Smith Barney, May 2, 2000.
- Benzschawel, Terry, and Dennis Adler. "Cost of Ratings Changes in the Corporate Bond Market." *Bond Market Roundup: Strategy*, June 29, 2001, pp. 42–47.
- "Default and Recovery Rates of Corporate Bond Issuers: 2000." Moody's Investors Service, February 2001.
- "DCR's Criteria For Rating 'Equity' of Cash Flow CDOs." Duff & Phelps, January 2000.
- McDermott, Glen. "The ABCs of CDO Equity." Salomon Smith Barney, July 2000.
- Sharpe, William F. "The Sharpe Ratio." *The Journal of Portfolio Management*, Fall 1994, pp. 49–58.

To order reprints of this article please contact Ajani Malik at amalik@iijournals.com or 212-224-3205.

©Euromoney Institutional Investor PLC. This material must be used for the customer's internal business use only and a maximum of ten (10) hard copy print-outs may be made. No further copying or transmission of this material is allowed without the express permission of Euromoney Institutional Investor PLC. Copyright of Journal of Portfolio Management is the property of Euromoney Publications PLC and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.