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Structured Credit

CDO Rating Methodologies Review

We compare various CDO rating models and examine the impact of different methodologies on default and loss distributions and credit enhancement levels.

Highlights of This Issue

Differences Among Rating Agency Models

Moody's uses a portfolio ("top down") approach to rate CDOs. A binomial expansion technology (BET) is used to approximate the default distribution.

Fitch's default VECTOR model employs an asset-level ("bottom-up") approach and computes the default distribution by a multi-period simulation of the actual portfolio.

S & P's CDO Evaluator is also an asset-based model, but with one-period simulation.

Calculation of Expected Loss

The expected portfolio loss is the risk measure from which the credit protection (subordination) is derived for a desired tranche rating. The three main factors driving the loss distribution are 1) default probability, 2) recovery rate, and 3) default correlation.

The cumulative default probability matrix is the reference point for the portfolio default rate in a CDO rating process. The cumulative loss probability matrix serves as the "target" loss rate for determining the tranches' subordination level.

Default Distribution and Credit Enhancement

The asset-based VECTOR model accounts for a wider dispersion of possible defaults and produces a fatter right tail in its default distribution than the portfolio-based BET model, resulting in higher rating default rate levels.

A hypothetical portfolio of leveraged loans is analyzed using three rating models. Both Moody's and Fitch's models result in similar credit enhancement levels. S&P's model shows lower SDR levels than Fitch's RDR levels.

Recovery Assumption

The recovery rate assumptions vary by collateral asset types, and have a significant impact on the ultimate credit enhancement levels. Investors should carefully examine the recovery assumptions in CDO rating models when determining which model will provide a more conservative credit enhancement level.

Default Correlation

Across methodologies, increases in default correlation among portfolio assets will cause increases in subordination levels. The impact is greater on tranches with higher ratings. Different models use different correlation assumptions, which in turn, generate different risk profiles.

Rating Distribution

The average rating factor is a limited indicator of the credit quality of a pool. The distribution of ratings should also be analyzed carefully.

Refer to important disclosures on page 29.
Analyst Certification on page 28.

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1. Summary

- The objective of this report is to provide CDO investors with an in-depth view of the rating methodologies and to display the differences in various assumptions and inputs driving the portfolio expected loss calculation.
- Moody's uses a portfolio ("top down") approach to rate CDOs. A binomial expansion technology (BET) is used to approximate the default distribution. Fitch's default VECTOR model employs an asset-level ("bottom-up") approach and computes the default distribution by a multi-period simulation of the actual portfolio. S & P's CDO Evaluator is also an asset-based model, but with one-period simulation. Table 1 provides the summary of rating agencies' methodology.
- We tested a hypothetical portfolio of leveraged loans against all three models and examine the relative differences in credit enhancement levels by tranche rating.
- Our results demonstrate that the asset-based VECTOR model accounts for a wider dispersion of possible defaults and produces a fatter right tail in its default distribution than the portfolio-based BET model, resulting in higher rating default rate (RDR) levels. However, a more conservative recovery assumption used in the BET model has compensated for the low RDR values, and thus brings the credit enhancement values to the level similar to the VECTOR model (Table 2).
- A wide range of recovery rates have been applied in the CDO models depending upon collateral asset type, domicile, tranche rating and priority of payment. The recovery rate has a significant impact on the ultimate credit enhancement levels, especially to lower tranches. Investors should carefully examine the recovery assumptions in CDO rating models and stress recovery rates accordingly.
- An increase in default correlation will cause increases in credit enhancement levels. The impact is greater on tranches with higher ratings. Although both S&P and Fitch employ a asset-level simulation approach, the difference in correlation assumptions results in difference in SDR and RDR levels.
- The average rating factor is a limited indicator of the credit quality of a pool. The distribution of ratings should also be taken into account.
- Due to the complexity of various rating methodologies, it is difficult to make generalizations regarding which rating approach will result in the most conservative credit enhancement levels for a rated portfolio. A rating outcome varies depending on the modeling approaches, inputs, stress factors, as well as qualitative aspects of the rating, such as manager's experience and legal features of the proposed portfolio.

Table 1: Summary on Rating Agencies' Methodology

Rating Agency	Moody's	Fitch Ratings	S & P
Model	BET Model	VECTOR Model	Evaluator Model
Rating Approach	Portfolio-level	Asset-level	Asset-level
Default Distribution Approximation	Binomial expansion formula	Monte Carlo simulation	Monte Carlo simulation
Simulation Period	N/A	Multi-step	Single-step
Inputs			
Correlation	Single diversity score	Correlation matrix	Correlation matrix
Cumulative Default Probability (p)	One p for the portfolio	One probability curve for each asset	One p for each asset
Stress Factors for p	Stressed at portfolio level	Stressed for selected assets (optional)	Stressed at portfolio level ¹
Recovery Rate for Asset Cashflow	Range from 1.0 to 1.5		Range from 0.6 to 1.2
Default Timing	30%-67% ²	24%-70% ³	15%-60% ⁴
	Pre-determined	Driven by simulation	Driven by simulation
Results			
Default Distribution	Thinner right tail than VECTOR and Evaluator	Fatter right tail than BET and Evaluator	Right tail falls below VECTOR model
Rating Default Rate	Lower than VECTOR model	Higher than BET and Evaluator	Lower than VECTOR model
Rating Loss Rate	Similar to VECTOR model	Similar to BET model	N/A

Source: Merrill Lynch

Table 2: Rating Default Rate (RDR) and Rating Loss Rate (RLR) of a Hypothetical Leveraged Loan Portfolio, Results from Moody's and Fitch's Models

Rating	Rating Default Rate (RDR)		Rating Loss Rate (RLR)	
	Moody's BET Model ⁵	Fitch's VECTOR Model	Moody's BET Model ⁶	Fitch's VECTOR Model ⁷
AAA	50.7%	53.1%	22.8%	22.6%
AA	43.3%	46.3%	19.4%	18.8%
A	37.6%	42.1%	15.4%	15.6%
BBB	33.0%	36.6%	12.0%	12.3%
BB	27.1%	29.5%	8.9%	9.4%
B	21.1%	24.2%	7.1%	7.3%

Source: Merrill Lynch, Moody's, Fitch Ratings

¹ Stress factor is applied to portfolio scenario default rate (SDR).

² The actual recovery rate depends on collateral asset type, domicile, tranche rating and priority of payment (see Table 5).

³ The actual recovery rate depends on collateral asset type, domicile, tranche rating and priority of payment (see Table 6).

⁴ The actual recovery rate depends on collateral asset type and priority of payment (see Table 7).

⁵ RDR is not a direct output from the BET model. We did the calculation for the purpose of comparing the BET model to the Fitch's VECTOR model.

⁶ Moody's Recovery rates are listed in Table 5.

⁷ Fitch's Recovery rates are listed in Table 6.

2. Overview

One of the major risks a CDO investor assumes is the modeling risk inherent in the rating agency algorithms used to size CDO credit enhancement levels. It is well-known that there are fundamental differences in rating approaches employed by rating agencies. Most models incorporate historical experiences in default rates, recovery rates and asset correlation with either a statistical or a simulation approach to build default distributions. Assumptions and inputs associated with each model vary. This research report gives an overview of each agency's methodology and summarizes the major assumptions driving the ultimate credit enhancement levels of a CDO structure.

■ CDO Assets

A wide range of asset classes have been securitized using CDO technology. The asset classes that work best for CDOs are those that generate relatively stable cash flows. Asset sectors that currently fall into this category are:

- Leveraged Loans (referred to as CLOs).
- CMBS/REITS/ABS (referred to as Multi-sector or ABS CDOs).
- Sovereign Emerging Market Debt (referred to as EM CDOs).
- Bank and Insurance Trust Preferred Shares (referred to as TRUPS CDOs).
- Investment Grade Corporates (referred to as IG Corporates or CBOs).
- Municipal bonds.

The securities included in a CDO structure can be either fixed or floating rate obligations with a wide range of maturities. Leveraged loans are secured and most corporate debt is generally unsecured.

■ Capital Structure of a CDO

In a CDO structure, the credit risk of portfolio assets is passed to investors on a **tiered** (non-pro rata) basis. The net effect of tiering risks in a CDO is to dilute portfolio risk (and returns) for some investors while increasing it for others. For example, in a Leveraged Loan CDO where \$100MM is invested in senior bank loans, the tiering of investor classes and the associated risk and return would be as follows:

Table 3: Generic CLO Capital Structure

Investor Class	%Cap Structure	Risk/Rating	% Annual Return	Subordination
Class A Shares or Debt	74.0%	AAA	5.5%	26%
Class B Shares or Debt	5.0%	AA	5.90%	21%
Class C Shares or Debt	8.0%	BBB	6.65%	13%
Class D Shares or Debt	6.0%	BB	8%	7%
Total Debt or Rated Shares	93.0%			
Preferred Shares	7.0%	not rated	18%	0%
Total Proceeds Raised by CDO	100%			

Source: Merrill Lynch

Note that in Table 3, Class A debt has the highest subordination level and the lowest return. Investors receive their interest **first** while absorbing, if necessary, portfolio losses **last**. Thus, although Class A investors have the lowest return, they also have the lowest risk (highest protection).

Conversely, Preferred Shares have the highest return, and have the highest risk, protection is limited to excess spread. These shares are allocated portfolio losses first and paid a current return only after all the debt holders have been paid. Also, should defaults exceed a certain level, cash flows that would normally go to the Preferred Shares are redirected to pay down the Class A debt⁸.

⁸ See detailed discussion in "Introduction to CDO Investment", Merrill Lynch Fixed Income Research, 2 October 2003

3. CDO Rating Methodologies

■ Overview

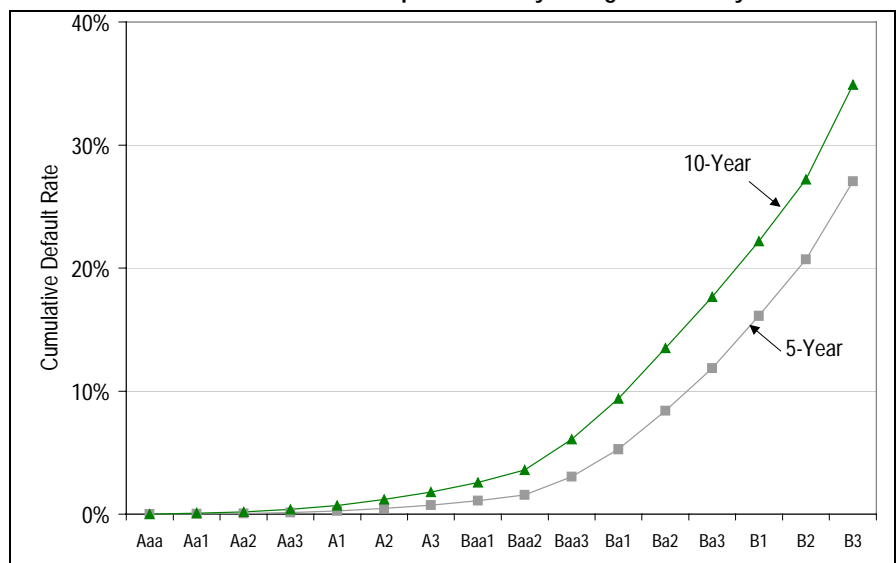
The expected portfolio loss is the risk measure from which the credit protection (subordination) is derived for a desired tranche rating. It is defined as the expected value of portfolio loss distribution. The three main factors driving the loss distribution are:

1. default probability
2. recovery rate, and
3. default correlation.

Default probability is the likelihood of a debt obligation's (bond or loan) inability to meet its debt payments. Empirical approaches have been adopted by rating agencies to measure default probability. Based on historical data of corporate debt performance, the default rates are calculated by rating category and by term to maturity. It is well known that a direct relationship exists between the likelihood of an asset's default and its rating (Chart 1). Historically, the cumulative default rate is found to be below 1% for assets rated 'A' and higher with a maturity of five years. Moving down the rating scale, the cumulative default rate increases and the likelihood of default is above 20% in 'B2' rated assets with the same term to maturity. The default probability also increases as the life to maturity extends. A short-term one-year 'Ba' asset has a default probability of less than 2%. However, a five-year 'Ba' asset has a default probability of greater than 8%. Therefore, both rating and maturity are important factors in determining default probability, one of the key inputs to rating agencies' CDO models.

For ABS and MBS products, due to limited studies available on default probability, the corporate default probabilities are applied to ABS assets with adjustments. Historical transition studies have suggested that the default risk of structured finance products is lower than that of corporate bonds.

Chart 1: Cumulative Default Rate of Corporate Debt by Rating and Maturity



Source: Merrill Lynch, Moody's

The actual **recovery rate** of an asset varies across different industry sectors, different periods of time, different asset types, etc. It also depends on the priority of the payment and whether the asset is a secured or unsecured obligation. The recovery rate is defined as the percentage of par value of recovery amount. The main approaches in deriving recovery rate include a) building quantitative models for recoveries and b) relying on historical recovery experiences.

Investors should pay attention to the recovery rate assumptions used in different models and stress recovery rates accordingly

As we will discuss below, recovery rate assumptions have a significant impact on the expected loss and return of a portfolio and therefore the ultimate credit enhancement levels. Investors should pay attention to recovery rate assumptions used in different models and stress recovery rates accordingly.

Default correlation measures the tendency of assets to default together. To evaluate the risk profile of a CDO portfolio, we not only need to understand the default behavior of each single asset, but also how multiple assets default at the same time. Some models use equity return correlation as a proxy for default correlation. Fitch recently published historical results on industry correlation using equity correlation. These efforts are useful in terms of giving investors a reasonable idea of default correlation.

For the purpose of analyzing modeling risks, we use the **rating loss rate**, a minimum level of loss that a tranche should be able to withstand given its credit rating, as the measure of credit enhancement level. To independently evaluate the methodologies for default distribution approximation, the **rating default rate** is used, which is equivalent to the rating loss rate with 0% recovery rate.

In practice, the rating agencies decide the final credit enhancement levels of a CDO transaction by also incorporating other qualitative aspects such as a manager's CDO experience and legal features.

■ Moody's Methodology

Moody's uses a **portfolio ("top down")** approach to rate CDOs. The quality of a portfolio to be rated is measured by a set of aggregate parameters such as diversity score, weighted average rating and weighted average life. Moody's chooses a binomial approximation approach to model portfolio default distribution. The advantage is its simplicity and less computationally intensive. The primary inputs to Moody's model are portfolio default and recovery rates along with the aggregate parameters of the portfolio.

Diversity Score

Moody's uses diversity score (D) to measure the collateral concentration in terms of number of issuers and industries in an actual pool. For corporate bonds, the portfolio diversity score is determined using the **Diversity Score Calculator**. The procedures are as follows:

- 1) An unit score is calculated for each obligor.
- 2) Obligors are grouped based on Moody's industry classification.
- 3) An aggregate industry unit score is computed by summing all unit scores belong to the industry group.
- 4) An industry diversity score is then mapped by reference to the Diversity Score Table for the related aggregate industry unit score.
- 5) The final diversity score of the portfolio is the numerical sum of all industry diversity scores.

A CLO/CBO portfolio is considered to be diversified if its score is greater than 20. No explicit default correlation is incorporated into the diversity score calculation, and it is implied by the industry concentration.

The default risk between asset-backed securities is, in general, more highly correlated than that of a pool of corporate bonds. Moody's uses an **Alternative Diversity Score** method to analyze ABS CDO pools. The inputs to the Alternative Diversity Score method include:

- 1) the default probability of an asset implied by its rating and maturity,
- 2) the face value of the asset, and
- 3) the default correlation coefficient among assets⁹.

⁹ See "ABS CDO Primer", Merrill Lynch Fixed Income Research, 6 October 2003

Once D is determined, a “target” portfolio of D positions is constructed, all having identical characteristics in terms of par amount, rating, average life, and default and recovery rates. For example, if the portfolio amount is \$100 million and the diversity score is 50, Moody’s rating method assumes that the portfolio has 50 positions at \$2 million each. The default probability distribution and credit enhancement levels are derived based on this “target” portfolio.

Table 4 depicts the relative impact of diversity score on the subordination level, calculated based on the characteristics of a hypothetical CLO portfolio with an average ‘B’ rating. The lower a pool’s diversity, the greater the potential impact any given default has on the deal, thus requiring more protection. All else being equal, doubling the diversity score reduces the subordination level by approximately 20% for an ‘Aaa’ rating. The impact diminishes for lower rating categories; a 13% reduction is achieved at ‘B’ rating.

Table 4: Subordination Level by Tranche Rating (Single ‘B’ CLO Portfolio)

Diversity Score	Rating					
	Aaa	Aa	A	Baa	Ba	B
25	27.0%	22.8%	19.6%	17.5%	14.2%	11.7%
50	21.5%	18.5%	16.2%	14.4%	12.0%	10.2%
Relative Difference	20.3%	18.8%	17.6%	17.6%	15.5%	13.2%

Source: Merrill Lynch

Weighted Average Rating

The average rating of a CDO portfolio is determined by the rating factors of the underlying assets (i.e., a numerical rating corresponding to each alphabetical rating) weighted by par value. Moody’s rating factor is the historical 10-year corporate default probability in basis points (i.e., multiply the default probability by 10,000). For example, the 10-year cumulative default probability of a bond rated ‘B1’ is 22.2% and the corresponding rating factor for the bond is 2220. A portfolio with a mix of 36% ‘Ba2’ and 64% ‘B2’ will result in a weighted average rating of 2227 or a ‘B1’ rating.

Not only the average rating but also the rating distribution will alter the default distribution patterns.

The average portfolio rating affects the default distribution. The higher the average rating, the better the credit quality, thus the lower the default probability. Not only the average rating but also the rating distribution will alter the default distribution patterns (see discussion in section *Portfolio Rating Distribution* below).

Moody’s Idealized Cumulative Default and Loss Probability Tables

Moody’s developed the cumulative default probability table based on the historical performance of its rated obligors. The data include actual credit experiences of corporate issuers that sold long-term public debt. The methodology for calculating default rates uses the obligor as the unit of study. Therefore, the default probability is computed as the frequency of issuer defaults to the total number of issuers outstanding. A default probability table is constructed wherein bonds are categorized by rating class and term to maturity. For example, a 5-year default probability of 16.12% means that 16.12% of the issuers in a portfolio of bonds rated ‘B1’ can be expected to default during a 5-year period.

In recent studies, Moody’s also adopted the dollar-weighted approach to calculate default rates¹⁰. One obvious difference between the two methods is the biases towards issuers with large debt issues when a dollar-weighted approach is applied.

¹⁰ See “Default & Recovery Rates of Corporate Bond Issuers”, Moody’s Investors Service, February 2003

The idealized cumulative default probability table is the reference point for portfolio default rate in the CDO rating process.

The idealized cumulative loss table serves as the “target” loss rate for determining a tranches’ subordination level.

In calculating default rates, the historical data is adjusted for statistical anomalies. Bonds in each category are further examined in terms of the mean and standard deviation. Extreme values are excluded from the default probability calculation. The resulting table is known as the **idealized cumulative default probability table**, which is the reference point for portfolio default rates in the CDO rating process.

A portfolio’s cumulative default probability can easily be determined from this table once its weighted average rating and weighted average years to maturity are computed. The table is also the reference point for ABS CDO portfolio as well as for synthetic CDO valuations.

The idealized cumulative loss table serves as the “target” loss rate for determining a tranche’s subordination level. The idealized cumulative **loss** probability is obtained by multiplying the idealized cumulative default probability by 55% (assuming 45% recovery rate). As an example, the cumulative loss probability for a ‘B1’ rated tranche over a 5-year period equals 8.9% (16.12%*0.55). This loss severity (55%) is applied to all rating categories and maturities in the table.

Binomial Expansion Technology (BET)

As mentioned in the section *Diversity Score*, to use the BET method, a “target” portfolio is created containing D number of uncorrelated securities with each security having the same default probability and recovery rate. Once the weighted average rating is determined for the rated portfolio, the default probability (p) is mapped from the idealized cumulative default probability table¹¹ for a specified average term to maturity.

The binomial expansion technique provides the approximation to the distribution of default probability under possible default scenarios (# of scenarios = D+1). To illustrate, assuming D of 53 and p of 16.12%, Chart 2 shows the distribution of default probability in terms of number of defaults. The x-axis represents possible defaults in the portfolio, while the left y-axis corresponds to the probabilities associated with them. For this particular portfolio, the probability for a best case scenario (zero default) is 0.009%. The most likely default scenario is that 8 out of 53 assets will default, for which the probability is 14.8%. The default probabilities decline after reaching the peak. The possibility of more than 30 defaults in this case is almost zero. It is unlikely that all 53 assets in the portfolio will default (worst case scenario).

The default rate for a given scenario is simply the number of defaults divided by the diversity score (D). Thus, the default rate corresponding to 8 defaults is 15.1% (8/53). Note that all 53 bonds have the same par value, therefore, the default rate can be expressed either by default amount or by number of bonds defaulted.

The expected value (i.e., mean) and the standard deviation of the binomial distribution equal 8.5 and 2.7¹² defaults respectively. Thus, one standard deviation from the mean covers the number of defaults ranging from 5 to 11, or from 9% to 21%.

For the aforementioned model portfolio, what is the probability that at least 11 bonds will default? We may add all default probabilities for 11, 12, ...53 defaults and the result is 22.6%. The inverse S-shaped curve shown in Chart 2 represents the cumulative binomial distribution function, from which we can obtain the probability of at least k number of defaults.

Chart 3 shows the same default distribution as Chart 2, with the exception being that the probability is plotted against default rate, instead of the number of defaults. Let us assume that 22.6% cumulative probability is the “target” default rate for a tranche to achieve a ‘B2’ rating. Its tranche attachment point is 20.8% (11/53). Similarly, to achieve an ‘A2’ rating, the “target” rate is set to 0.47%, which corresponds to at least 17 defaults, or the attachment point of 32%.

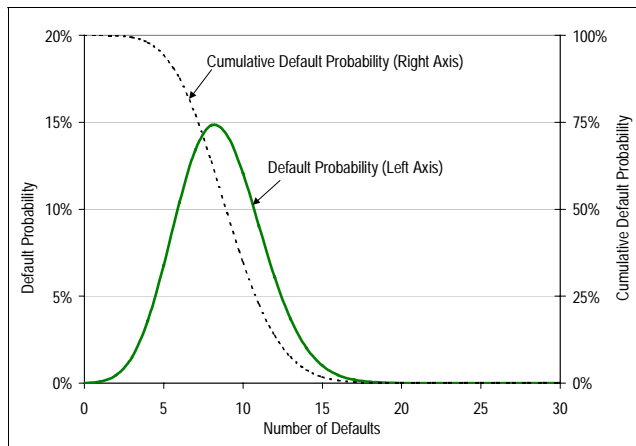
¹¹ Note that when the rating number for the portfolio “falls” in between rating categories, Moody’s will interpolate the default probabilities for the respective rating categories to come up with a default probability for the portfolio.

¹² The mean value for the binomial distribution is $D * p$ and the standard deviation is $\sqrt{D * p * (1 - p)}$.

Although the rating default rate is not a direct output from the BET model, we did the calculation for the purpose of comparing the BET model with Fitch's VECTOR model, independent of recovery rate assumptions. As discussed in later sections, Fitch's rating default rate (RDR) and S&P's scenario default rate (SDR) are determined in a similar way.

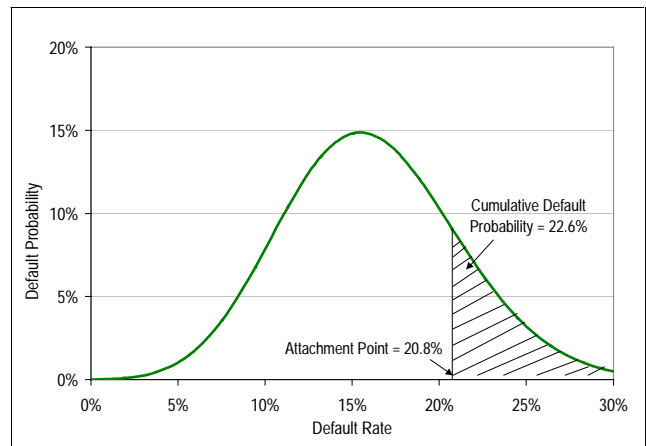
Note that in Moody's BET approach the cumulative default probability (p) is stressed under each rating category. A stress factor of 1.5 is applied to an 'Aaa' rating, and a stress factor of 1.0 is applied to a 'B' rating¹³. Therefore, there is a distinctive default distribution associated with each rating.

Chart 2: Default Distribution in Terms of Number of Defaults From BET Model: Diversity Score=53, Cumulative Default Rate=16.12%



Source: Merrill Lynch

Chart 3: Default Distribution in Terms of Default Rate. Cumulative Default Probability and Tranche Attachment Point are Determined From the Distribution



Source: Merrill Lynch

Recovery Rate

In Moody's CDO rating process, an average recovery rate of a CDO portfolio is determined based on the type of underlying assets and the asset's priority in its original capital structure. It also depends on the tranche rating. For example, with the same collateral pool, a lower recovery rate is applied in order to achieve a higher tranche rating. Table 5 lists the recovery rates for US corporate assets.

In case of ABS CDOs, the recovery rate is based not only on the security's priority in the capital structure, but also on its size relative to the entire portfolio. For example, Moody's applies a higher recovery rate to the senior ABS tranches than to subordinated ABS tranches. The distinction is also made whether a particular asset type is greater than 70% or less than 10% relative to its portfolio.¹⁴

The average recovery rate is then used in cashflow calculations, from which the loss under each default scenario, as well as the expected loss from all possible default scenarios, are computed (see section *Expected Loss Calculation* for detailed discussion).

The recovery rate assumption has a significant impact on tranche loss rates. We estimated such an impact by using a simple two-tier structure (without presence of any triggers) and found that the tranche loss rate levels are increased by 18% for a 10% reduction in recovery rate level (e.g., from 55% to 45%).

¹³ For a complete list of stress factors see "ABS CDO Primer" by Merrill Lynch Fixed Income Research, 6 October 2003.

¹⁴ See "ABS CDO Primer", Merrill Lynch Fixed Income Research, October 6, 2003.

Table 5: Moody's Recovery Assumptions on US Corporate Assets

Asset Type	Seniority	Aaa	Aa	A	Baa	Ba	B
Bond	Senior Unsecured	30%	30%	33%	36%	40%	40%
Loan	Senior Secured ¹⁵	52%	52%	57%	62%	66%	67%
Loan	Senior Unsecured ¹¹	40%	41%	45%	50%	54%	55%

Source: Merrill Lynch, Fitch Ratings

Default Timing Assumption

An additional assumption of default timing is required in Moody's BET model. It is assumed to be frond-loaded, where 50% of the expected default amount is allocated in year one and the remaining 50% is divided evenly among the remaining years to maturity. Consider a scenario in which 8 out of 53 bonds defaulted over a 5-year period, each having a par value of \$5 million. The default amount by the end of year one reaches \$20 million (50% of \$40 million), and an additional \$5 million in year two (12.5% of \$40 million) and so on. The total collateral default amounts to \$40 million over the five-year period, which is equivalent to the default rate of 15.1%. Applying the method to all D+1 scenarios, we have a vector of default amounts for each scenario.

Expected Loss Calculation

Once the collateral default amount is calculated for a specified scenario, the actual loss amount at the end of each year can easily be obtained for a given recovery rate. Moody's model assumes no lag between default and recovery. Using the example illustrated in the previous section, in which 8 out of 53 bonds defaulted, the collateral loss amount at the end of year one is \$11 million if a recovery rate of 45% is assumed. As a result, the collateral ending balance is \$254.0 million. Further assuming that the underlying assets are leveraged loans yielding 5% per annum, the portfolio income at the end of year one is \$6.35 million. In general, the portfolio income will consist of both interest and principal collections if the portfolio also contains amortizing assets.

Using its coupon rate and par value, we can compute the cash flow of a tranche to be rated, subject to the portfolio income available for distribution. The present value (PV) is obtained by discounting the tranches' cash flow with its coupon rate. The difference between the tranches' par value and PV is defined as the total principal loss of the tranche. Note that collateral loss may not necessarily result in tranche loss if there are subordinated tranches backing the senior tranche to be rated.

The expected loss is calculated as the sum product of the default probability from the binomial expansion formula and the principal loss for all D+1 scenarios. Finally, the tranche's rating is determined by mapping the expected loss to the "target" loss probability in the cumulative loss table. In practice, a CDO structure is continuously being adjusted until a desired rating is tested to pass.

The BET methodology is very practical for rating CDO portfolios where the underlying assets are relatively homogeneous. In cases where the portfolio assets exhibit heterogeneous characteristics such as a barbelled distribution in rating (see discussion below), or a wide distribution in size or maturity, Moody's uses a multiple BET approach by dividing the portfolio into subgroups and by applying the BET to each subgroup¹⁶. Moody's also developed other alternative approaches to improve the accuracy in the assessment of default distribution for complex pools of assets¹⁷.

¹⁵ Average of Type I,II, and III loans.¹⁶ See "Moody's Approach to Rating Synthetic CDO", Moody's Investors Service, 2002¹⁷ See "The Fourier Transform Method – Overview", Moody's Investors Service, 15 January 2003

Fitch's default VECTOR model employs an asset-level (or "bottom-up") approach and computes the default and loss distribution from the actual portfolio.

■ Fitch's VECTOR Model

Recently, Fitch Ratings introduced its new methodology for evaluating and rating CDO tranches. Using a different approach from Moody's, Fitch's default VECTOR model employs an asset-level (or "**bottom-up**") approach and computes the default and loss distribution from the actual portfolio rather than a simplified portfolio of pseudo-assets. Below are the three main factors affecting the expected losses for a given CDO portfolio.

- First, the **default probability**. The VECTOR model derives the default probability from Fitch's credit ratings based on the historical experiences in corporate bonds. Similar to Moody's idealized cumulative default probability table, Fitch uses the default matrix table from which the cumulative default rate is obtained for a given rating and maturity. Each underlying security (i.e., asset) is assigned a cumulative default curve based on its rating. A conditional (marginal) default curve can be derived from the cumulative default curve and thus the probability of default in the current period given its survival to the end of the previous period is known.
- For ABS products, due to limited default studies on ABS, Fitch has not developed a default matrix. To overcome this, the VECTOR model enables users to adjust the default probability implied from the default matrix of corporate bonds. A historical transition study has told us that the default risk of structured finance products is lower than that of corporate bonds¹⁸. The user also needs to adjust the default probability when the definition of a credit event is different, especially in synthetic deals.

Charts 4 and 5 show the cumulative and conditional default probabilities of Moody's 'B1' rating, Fitch and S&P's 'B+' rating. As can be seen, the cumulative probabilities are very similar. However, the applications of these probabilities in their models are very different. The BET model uses one particular cumulative default probability corresponding to the weighted average rating of the underlying portfolio and the weighted average life number, while the VECTOR model uses the entire conditional default rate curve. The Evaluator model assigns one particular default probability to each asset based on its rating and term (see discussion in section *Standard and Poor's Evaluator Model*).

- Second, the **recovery rate**. Similar to Moody's, Fitch also provides recovery assumptions based on asset type (corporate bonds, loans, or ABS), country, priority of payment and rating. Table 6 shows the recovery assumptions for US corporate assets¹⁹. There are two dimensions in the table – the underlying assets' seniority relative to its original structure and the desired rating of a tranche. The number under the 'B' rating is the baseline from empirical recovery studies. Therefore, for a senior secured asset with a non-investment grade rating (e.g., 'BB' or lower), a 70% recovery rate is assigned when a default occurs. Fitch describes it a "tiered recovery assumption". Depending upon the target rating, the base case recovery is adjusted downward for higher ratings, i.e., more stress is applied. For example, a lower recovery rate of 56% is applied to the same asset pool when rating an 'AAA' tranche. Fitch's recovery rates for CBO/CLO are higher than Moody's; a maximum difference of 8% is seen in 'A' tranche rating.

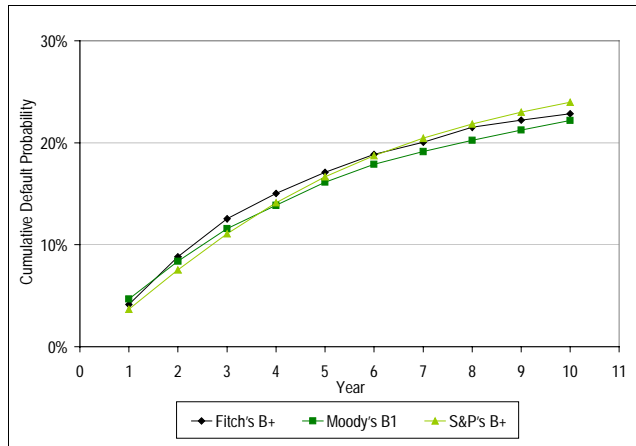
In the case of an ABS CDO, the security's priority within the capital structure (senior or subordinated), the percentage of the security in relation to the total amount of the collateral pool as well as the rating are all taken into account.

¹⁸ See "Structured Finance Rating Transition Study", Fitch Ratings, 8 May 2002 and "Fitch Historical Corporate Bond Ratings Transition Study", Fitch Ratings, 18 November 2002

¹⁹ For other asset types, refer to "Global Rating Criteria for Collateralised Debt Obligations", Fitch Ratings, 1 August 2003

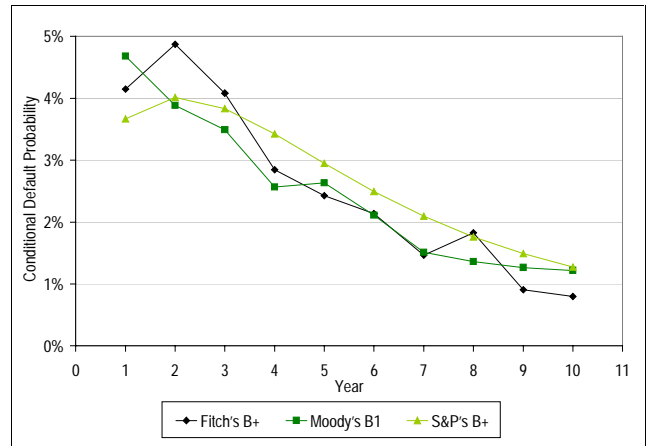
According to Fitch, during each simulation run, six associated recovery rates (from 'B' to 'AAA') are recorded each time an asset defaults. After the simulation is done, a weighted average recovery rate is calculated for each stress scenario (from 'B' to 'AAA'), which is the Rating Recovery Rate (RRR).

Chart 4: Cumulative Default probability For 'B' Rated Assets



Source: Merrill Lynch, Moody's, Fitch, S&P

Chart 5: Conditional Default probability For 'B' Rated Assets



Source: Merrill Lynch, Moody's, Fitch, S&P

Table 6: Fitch's Recovery Assumptions on US Corporate Assets

Domicile	Seniority	AAA	AA	A	BBB	BB	B
United States	REITS	52.0%	55.3%	58.5%	61.8%	63.4%	65.0%
United States	Senior Secured (Non IG)	56.0%	59.5%	63.0%	66.5%	68.3%	70.0%
United States	Junior Secured (Non IG)	24.0%	25.5%	27.0%	28.5%	29.3%	30.0%
United States	Senior Unsecured (Non IG)	36.0%	38.3%	40.5%	42.8%	43.9%	45.0%
United States	Subordinate (Non IG)	24.0%	25.5%	27.0%	28.5%	29.3%	30.0%
United States	Senior Unsecured (IG)	44.0%	46.8%	49.5%	52.3%	53.6%	55.0%
United States	Subordinate (IG)	24.0%	25.5%	27.0%	28.5%	29.3%	30.0%

Source: Merrill Lynch, Fitch Ratings

- Third, the **default correlation**. To put it simply, the default correlation is a measurement of the tendency of assets to default together. Instead of modeling the default correlation directly, the VECTOR model uses asset correlation to generate multiple defaults through the Copula method²⁰. Since it is difficult to measure the asset correlation directly, the model instead uses equity return correlation. The correlation matrix consists of correlation coefficients calibrated from historical equity return data of 25 industries and 5 regions. For structured finance products, the correlations are developed according to some empirical evidence that correlations between ABS assets are higher compared to corporates due to the increased systematic risk. No stress factors are applied to the correlation matrix.

For example, the intra-industry correlation in US real estate is 28% and the correlation between US real estate and Euro real estate is 7%. On average, stronger correlations are found within industries than between industries. Due to the existence of asset correlation, the default threshold is calculated from joint distribution functions.

²⁰ See "On Default Correlation: A Copula Function Approach", The Journal of Fixed Income, March 2000.

Simulation Process

The VECTOR model applies a multi-period Monte Carlo simulation process. The basic procedures are as follows:

- **Step 1**, during the first period, use the rating-specific conditional default probability to derive the default threshold by inverting the standard normal cumulative distribution function.
- **Step 2**, use the default thresholds and the asset correlation to generate multiple defaults through a normal Copula function.
- **Step 3**, for defaulted assets, record the default and recovery amounts and then remove the assets.
- **Step 4**, move on to the next period and repeat Steps 1 to 3 until all assets either default or reach maturity.
- **Step 5**, the default rate is calculated as the total defaulted amount divided by initial principal, and the frequency of each default rate is calculated by counting the number of each observation to generate the default distribution. The loss distribution is derived in a similar matter.

As an example, consider an asset with a 'B+' rating, the default threshold (-1.73) is computed from the conditional default rate for year one (4.15%, Table 8), by inverting the standard normal cumulative distribution function. The simulation on the change in asset value is compared with the default threshold. A default occurs if the simulated asset value is below -1.7. If no default occurs in the first year, the default threshold for the second year (-1.66) is computed from the conditional default probability of 4.87% (Table 8) and another simulation process is initiated. The simulation process ends when 1) asset defaults or 2) asset reaches maturity.

The scenarios and default rates are predetermined in the BET model, while in the simulation-based model they are driven by conditional default curves.

Obviously, fundamental differences between the BET model and the simulation-based models are that the scenarios and default rates are predetermined in the BET model. If the diversity score is 53 then there can only be 54 scenarios and default rates, and the distribution is driven by a single default probability number. In the simulation-based model, the scenarios and distribution are driven solely by the conditional default curves (a series of default probabilities), asset correlation and recovery rates. Another difference lies in default timing. The BET model predetermined the timing of default while the VECTOR model allows the default to occur randomly and the timing is controlled by the conditional default curve.

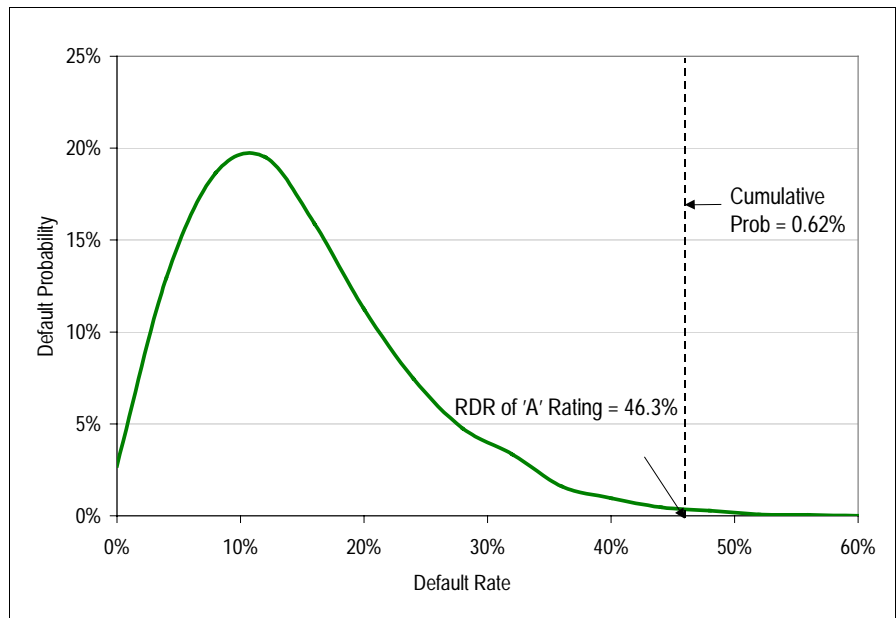
The VECTOR Model Output: RDR and RLR

The outputs of the VECTOR model are Rating Default Rate (RDR) and Rating Loss Rate (RLR). The RDR is derived from the cumulative default probability targeted for a specific rating. It is determined based on the default distribution such that the cumulative probability (from the right tail) is equal to the cumulative default probability of the target rating. As an example, Chart 6 shows the default distribution from the simulation process for a hypothetical portfolio of senior-secured leveraged loans. Let us assume the target default rate associated with an 'A' rating in a 5-year period is 0.62%. We accumulate the default probability from the right (from the worst case) until the sum reaches 0.62%. The corresponding attachment point, i.e., RDR is 46.3%. The rating recovery rate (RRR) is 63% for an 'A' rated asset (Table 3). The Rating Loss Rate (RLR) is derived in a similar way as RDR.

In this case the RLR is 17.13%. In other words, for the tranche to be rated 'A' the loss percentage can not exceed 17.13% or the credit enhancement level is set to be 17.13%. In practice the rating agencies decide the final credit enhancement levels by also considering other risk factors such as stressing, structural features, manager quality, etc.

In summary, Fitch's new rating methodologies take into account asset level details, which will result in more precise loss expectation of an overall portfolio.

Chart 6: Default Distribution From VECTOR Simulation Model. RDR is Determined From the Distribution



Source: Merrill Lynch, Fitch Ratings

■ **Standard and Poor’s Evaluator Model**

Standard and Poor’s Evaluator model was the first rating model to directly incorporate correlation through a simulation process. The Evaluator model is used to evaluate the credit quality of the collateral assets of a CDO portfolio. Methodology-wise, the Evaluator model is similar to Fitch’s VECTOR model – both rely on Monte Carlo simulation and use credit rating and associated default probability to simulate the default event. However, there are also some major differences between the two methodologies as summarized below:

Simulation Process

Unlike the VECTOR’s annual multi-step simulation process, the Evaluator only simulates over one period. For each asset, it applies the cumulative default probability associated with its rating and term to maturity to simulate whether it will default or not.

For ABS CDOs, a single default rate is assigned to each asset based on its rating while the maturity term is not taken into account. In other words, the default rate for an ABS asset with one-year life will have the same default rate as an asset with five-year life.

Recovery Rate Assumption

A range of recovery rates are used by S&P for US corporate bonds and loans (Table 7). The baseline recovery rate is 35% for bonds and 55% for loans. Stress factors are applied to the baseline recovery assumptions based on the due diligence of portfolio managers’ quality, as indicated in the range of recovery rates. No distinction is made for tranche rating. For ABS assets, higher recovery rates are used and they are stressed based on different tranche ratings.

The Evaluator model is similar to Fitch’s VECTOR model – both rely on Monte Carlo simulation and use credit rating and associated default probability to simulate the default event. Evaluator only simulates one period.

The baseline recovery rate is 35% for bonds and 55% for loans. Stress factors are applied to the baseline recovery assumptions based on portfolio managers’ experience.

Table 7: S&P's Recovery Assumptions on US Corporate Assets

	Bonds	Loans
Senior Secured	40%-55%	50%-60%
Senior Unsecured	25%-44%	25%-50%
Subordinated	15%-28%%	15%-28%

Source: Merrill Lynch, S&P

Correlation Measure

The Evaluator model handles correlation by classifying each corporate industry into three categories: 1) local, 2) regional and 3) global²¹. The distinction is also made for “between sector” assets and “within sector” assets. A zero correlation is assumed for “between sector” corporate assets. For “within sector” assets, a value ranging from 0 to 0.3 is assigned to each asset depending upon its industry class. The performance of corporate sectors and ABS sectors are assumed to be uncorrelated.

The Output from the Evaluator Model

The output from the Evaluator model is the **scenario default rate (SDR)**, a minimum level of default rate that a tranche should be able to withstand given its credit rating. The SDR is derived in a similar way as the RDR from the VECTOR model. It is further adjusted by a stress factor ranging from 0.6 to 1.2. For example, the SDR for an ‘A’ rating is multiplied by 1.02, and the SDRs for lower ratings are stressed downward. The credit enhancement levels are determined from the SDR values using a cashflow model along with recovery rate assumptions.

Other portfolio benchmarks include a) weighted average rating (WAR), b) default measure (DM), c) variability measure (VM) and d) correlation measure (CM). These benchmark measures are very useful for cross transaction comparisons.

Note that VM (defined as the standard deviation of the default distribution) measures the degree to which actual portfolio default rate may differ from average.

In summary, the Evaluator model can handle complex credit relationships among assets such as bi-variate risk, CDO of CDOs, multiple tranches from same ABS transaction and assets with global, regional, or local credit characteristics.

The scenario default rate (SDR) is the minimum level of default rate that a tranche should be able to withstand given its credit rating.

²¹ See “Using Standard & Poor’s CDO Evaluator”, Evaluator User Guide.

4. Sample Portfolio and Results

As discussed in the previous section, there are similarities and differences in the three rating methodologies. In this section, we tested a sample portfolio against all three models and examine the relative differences in credit enhancement levels by tranche rating. The discussion will be focused on the impact of various assumptions and inputs to the models. By evaluating different models using a sample portfolio we can make more meaningful comparisons from the same reference point, and assess the impact of risk factors on results.

■ Sample portfolio

The sample portfolio consists of a diversified pool of senior-secured leveraged loans with an average 'B1' rating.

We created a hypothetical portfolio consisting of a diversified pool of senior-secured leveraged loans. The aggregate parameters of the pool are as follows: a) diversity score 53, b) weighted average rating 'B1', c) weighted average life to maturity 5 years, and d) portfolio balance \$380 million.

It should be noted that our sample portfolio uses leveraged loans. Applying the three rating methodologies to a portfolio of corporate bonds or ABS may provide different results.

Inputs to Moody's BET Model

- a) The weighted average coupon of the pool is 5.7%.
- b) The initial cumulative default probability of 16.12% is obtained by reference to the cumulative default probability table for the 'B1' rating and the 5-year maturity. Stress factors applied to the default probabilities ranging from 1.0 for a 'B1' tranche rating to 1.5 for a 'Aaa' tranche rating.
- c) The diversity score of 53 is calculated by taking into account the industry and issuer concentrations in the actual portfolio.
- d) The default timing is assumed as follows: 50% occurs at the end of year one and 12.5% at the end of each year of the four subsequent years.
- e) The discount rate and re-investment rate are also assumed to be 5.7%.
- f) Recovery rates for senior-secured loans are used (Table 5).

Inputs to Fitch's VECTOR Model

- a) The asset-level approach of Fitch's model requires the detailed indicatives of each asset including asset type, par balance, coupon, industry code, maturity date, initial rating and payment priority.
- b) The default probability is obtained from the default matrix table. As an example, Table 8 lists the default probabilities for a 'B+' rated asset.
- c) The asset correlation coefficients are mapped from Fitch's correlation matrix table according to its industry code²². The portfolio correlation level (PCL) of the sample portfolio is 0.22.
- d) No additional assumptions are applied for default timing. Instead, a conditional default probability curve for 'B+' rated assets is used (Table 8).
- e) No discount factor is applied.
- f) 10,000 simulation runs are used.
- g) The sample portfolio contains the senior-secured, non-investment grade assets (loans). The recovery rate assumption is listed in Table 6.

²² "Global Rating Criteria for Collateralised Debt Obligations", Fitch Ratings, 1 August, 2003

Table 8: Cumulative and Conditional Default Probability for 'B+' Rating

Year	1	2	3	4	5
Cumulative Default Probability	4.15%	8.81%	12.54%	15.02%	17.09%
Conditional Default Probability	4.15%	4.87%	4.08%	2.84%	2.43%

Source: CDO Default Matrix, Fitch Ratings

The VECTOR model will produce a higher tranche subordination level than the BET model due to its fatter right tail in the default distribution.

The asset-based VECTOR model produces a distribution with wider variation as compared to the portfolio-based BET model.

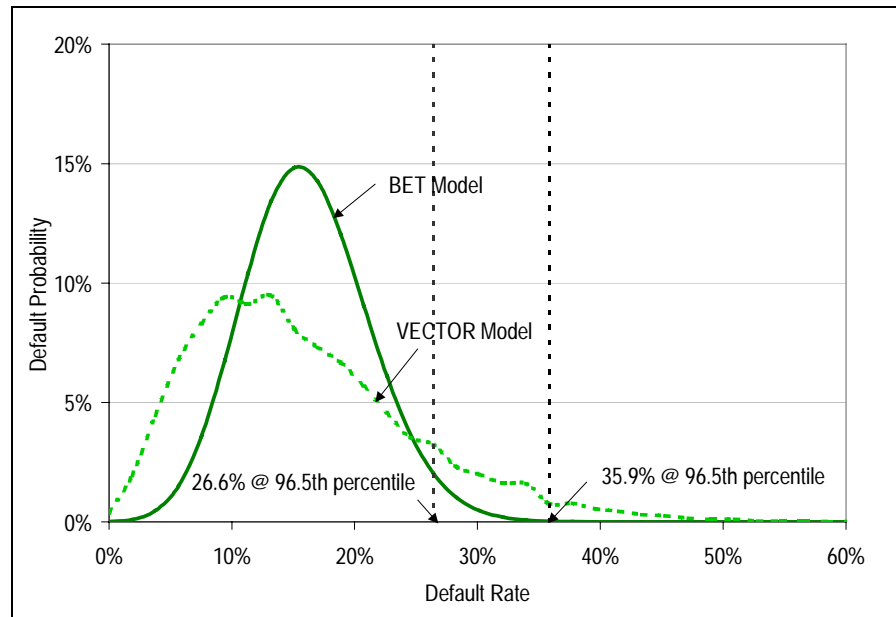
Inputs to S&P's CDO Evaluator

- The CDO Evaluate also requires the asset level data, which include asset type, S&P credit rating, weighted average maturity and par balance. The asset type is classified by specific industry or ABS type.
- A correlation table is used in the model, from which the correlation between different asset types is obtained to generate default distribution.

■ Default Probability Distribution

By controlling the inputs to both BET and VECTOR models, Chart 7 shows the analytical and simulated results for the default probability distribution based on our sample portfolio. The difference in distribution pattern resulting from the two methodologies is evident. Although the expected values of the two distributions are similar (BET 16.1%, VECTOR 15.8%), the distribution generated from the VECTOR model has a wider dispersion and a fatter tail to the right than the distribution from the BET model, indicating that more frequent extreme observations are likely to occur in high default rates. Consequently, in the VECTOR model, the 96.5th percentile corresponds to a default rate of 35.9%. At the same percentile, a default rate of 26.6% is found from the BET default distribution (Table 9). Ignoring recovery rates and other inputs, the VECTOR model will produce a higher tranche subordination level than the BET model.

The main reason that VECTOR model produces a distribution with wider variation as compared to BET is that it is an **asset-level model**. The simulation procedures take into account asset details without diminishing the possibility of large defaults. On the contrary, the BET is a **portfolio-level model** which will underestimate the outcome of extreme cases.

Chart 7: Default Distribution From the BET Model and From the VECTOR Model


Source: Merrill Lynch, Fitch Ratings, Moody's

Table 9: Summary of Default Distributions (BET and VECTOR Models)

	BET Model	VECTOR Model
Expected Value	16.1%	15.8%
Standard Deviation	5.0%	10.4%
Default Rate @ 96.5 th Percentile	26.6%	35.9%
Most Likely Default Scenario	Probability	9.5%
	Default Rate	13.2%

Source: Merrill Lynch

■ Tranche Attachment Point

A tranche attachment point is the rating loss rate corresponding to a required rating. The determination of attachment points involves the following steps:

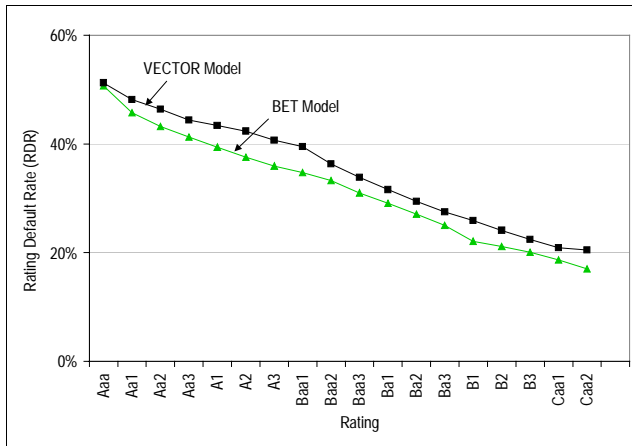
- 1) Calculate the cumulative loss probability by summing the probabilities in descending order of loss rate (starting from the highest).
- 2) Match the cumulative loss probability to the “target” loss rate for a required rating category. For example, to achieve Moody’s ‘B1’ rating, the 5-year “target” loss rate of 9.2% is compared to the cumulative loss probability from step 1. The corresponding loss rate is approximately 8.62%. This is defined as the attachment point for a ‘B1’ rated tranche.

Independent from recovery assumptions the VECTOR model shows consistently higher RDRs than the BET model, indicating a more conservative approach.

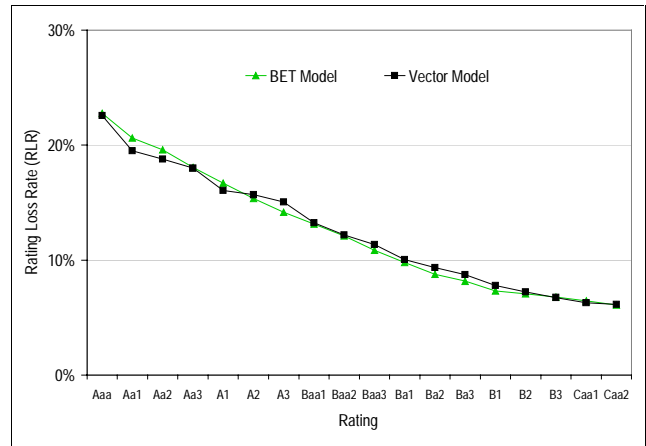
When the attachment points are viewed with 0% recovery, they are equivalent to RDR or SDR. Thus, the RDR results are independent from recovery assumptions. Chart 8 shows the analytical and simulated results for the RDR levels (also see Table 2). The VECTOR model shows consistently higher RDRs than the BET model, indicating that it is a more conservative approach. As mentioned above the asset-based simulation model accounts for more extreme cases of defaults therefore a fatter right tail in the default distribution.

Coupled with their own recovery rate assumptions (Tables 5 and 6), the rating loss rates are obtained from both the BET and the VECTOR models. Note that Moody’s recovery rates are lower than Fitch’s and the maximum difference of 8% is seen in ‘A’ tranche rating. As can be seen in Chart 9, the RLR levels are similar. Moody’s RLRs are above Fitch’s for ratings ‘A1’ and higher, and below Fitch’s levels for ‘A2’ and lower (also see Table 2). The more conservative recovery assumptions used in the BET model have compensated for the low RDR values, and thus bring the RLR values to the level similar to the VECTOR model.

Our analysis suggests that both default distribution and recovery rates are important in determining the credit enhancement levels. Investors should carefully examine the recovery assumptions in both models when determining which model will provide a more conservative credit enhancement level.

Chart 8: Rating Default Rate: VECTOR Model and BET Model


Source: Merrill Lynch, Fitch, Moody's

Chart 9: Rating Loss Rate: VECTOR Model and BET Model


Source: Merrill Lynch, Fitch, Moody's

■ Results From Fitch's VECTOR Model

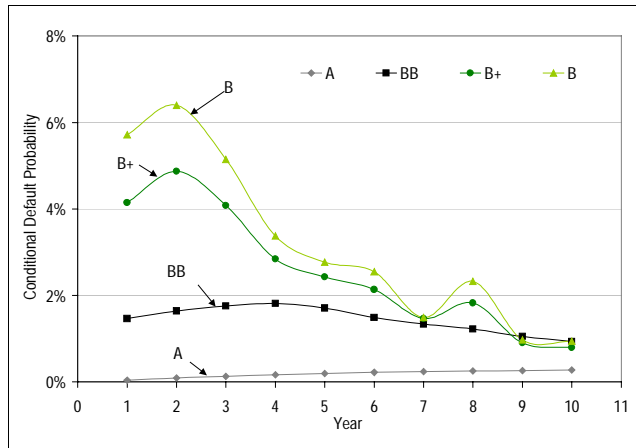
Conditional Default Rate and Default Timing

Since the VECTOR model applies a multi-step Monte Carlo simulation process, it actually uses the conditional default rate curves. As it turns out, the default and loss distributions are affected not only by the level of the default rates but also by the shape of the conditional default rate curve.

Empirical evidence shows that the conditional default rate of higher rating is lower than that of lower rating, but the shape of the curves is quite different. For ratings of 'A' and higher, the conditional default rate increases with the term to maturity, while for ratings below 'A', default peaks in the first 2-3 years and then declines (Chart 10). These trends dictate whether the default timing will be front-loaded, uniformly distributed, or back-loaded.

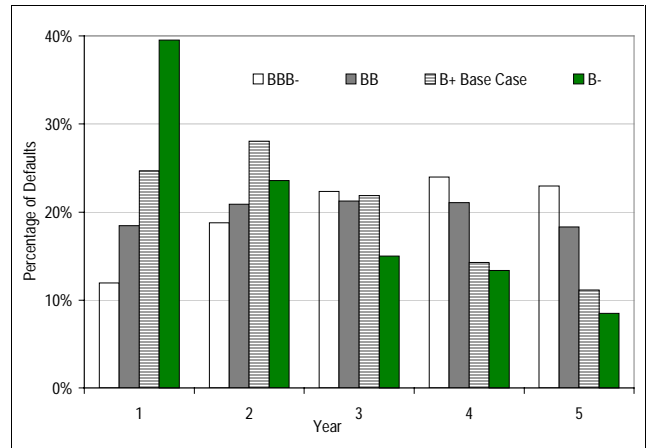
Assuming all assets in a portfolio have a 'B+' rating (base case), 'BBB-' rating, 'BB' rating, or 'B-' rating, we run the VECTOR model respectively and examine the pattern of default timing (Chart 11). The y-axis is the percentage of defaults at each time period over a 5-year period. As can be seen, the default timing for ratings 'B+' and below is front-loaded, 'BB' is relatively uniform, and 'BBB-' is back-loaded. Unlike Moody's model in which the default timing is exogenous and somewhat arbitrarily predetermined, Fitch's VECTOR model allows the rating (i.e. the quality of the collateral) and thus the default curve to determine when a default will happen. It is important to be aware of this difference because the timing of a default will alter the loss distribution profile and thus the credit enhancement levels.

Chart 10: Fitch’s Conditional Default Probability By Rating



Source: Merrill Lynch, Fitch Ratings

Chart 11: Default Timing of Different Ratings (VECTOR Model)



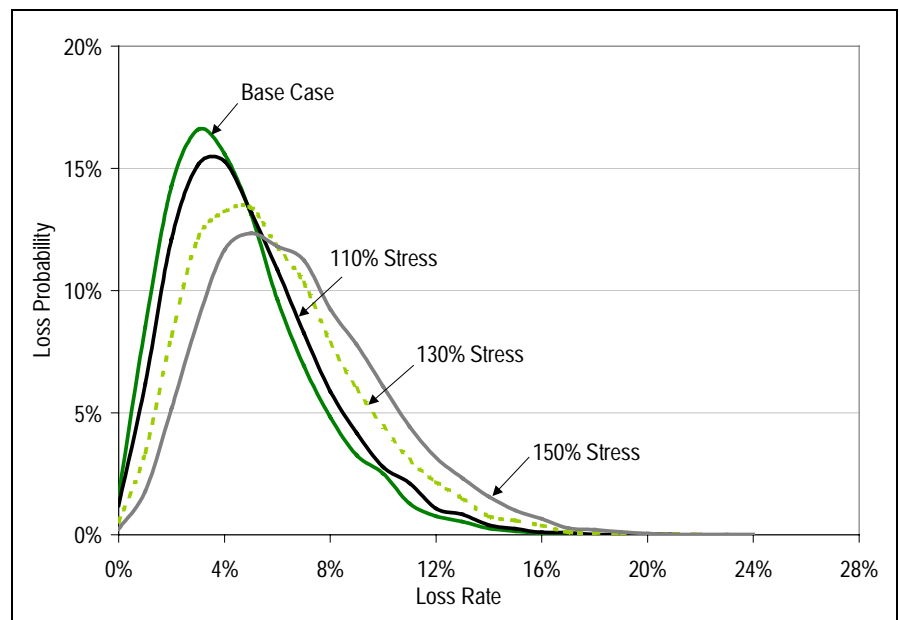
Source: Merrill Lynch, Fitch Ratings

Stress Default Probability

The VECTOR model enables the user to stress the default probability. For example, the user can multiply the default probability by a stress factor for all or some of the assets in the pool. The benefit of having this option is that a user can stress the assets of most concern without having to stress the entire portfolio.

We stress the default probability of all assets in the sample portfolio by 110%, 130% and 150% respectively and show the result in Chart 12. Notice that stressing default rate is equivalent to a parallel shift to the entire default curve. The more we stress the default rate, the more the distribution shifts toward the right, the direction of higher default risk. The credit enhancement level (i.e., RLR) will also move higher due to a fatter right tail in the loss distributions.

Chart 12: Default Distribution From the BET Model and From the VECTOR Model



Source: Merrill Lynch, Fitch Ratings, Moody's

Impact of Recovery Rate

The VECTOR model also provides the user with the option to stress the recovery rate. Stressing the recovery rate will not change the default distribution and timing, but will change the loss distribution and rating default rates (RLR). To assess the impact of the recovery rate, we ran two recovery scenarios: 1) use the baseline recovery rates, and 2) use a stress factor of 0.9. Table 10 shows the RLR for these two scenarios. It is evident that the RLR is quite sensitive to the recovery assumptions. Take 'B' rating as an example, the RLR jumps to 8.9% after reducing the recovery rate to 63%, versus a RLR of 7.2% in the base case with a 70% recovery rate. Also notice that under the same stress condition, the impact is greater on lower rated tranches.

Table 10: RLR Levels Under Two Recovery Rate Scenarios (VECTOR Model)

Rating	Recovery Rate		Rating Loss Rate (RLR)		Ratio
	Base Case	Stress Factor 0.9	Base Case	Stress Factor 0.9	
AAA	56.0%	50.4%	22.6%	25.4%	1.1
AA	59.5%	53.6%	18.8%	21.6%	1.1
A	63.0%	56.7%	15.7%	18.3%	1.2
BBB	66.5%	59.9%	12.2%	14.6%	1.2
BB	68.3%	61.5%	9.3%	11.4%	1.2
B	70.0%	63.0%	7.2%	8.9%	1.2
CCC	70.0%	63.0%	6.1%	7.6%	1.2

Source: Merrill Lynch, Fitch Ratings

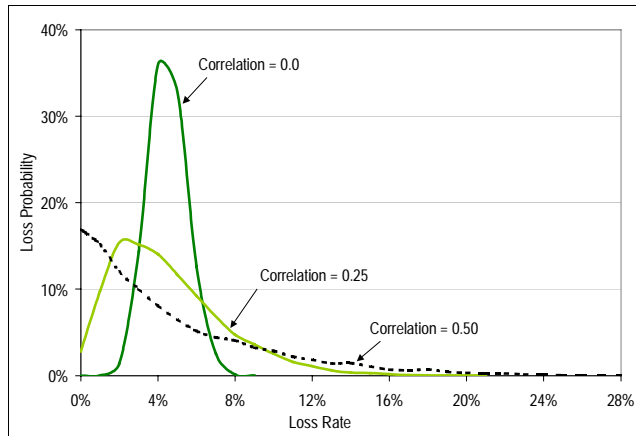
Impact of Default Correlation

Simply put, default correlation is a measurement of the assets' tendency to default together. To model a CDO deal, not only do we need to understand the default behavior of a single asset, but also how multiple assets default. Fitch's VECTOR model handles the default correlation risk by employing equity correlations as the indicator for asset correlation.

As the correlation increases, the probability of multiple defaults and higher total losses increases and the tail of the distribution grows increasingly fatter.

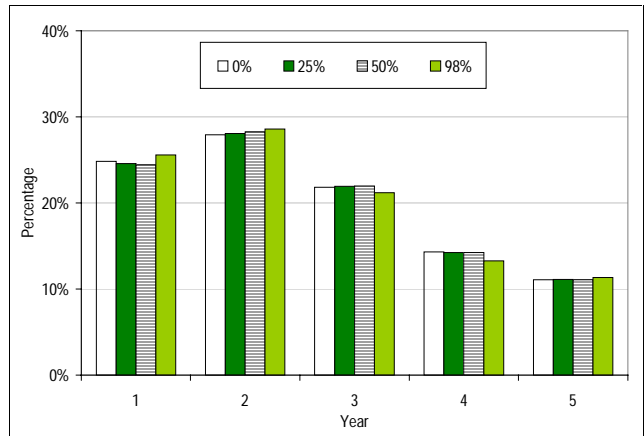
As shown in Chart 13, different correlation assumptions will generate very different loss distribution patterns. When the correlation is zero, (i.e., all the assets are independent), the distribution is close to symmetric and centered around the mean. As we increase the correlation, the probability of multiple defaults and higher total losses increases. Graphically, we notice that the tail of the distribution grows fatter with increasing correlation. Meanwhile, the probability of lower defaults also becomes higher. Ultimately, as the correlation approaches 1.0, it is more likely that all the assets will default at the same time or none will default. However, the default timing seems to be similar under different correlation assumptions (Chart 14). As a reference point, the portfolio correlation level for the sample portfolio is 0.22.

Chart 13: Loss Distribution by Correlation



Source: Merrill Lynch, Fitch

Chart 14: Default Timing by Correlation



Source: Merrill Lynch, Fitch

Table 11 shows the rating loss rate level (RLR) under different correlation assumptions. The higher the correlation the higher the credit enhancement level. The VECTOR model does not stress the correlation for different tranche ratings although users may supply their own correlation assumptions to overwrite the underlying correlation matrix.

Table 11: Rating Loss Rate (RLR) vs. Correlation (VECTOR Model)

Rating	RLR - 0 correlation	RLR - 0.25 correlation	RLR - 0.50 correlation
AAA	11.5%	24.1%	35.4%
AA	10.1%	19.9%	30.0%
A	9.0%	16.5%	24.5%
BBB	7.7%	12.8%	18.4%
BB	6.7%	9.7%	12.6%
B	5.9%	7.4%	8.7%

Source: Merrill Lynch, Fitch Ratings

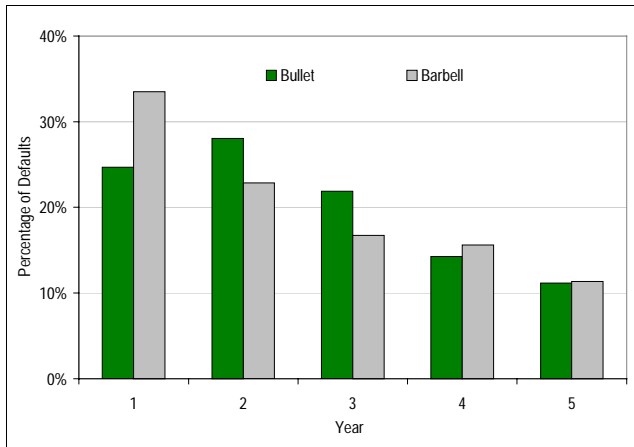
Portfolio Rating Distribution

The distribution of ratings is just as important as the credit level of the underlying assets. So far we have been assuming that all of the assets have the same ‘B+’ rating (a “bullet” distribution), however, a portfolio can also be composed of assets with mixed ratings (“barbell” distribution). A composition of ‘BB’ and ‘B-’ assets with a ‘B+’ average rating is compared with the “bullet” distribution.

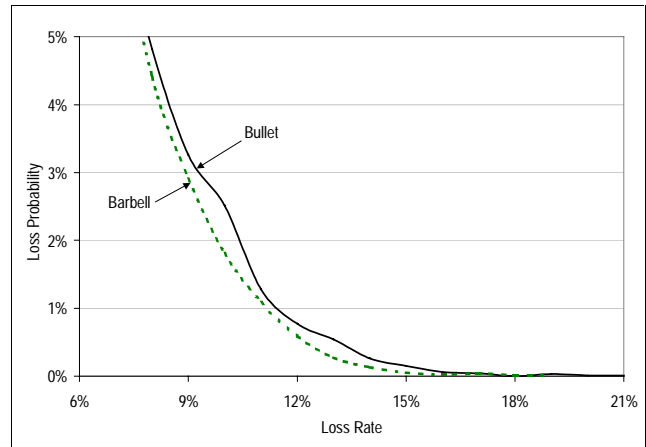
We observe that different rating distributions can result in different loss distributions. The outcome depends on the average rating level as well as how the barbell portfolio is structured. The main point here is that although the WARF is the same, it does NOT mean that they are of the same credit quality. The rating factor is essentially the 10-year corporate default rate. In Chart 10 we can see that the spread between the 10-year default rate with various ratings is much smaller than the difference between the default rates of shorter maturities. The credit risk of the barbell distribution could be higher or lower than the bullet distribution (in terms of default and loss rates). In addition, the patterns of default timing may vary due to different default curve shapes. Chart 15 shows these patterns and we can see that the barbell is more front-loaded. Although there is no discount factor involved in the VECTOR model, default timing still matters since the default threshold is different during various time periods in a multi-step simulation.

In our example, the barbell distribution has a thinner right tail than the bullet distribution (Chart 16). The implication is that the required credit enhancement level (RLR) is lower for the barbell distribution (Table 12). The maximum difference in RLR resulting from the two rating distributions is approximately 2%.

The average rating factor is NOT sufficient to judge the credit quality of a pool, the distribution of ratings is equally important.

Chart 15: Default Timing of Different Rating Distributions


Source: Merrill Lynch, Fitch Ratings

Chart 16: Right Tail of Loss Distribution. Bullet Distribution Has a Fatter Right Tail.


Source: Merrill Lynch, Fitch Rating

Table 12: Rating Loss Rate vs. Rating Distribution

Rating	RLR- Bullet	RLR - Barbell
AAA	22.55%	20.48%
AA	18.79%	16.97%
A	15.67%	14.29%
BBB	12.18%	11.37%
BB	9.34%	8.70%
B	7.24%	6.84%
CCC	6.14%	5.86%

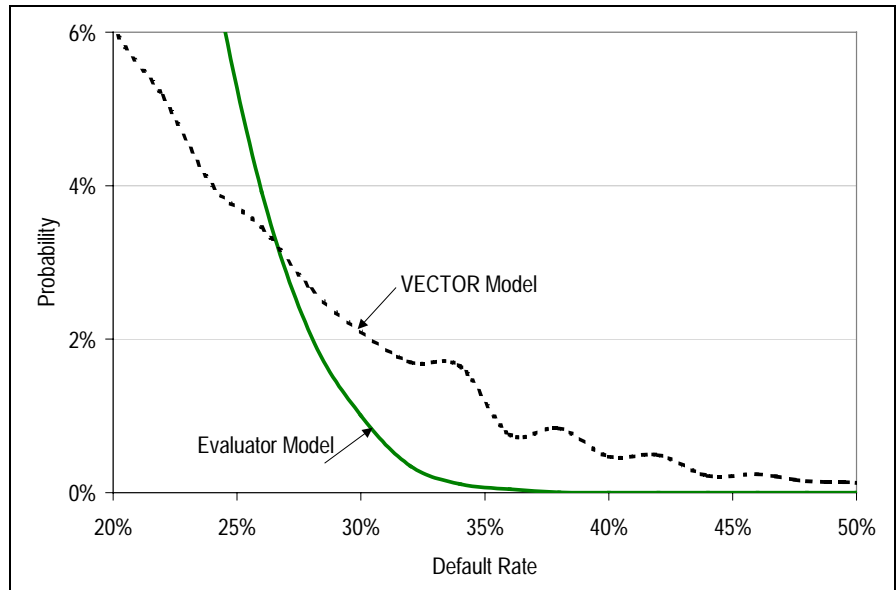
Source: Merrill Lynch, Fitch Ratings

■ Results From S&P's CDO Evaluator

Default Distribution: Evaluator and VECTOR Models

Although both models are asset-based simulation models, the default distributions generated from the CDO Evaluator and the VECTOR model are quite different. Wider dispersion and fatter right tail are seen from the VECTOR model (Chart 17). Not surprisingly, S&P's SDR levels are lower than Fitch's RDR levels across all rating classes (Table 13). Two main reasons causing such a difference are correlation and cumulative default probabilities and are summarized in the following two sections. The stress on default rate in the Evaluator model is done at the RDR level, which is equivalent to stressing all underlying assets.

Chart 17: Right Tail of Default Distribution From the Evaluator Model and the VECTOR Model.



Source: Merrill Lynch, S&P, and Fitch

Table 13: S&P's SDR vs. Fitch's RDR for a Leveraged Loan Portfolio

Desired Rating	AAA	AA	A	BBB	BB	B	CCC
SDR	33.1%	31.2%	30.4%	28.5%	24.6%	22.3%	19.9%
RDR	51.3%	46.4%	42.4%	36.4%	29.4%	24.1%	20.5%

Source: Merrill Lynch, Fitch, S&P

Correlation Measure

First, the difference is due to correlation assumptions. As discussed in the section *Impact of Default Correlation*, Fitch applies a correlation matrix to each asset based on industry groups. A portfolio correlation level (PCL) computed for the sample portfolio is 0.22.

In contrast, S&P uses a correlation measure (CM) to quantify portfolio correlation and the CM for the sample portfolio is 1.39. The CM is defined as the ratio of standard deviation of default rates with correlation to the standard deviation with zero correlation. The CM is 1.0 if no correlation exists among assets. Higher CM corresponds to higher correlation among assets.

It is difficult to quantitatively compare the two correlation values due to the differences in definition. Since the VECTOR model allows users to supply a constant pair-wise correlation value (thus the PCL will be just a user supplied value) while the correlation assumptions in the CDO Evaluator are fixed. We calculate the CM according to S&P's definition, but using the distribution generated from the VECTOR model. Table 14 shows the CM values for a range of PCL's.

In reference to our sample portfolio, the CM of 1.39 implies a 0.032 PCL while the VECTOR model shows a PCL of 0.22. The CDO Evaluator implies a much lower portfolio correlation than the VECTOR model. This difference in correlation is one of the main reasons why the resulting SDR from the CDO Evaluator is lower than the RDR from the VECTOR model.

Table 14: Portfolio Correlation Level (PCL) vs. Correlation Measure (CM) for a Leveraged Loan Portfolio with Average 'B+' Rating

PCL	0.0	0.032	0.20	0.22	0.40	0.60	0.80
CM	1.0	1.39	2.91	3.04	4.71	7.16	13.6

Source: Merrill Lynch, Fitch Ratings

Cumulative Default Probability

Second, there is a significant difference in the cumulative default probability, a reference point for all three rating methodologies. As an example, Table 15 shows such values for the 5-year maturity. For example, at the BB/Ba2 level, the cumulative default rate is 11.25% for S&P and is 8.41% for Fitch. Even suppose both models produce the same default distribution, a higher cutoff point means a larger cumulative area from the right of the distribution. This will imply a lower attachment point (see section *Tranche Attachment Point* for detailed discussion).

Table 15: 5-Year Cumulative Default Rates by Rating Agency

Rating	AAA/Aaa	AA/Aa2	A/A2	BBB /Baa2	BB/Ba2	B/B2
S&P	0.28%	0.76%	1.11%	2.50%	11.25%	23.49%
Fitch	0.05%	0.26%	0.62%	1.89%	8.11%	21.36%
Moody's	0.00%	0.07%	0.47%	1.58%	8.41%	20.71%

Source: Merrill Lynch, Moody's, Fitch, S&P

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Analyst Certification

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