Moody's Revisits its Assumptions Regarding Structured Finance Default (and Asset) Correlations for CDOs

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I. SUMMARY

Late last year, Moody's published a correlation framework for corporate instruments that we now apply to synthetic CDOs.[1] The framework consists of a set of asset correlations derived primarily from co-movements in Moody's ratings, and is implemented via an additive factor ("tree") scheme. Asset correlations vary for pairs of firms within and across industries, as well as by geographic region.

Since CDOs are increasingly backed by, or if synthetic, reference, structured instruments, it is important to have a corresponding set of asset correlation assumptions for asset-backed securities (ABS), residential-mortgage backed securities (RMBS), commercial mortgage-backed securities (CMBS), as well as CDO tranches themselves. Moody's has, in fact, developed such a framework for use within its CDOROM™ model. We describe this framework over the balance of this article.

II. MOODY'S PRIOR CORRELATION ASSUMPTIONS FOR MULTISECTOR CDOS

To understand the system of asset correlations that we present below, it is helpful to contrast the new regime with Moody's prior assumptions.

Correlations for resecuritizations were initially defined via a set of default correlations for pairs of instruments within and across structured finance sectors[2]. Default, rather than asset, correlations were required inputs for the Binomial Expansion Technique (BET), which has historically been used by Moody's for the analysis of multisector CDOs[3]. Moody's integrated information from three different sources to develop an initial set of default correlation assumptions, as follows.

** Jeremy Gluck, prior to his retirement, was one of the primary contributors to this report while serving as an SVP within Moody's Derivatives team

1 See "Moody's Revisits its Assumptions Regarding Corporate Default (and Asset) Correlations for CDOs," Moody's Rating Methodology, November 2004. These assumptions are used primarily for static synthetics, but have been adapted within a trading model for a few managed synthetics as well.

2 See "Moody's Approach to Rating Multisector CDOs," Moody's Special Report, September 2000.

3 See "The Binomial Expansion Method Applied to CBO/CLO Analysis," Moody's Special Report, December 1996.

- **In the case of REIT debt**-and only in this case-an active equity market existed from which it was possible to infer default correlations. Specifically, by relating equity return correlations to ratings, we were able to measure asset correlations for REITs from various subsectors, from which default correlations were then inferred.
- **In the case of CDOs**, it was possible to develop an 'observed' set of default correlations by simulating the performance of pairs of CDOs with collateral pools that were somehow related. The degree to which the pools were related was expressed in terms of the overlap by industry and obligor across the pools. Hence for different CDO sectors, we calculated typical industry and obligor overlaps, simulated cash flows for typical structures, and measured the incidence of joint default.
- **For other structured sectors**, a lack of similar data required a more ad hoc approach. For these asset classes, we relied on an extensive set of interviews with Moody's expert analysts for each sector. Frequent comparisons across asset classes ensured that the rank ordering of correlation levels was appropriate in the eyes of the structured finance analysts.

Recognizing that default correlations should vary with default probability, we varied default correlation assumptions as the investment-grade (IG) or non-investment grade (NIG) status of a particular pair of credits varied. Since early resecuritizations were generally backed by **Baa**-rated credits, the IG assumptions were geared toward this rating level. However, those assumptions are quite conservative for pools of highly-rated credits, which increasingly back (or are referenced by) multisector CDOs.

III. ALTERNATIVE APPROACHES FOR MEASURING STRUCTURED FINANCE CREDIT CORRELATION

As in the case of corporate obligations, there are several different approaches for inferring either default or asset correlations for structured credits[4]:

- The behavior of credit spreads
- The joint behavior of the asset pools that underlay structured transactions
- Co-movements in ratings

Each of these has advantages and disadvantages:

Drawing Inferences from Credit Spreads

As in the corporate context, credit spreads may be an attractive source of information for inferring credit correlations because they are market measures that reflect market views regarding default and loss. Spreads are available for most, though certainly not all, structured finance sectors.

The chief obstacle here is also the primary problem in the corporate context-it is very difficult to separate the credit-related component of the spread from other components, such as liquidity effects, tax effects, risk aversion, etc. The task is made more difficult because the contributions of these non-credit factors to spreads almost certainly vary over time.

Indeed, the problem is exacerbated in the structured finance context because structured instruments are generally quite illiquid.[5] Because structured tranches trade infrequently, it is thus difficult to observe true market spreads. Spreads are much more likely to be the result of 'matrix pricing' that effectively imposes its own non-credit-related correlation matrix on various structured asset classes. Moreover, while the "cleanest" credit spread data in the corporate context are probably drawn from the credit default swap (CDS) market, there is no meaningful CDS market for structured instruments.

Drawing Inferences from the Behavior of the Underlying Assets

A more promising approach that is empirical, but not market driven, is to relate the performance of the assets that back structured transactions to the credit correlations of structured finance tranches. This approach requires two sets of information: the behavior of the underlying collateral, and the structures of transactions for each asset class. For example, it isn't sufficient to know the correlation between, say, credit card receivables and residential mortgage delinquencies. Rather, one needs to understand how the performance of the asset pools (delinquencies, nonperforming loans, recoveries, prepayments, etc.) is related for the two asset classes, as well as the way in which collateral performance affects losses associated with credit card ABS and RMBS tranches.

4 One approach that is relevant for corporate obligors-inferring asset correlations from equity behavior within a variant of the Merton model-is not directly relevant in the structured finance context.

5 Although this is often true, there are, of course exceptions. For example, standard **Aaa**-rated credit card ABS tranches may be quite liquid. But even in that case the issues similar to those encountered with the use of correlations from corporate spreads (spread reflecting liquidity and/or herd investment) will still occur here.

The only apparent method for implementing this approach is to simulate the joint behavior-in all its dimensions-of the underlying pools, while "running the asset performance through" actual structures (tranching and cash-flow waterfalls) for credit card and RMBS structures. This is theoretically possible, but the data issues are rather daunting. For many less traditional asset classes, collateral performance data are inadequate to allow a meaningful simulation. Moreover, even this exercise would not capture the potential for event risk, which may have a significant impact on correlation (and which we address via the 'Key Agent' concept below).

Drawing Inferences from Co-Movements in Ratings

The third approach is essentially what we have implemented in the corporate context: inferring asset correlations from joint rating transitions. Of course, in the structured finance context, we define our "industries" to be asset sectors like ABS, RMBS, CMBS and CDOs, rather than corporate industries.

As in the case of corporates, the advantages of the ratings-based approach are consistency with the modeling of defaults and recoveries (which are also ratings-based) and fairly wide coverage. But as with other approaches, the data will tend to be sparse for the newer or more exotic sectors within structured finance. It can at least be said that rating co-movements are fairly easy to observe for these exotic sectors, while meaningful credit spreads or historical pool performance data may be quite difficult to produce.

IV. MOODY'S AGAIN PREFERS ASSET CORRELATIONS INFERRED FROM RATINGS TRANSITIONS

Echoing our choice in the corporate sector, Moody's prefers to rely on the Directional Ratings Transition Matrix (DRTM) approach to derive a set of asset correlations for structured credits. The choice of the DTRM is based on:

1. **The availability of data**-as noted above, rating transitions are available for the major structured finance sectors and are readily accessible. Moreover, they will be readily accessible in the future for the purpose of updating and extending parameter estimates. One important extension is the application of the technique to assess correlations between structured and corporate instruments, to which the DRTM is well suited.
2. **Consistency with other aspects of Moody's CDO ratings**-one state to which a rating may transition is default. The DRTM yields asset correlation estimates that are thus consistent with the ratings-based measures of default and loss that Moody's uses to model CDOs.

The preference for using asset, rather than default correlations, is identical to that in the corporate context:

1. Asset correlations are much easier to work with within a simulation framework, such as Moody's CDOROM model. More specifically, one can mathematically describe joint events of default in a computationally convenient and widely used way.
2. The reliance on asset correlations gives rise to a consistent set of default correlations that can be applied within the BET or another non-simulation framework. That is, by first choosing a set of asset correlations for entities within or across sectors, the implied default correlations are appropriately scaled for the default probabilities of the pair of obligations.[6]
3. The asset correlation approach is also quite natural in the structured finance context, where tranche performance clearly depends on the performance of the assets in the collateral pool, which may be correlated across transactions.

The actual application of the DRTM to structured finance ratings differs somewhat from that in the corporate sector. The reason is simply the availability of data: the structured finance market is much less mature than the corporate bond market, thus providing a much shorter history of rating transitions. Furthermore, structured finance ratings of particularly important sectors like RMBS have tended to be more stable than corporate ratings, suggesting that there have been fewer observed transitions per rated credit per year. The sparse data on structured finance rating transitions requires the application of a different technique to infer asset correlations than was applied in the corporate context. The details of the estimation process are described in *Appendix 1*.

6 One could use these correlations to derive discrete distributions for use in cash-flow CDOs. We are about to publish a Special Report explaining how the correlated BET methodology determines the default distribution.

V. ESTIMATES DERIVED FROM THE DRTM APPROACH: MAJOR STRUCTURED SECTORS

Regardless of approach, any meaningful estimation of asset correlations requires extensive data. Within the structured finance world, sufficient (multi-year) transition data exist for the major sectors: consumer-related ABS, RMBS, CMBS, high-yield (HY) corporate and other CDOs. Further distinctions can be made based on *a priori* views about the relationships between more refined or more exotic structured finance sectors, but the data are simply not sufficient to provide reliable estimates.

To arrive at robust correlation estimates, we examined rating co-movements in the major sectors over the last twenty years. By choosing this period, we were able to observe at least 1000 rating actions within each sector. The numbers of observations (all rating actions including the initial assignment of a rating) in each asset class during the sample period is presented in *Figure 1* below.

Figure 1

Number of Observations by Asset Class During Sample Period

Structured Finance Sector	Number of Rating Actions (including initial rating assignment)
Consumer ABS	4940 (total)
Auto	1072
Credit Card	1308
Student Loan	2560
RMBS	26612
CMBS	6114
HY Corporate CDOs	3045 (total)
High-Yield CBO	1955
High-Yield CLO	1090
Other CDOs*	1190

*Composite of resecuritization, emerging market, synthetic CDO subsectors

Application of the DTRM approach over the sample period, as described in *Appendix 1*, gives rise to the following asset correlation matrix (*Figure 2*):

Figure 2

Estimated Asset Correlations for Major structured finance Sectors

	Consumer ABS	RMBS	CMBS	Other CDOs	HY Corporate CDOs
Consumer ABS	18%	5%	2%	3%	5%
RMBS		12%	4%	3%	2%
CMBS			4%	2%	3%
Other CDOs				5%	5%
HY Corporate CDOs					11%

The relatively low intra-sector correlation level for the 'other CDOs' bucket reflects the aggregation of the different types of CDOs (resecuritization, synthetic arbitrage and emerging market) within this classification. In effect, these figures should be interpreted as inter-, rather than intra-sector, correlation numbers between resecuritization, synthetic arbitrage and emerging market CDOs. The low intra-sector correlation level for CMBS can also seem a bit awkward, but looking only at IG tranches the correlation is closer to 30%. That difference stems from two elements:

- The paydown structure of those CMBS implies that historically, we have seen cases where the Aaa /Aa tranches were upgraded due to high repayment and at the same time, the junior tranches, being mostly NIG, were downgraded because of defaults (although limited);
- Large loan CMBS have issued only IG tranches and their rating histories differ from the usual diversified CMBS pool.

VI. EXTRAPOLATION TO ALL STRUCTURED FINANCE SECTORS AND "TREE" REPRESENTATION

The data above provide substantial guidance toward selecting a full asset correlation framework. But because of the limited scope of the data-the fact that we can't derive asset correlations for each pair of narrowly-defined structured finance categories-we must supplement the estimates by imposing a set of assumptions within a well-reasoned scheme.

In the corporate context, it is natural to develop a scheme around industrial and geographic sectors, which is indeed the approach that we have adopted. For structured finance assets, the choices are somewhat less clear, but it makes intuitive sense that any classification scheme should be related to the underlying assets for each transaction type. We have thus developed a set of increasingly refined sector definitions, within which we would expect the performance of the underlying assets to be increasingly linked.

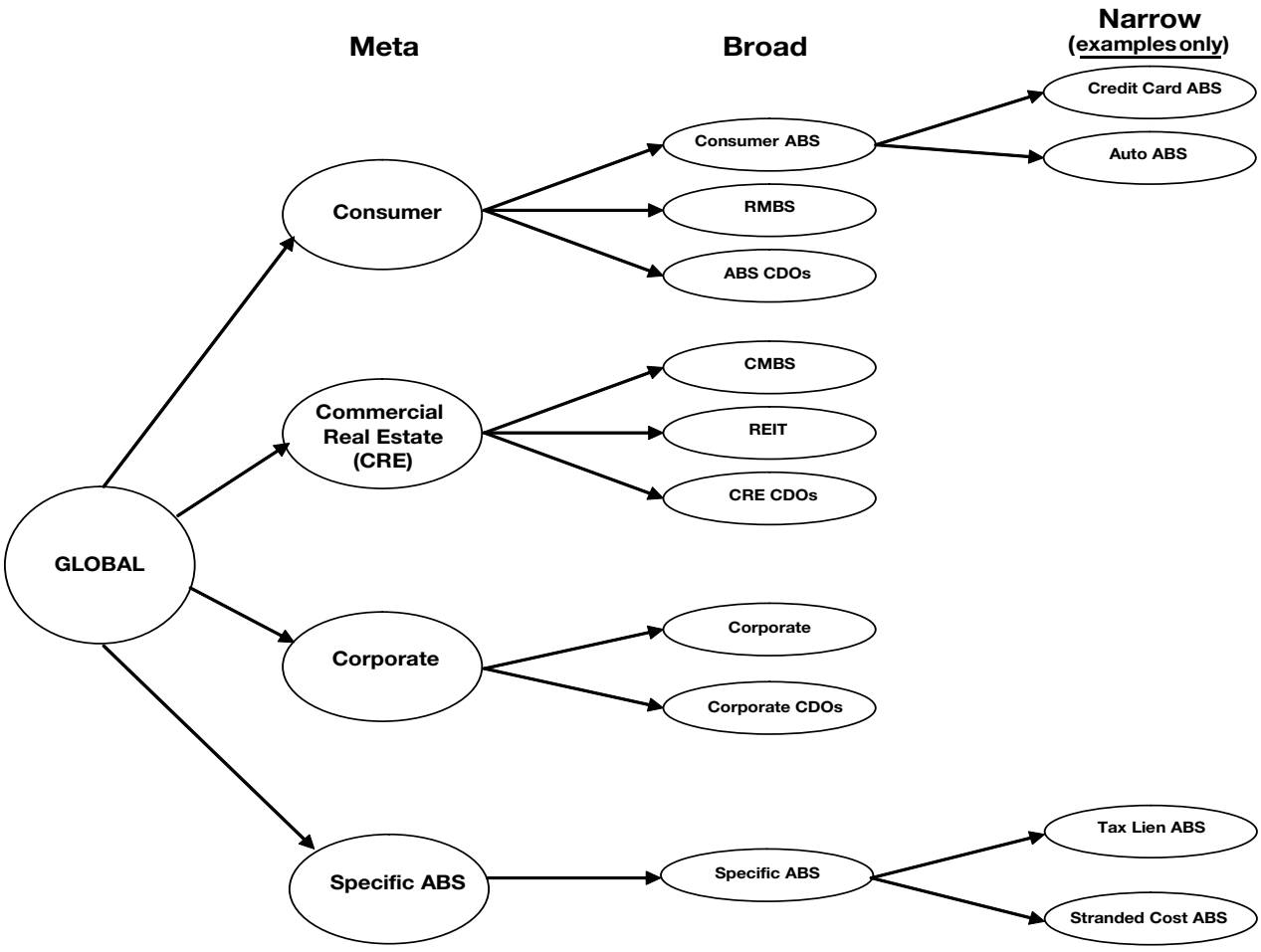
To be more precise, we first define a set of 'meta' categories within which there is a modest degree of linkage of the underlying assets. Beneath each of the meta sectors, there are broad sectors within which the underlying assets may be more tightly linked. Each broad sector is comprised of a set of narrow sectors.[7]

In general, if a pair of structured finance tranches are classified within the same meta sector, but are in different broad sectors, they will have only modest correlation. The correlation would be somewhat higher if credits have a common broad sector, and higher still if they have a common narrow sector.

We enforce these relationships by employing a 'tree' structure in which pair-wise correlation can be described by the extent to which two credits are on the same 'branch' of the tree, as well as the 'narrowness' (sector specificity) of the branch (*Figure 3*).

Figure 3

"Tree" Representation of Structured Finance Sector Classifications



7 See *Appendix 4* for a list of narrow sectors. *Appendix 4* also specifies ranges of FICO credit scores for classification of three RMBS narrow sectors.

The interpretation of *Figure 3* is as follows: suppose we have a pair of instruments within the credit card ABS subsector. These share:

1) Global Correlation
2) Meta Sector Correlation (Consumer)
3) Broad Sector Correlation (Consumer ABS)
4) Narrow Sector Correlation (Credit Card ABS)

The total asset correlation for this particular pair would thus be the sum of four factors corresponding to each of these sources of common performance. As indicated in *Appendix 2*[8], we would then sum values of 1%, 2%, 3% and 15% for a total asset correlation of 21%. By contrast, a credit card ABS tranche would have lower asset correlation with an auto ABS tranche because, despite the fact that they share the first of the three factors, they do not share the fourth. In this case, the total asset correlation would be 1%+2%+3%, for a total of 6%. Similar considerations apply for any pair of credits.

The 'specific ABS' category is somewhat unique and requires further explanation. This category is a catch-all that encompasses various types of 'exotic' ABS. The particular categories are not closely related to each other or, for that matter, to narrow sectors within other meta sectors. Hence for these, the add-on for correlation comes only from the global factor; i.e., the meta sector and broad sector contributions are zero. Hence, in *Figure 3* above, a tax lien ABS tranche and a stranded cost ABS tranche would share an asset correlation equal to the global factor. Of course, for a pair of credits within a particular narrow sector-e.g., tax lien ABS-we would consider the asset correlation to be quite high.

For two types of structured finance transactions - inventories securitization and whole business securitization - we have not created a specific category. A transaction in these categories will be treated as a single name corporate credit exposure to the originator of the transaction. While it is a simplification, in our view, it should capture the main characteristics of these transactions without any added complexity.

The choice of an additive framework is somewhat arbitrary, as is the choice of the factors themselves. The additive framework makes it relatively easy to match the asset correlations that are inferred from the DRTM approach, but this might also be possible within other schemes. One clear advantage of the additive form, however, is that the resulting asset correlation matrix is mathematically valid for the purpose of running simulations.[9]

The value of each of these factors is fully reported in *Appendix 2*. Again, it is important to keep in mind that our assigned values are based on a combination of the DRTM empirical results, as well as our *a priori* views as to the relationships between credits in various sectors.

VII. EXTENSIONS TO ACCOUNT FOR REGIONAL, VINTAGE, KEY AGENT AND SAME-TRANSACTION EFFECTS

For structured finance obligations, as for corporate instruments, factors other than sector may come into play in determining asset correlations. Regional considerations ought to be as relevant for structured finance as for corporate instruments, and we address this below. More specific to the structured finance world, asset correlation may also arise from vintage and certain 'key agent' effects for pairs of credits within a single narrowly defined sector. Of course, tranches issued out of the same structure should be very tightly linked.

Regional Effects

One would naturally expect that to the extent to which the underlying assets for a pair of structured finance transactions come from a single region, there would be some degree of common economic influence that would cause asset performance to be correlated. The more narrowly defined the region, the more we would anticipate that this would be true. But because the structured finance market is still relatively new outside the U.S. (and even within the U.S. for many sectors), one cannot realistically glean such effects-or the absence of such effects-from a DRTM study of, say, U.S. vs. European RMBS performance.[10] Rather, we make reasoned assumptions about the impact of regional factors based on our understanding of the underlying asset performance.

8 For the sake of simplicity, in that example we are not using the regional element of correlation computations. See Regional Effects under Section VII of this paper for a description of the additional computations.

9 The matrix which is so defined should have all the characteristics of a correlation matrix to be useful. One of these requirements is that the matrix be positive definite. Using an additive approach where all the factors that create dependencies are clearly and explicitly defined ensures this property.

10 An additional 'problem' is that European structured finance ratings have tended not to move very much, limiting observations on co-movements in ratings.

We assume that both sharing a common region and sharing a common country may be important in determining structured finance instrument asset correlation. The assumed geographical impact can take two forms:

1) It creates an additional dependency between obligations in the same meta sector, and/or

2) It increases the dependency only between obligations in the same narrow sector.

To make a comparison with the corporate world, the geographic impact can either be between any two corporate instruments in the same region-regardless of sector-or between corporate instruments in the same sector, but in same/different regions. The same considerations arise for structured finance transactions, but our treatment is somewhat different.

We first introduce a set of regional add-ons associated with the meta sector, which is a function of both the meta sector and region/country (see *Figure 4*), the region being defined as a continent. In Europe, and in Europe only, the additional correlation level will be different if two transactions are in the same country.

Figure 4

Regional Add-On Factors by Meta Sector

Meta Sector	North America	Europe: Different Countries	Europe: Same Country	Asia
Consumer	**3%**	**1%**	**5%**	**5%**
Commercial RE	**4%**	**4%**	**4%**	**4%**
Corporate	0%	0%	0%	0%
Specific ABS	0%	0%	0%	0%

These assumptions are based on intuition and the expertise of Moody's analysts. The zero correlations associated with the corporate and specific ABS meta sectors require further explanation. In forming our corporate asset correlation assumptions, we concluded that region alone was not a sufficient basis for assigning a correlation add-on. Rather, it should be the combination of region and subsector. For both corporate obligations and CDOs backed by corporate obligations, we assign correlation add-ons only at the narrow sector level. As for 'specific ABS,' these relatively 'exotic' subsectors are generally affected by idiosyncratic risks that are not closely associated with region.

As in the corporate world, we consider the structured finance universe to consist of both 'local' and 'global' subsets. The second set of add-ons is related to the narrow sectors and is applicable only to pairs of assets that belong to the same 'local" narrow sector and the same region. For consumer ABS, this add-on will have different consequences according to the region as follows:

- For North America, the add-on will apply to pairs of securities within North America;
- For Europe, an add-on applies only if a pair of securities is in a single sub-region. The sub-regions will be defined either as the Eurozone, or as all the countries of the non-Eurozone;
- For Asia, the add-on will apply to pairs of securities within the same country in Asia. Thus for Asia, the concept of sub-region will be equal to each of its countries.

The values of each of these regional add-ons and the definition of 'local' vs. 'global' are summarized in *Appendix 3*.

Vintage Effects

The performance of certain structured finance classes will depend partly on when the transactions were originated. Economic conditions and underwriting standards will vary with time, affecting the capital structures and/or asset quality of transactions issued. However, one would only expect this impact to be relevant for narrowly-defined subsectors, such as manufactured housing.

Here too, statistical evidence offers little guidance, but there is ample anecdotal evidence of the vintage impact. CDO losses have been closely associated with certain vintages within a subsector,[11] and -- over the long haul -- CMBS instruments have tended to fare well or badly according to vintage.

Lacking sufficient statistical information, we make assumptions about vintage effects based on the understanding of Moody's experts within each sector. In general, we assume that the effect of vintage trails off rapidly as the number of months between the origination of two transactions within a subsector increases. More precisely, we assume that the vintage impact may be high or low for each narrow sector (*Figure 5*):

11 See "Default & Loss Rates of U.S. CDOs: 1993-2003," Moody's Special Report, March 2005.

Figure 5

Add-Ons to Account for Vintage Effects

Sectors	Vintage Effect
ABS - Consumer - Consumer ABS - Auto and Personal Lease	L
ABS - Consumer - Consumer ABS - Credit Card	L
ABS - Consumer - Consumer ABS - Student Loans	L
ABS - Consumer - RMBS - First & Second Lien Prime	L
ABS - Consumer - RMBS - Midprime	L
ABS - Consumer - RMBS - Subprime	L
ABS - Consumer - RMBS - Manufactured Housing	L
ABS - Consumer - ABS CDOs	L
ABS - Specific - Specific - Tax Lien	H
ABS - Specific - Specific - Mutual Fund Fees	H
ABS - Specific - Specific - Structured Settlement	H
ABS - Specific - Specific - Utility Stranded Cost	H
ABS - Specific - Specific - Big Ticket Lease	H
ABS - Specific - Specific - IP (including Entertainment Royalties)	H
ABS - Specific - Specific - Dealer's Floorplan	H
ABS - Specific - Specific - Tobacco Bonds	H
ABS - Commercial Real Estate - CMBS - Conduit	H
ABS - Commercial Real Estate - CMBS - Credit Tenant Lease	H
ABS - Commercial Real Estate - CMBS - Large Loans	H
ABS - Commercial Real Estate - REITs - …	H
ABS - Commercial Real Estate - Real Estate CDOs	H
ABS - Corporate related - CDO - CDO^n exposed to IG	H
ABS - Corporate related - CDO - CDO^n exposed to HY	H
ABS - Corporate related - CDO - CDO^n exposed to EM	H
ABS - Corporate related - CDO - CDO^n exposed to SME/SME Lease	L
ABS - Corporate related - CDO - Franchise Loan	L

We also assume that the vintage effect drops by a factor of four as the time span between the closing dates for two transactions doubles. The particular correlation add-ons for the high- and low-impact sectors are:

- High-asset correlation add-on equals 20% /[2^(time difference in years)].
- Low-asset correlation add-on equals 10% /[2^(time difference in years)].

In general, the vintage add-on will apply to a pair of credits only if either the sector is global or the sector is local and both instruments are in the same region. The situation is, however, a bit more complicated for the consumer meta sector where the vintage penalty will only apply if:

- The narrow sector is global, or
- The narrow sector is local and the two credits are in North America, or
- The narrow sector is local and the two credits are in the same country in Asia (i.e. in the same sub-region), or
- The narrow sector is local and the two credits are either together in the Eurozone, or together in Europe outside of the Eurozone (i.e. in the same sub-region).

This particular treatment for the consumer meta sector reflects our view that consumer-related transaction performance tends not to be linked strictly to regional factors, but rather to national influences. Of particular importance is the role of the European monetary union, which imposes significant correlation in performance related to economic integration. By contrast, pools backing, say, CMBS, are more likely to be fully pan-European (with assets both inside and outside the Eurozone).

Key Agent Relationships

Another source of performance correlation in the structured finance world is the role played by agents who are critical to a transaction. For some asset classes, the originator may play the single most important such role. In others, the servicer may be the key. In the (managed) CDO world, the collateral manager may affect the performance of a transaction significantly. Transactions that share such key agents-again only within a narrow subsector-may see pool performance jointly affected by the agent.

The impact of a shared key agent can be captured via another additive factor. In *Figure 6*, we identify the key agent for each affected subsector, as well as the asset correlation add-on that applies to that sector.

Figure 6

Key Agent Asset Correlation Add-on Factors

Sector Name	Key Agent	Key Agent Penalty
ABS - Consumer - Consumer ABS - Auto and Personal Lease	Originator	20%
ABS - Consumer - Consumer ABS - Credit Card	Originator	20%
ABS - Consumer - Consumer ABS - Student Loans	Originator	30%
ABS - Consumer - RMBS - First & Second Lien Prime	Servicer	10%
ABS - Consumer - RMBS - Midprime	Servicer	10%
ABS - Consumer - RMBS - Subprime	Servicer	20%
ABS - Consumer - RMBS - Manufactured Housing	Servicer	30%
ABS - Consumer - ABS CDOs	Manager / None if static	20%
ABS - Specific - Specific - Tax Lien	Servicer	20%
ABS - Specific - Specific - Mutual Fund Fees	Manager	10%
ABS - Specific - Specific - Structured Settlement	Servicer	20%
ABS - Specific - Specific - Utility Stranded Cost	NA	NA
ABS - Specific - Specific - Big Ticket Lease	Servicer	20%
ABS - Specific - Specific - IP (including Entertainment Royalties)	Originator	20%
ABS - Specific - Specific - Dealer's Floorplan	Seller	30%
ABS - Specific - Specific - Tobacco Bonds	NA	NA
ABS - Commercial Real Estate - CMBS - Conduit	NA	NA
ABS - Commercial Real Estate - CMBS - Credit Tenant Lease	NA	NA
ABS - Commercial Real Estate - CMBS - Large Loans	NA	NA
ABS - Commercial Real Estate - REITs - …	Manager	0%
ABS - Commercial Real Estate - Real Estate CDOs	Manager / None if static	20%
ABS - Corporate related - CDO - CDO^n exposed to IG	Manager / None if static	20%
ABS - Corporate related - CDO - CDO^n exposed to HY	Manager / None if static	20%
ABS - Corporate related - CDO - CDO^n exposed to EM	Manager / None if static	20%
ABS - Corporate related - CDO - CDO^n exposed to SME/SME Lease	Manager / Originator	20%
ABS - Corporate related - CDO - Franchise Loan	Originator	20%

The Key Agent add-on will apply if two credits are either in the same 'global' narrow sector or, if they are both in the same 'local' narrow sector AND in the same region. The rationale is that both underwriting standards and servicing practices tend to differ from region to region, as the functions are typically performed by different teams.

Same-Transaction Effect: 100% Asset Correlation

Finally, two tranches that are issued out of the same transaction share identical asset performance characteristics. Thus we assign 100% asset correlation to these tranches. The degree of actual *default* correlation will then depend on how different the ratings (default probabilities) are for the two tranches.

VIII. CONCLUSION

We have presented a framework for incorporating asset correlation assumptions into the modeling of CDOs backed by structured finance obligations. The framework, which has already been incorporated into Moody's CDOROM tool for the evaluation of synthetics, is similar to that for modeling corporate instruments, but takes account of some of the unique features of structured finance collateral.

Given the limited history of structured finance ratings performance, the method of estimating asset correlations is also a bit different from that employed in the corporate context. This same limitation on data availability also suggests a need to revisit these assumptions as more data become available, particularly with respect to asset classes that currently lack a sufficient history of rating movements.

12 The Key Agent Penalty should only apply to private student loan securitization and not to public ones.

APPENDICES

Appendix 1: Method of Estimating Asset Correlations Based on Rating Transitions

This appendix illustrates Moody's motivation for, and application of, a parametric approach for inferring asset correlations from a structured finance DRTM. This contrasts with the Kendall's Tau approach that was used in the corporate context.

Robustness of Kendall's Tau Approach

In general, the robustness of the Kendall's Tau method increases as the horizon selected to measure rating changes increases. The reason for this accuracy gain is that with the more evenly distributed matrix that results from a longer horizon, the estimation of correlation using nine buckets as a representation of a continuous distribution becomes a less relevant simplification.

In the case of corporate study, the 5-year horizon for estimating the DRTM allows for robust correlation estimation. This can be easily verified by using an example of Banking DRTM (*Figure A1*) and testing the estimation results under hypothesis of joint normality.

Figure A1

Example of Application of Kendall's Tau on DRTM for Banking Sector

	1	**0**	**-1**	
1	4.22%	11.12%	1.96%	17.30%
0	11.12%	50.08%	8.93%	70.13%
-1	1.96%	8.93%	1.68%	12.57%
	17.30%	70.13%	12.57%	100.00%

Using the methodology that we have described elsewhere,[13] we compute Kendall's tau of 5.7% and asset correlation of 8.9% for this example. We can easily test the robustness of this estimate using a joint normal process to recreate a DRTM for Banking assuming the same marginal distribution and the same asset correlation of 8.9%. The table below reproduces our findings

Figure A2

Theoretical DRTM Based on Assumed Marginal Distributions & Joint Normality

	1	**0**	**-1**	
1	3.60%	11.97%	1.72%	17.29%
0	11.97%	49.29%	8.86%	70.12%
-1	1.72%	8.86%	1.98%	12.56%
	17.29%	70.12%	12.56%	

The theoretical DRTM reflected in *Figure A2* was constructed assuming bivariate joint normality:

$$Pr\left(Z_i < \Phi^{-1}(\alpha_i), Z_j < \Phi^{-1}(\alpha_j)\right) = \int_{-\infty}^{\Phi^{-1}(\alpha_i)} \int_{-\infty}^{\Phi^{-1}(\alpha_j)} \phi(x, y, \rho_{ij}) dx dy$$

where $_{ij}$ corresponds to the assumed correlation parameter of 8.9% and a_i and a_j are mapped using the marginal distribution implied by the DRTM.

By re-applying the methodology to this new DRTM that we have simulated based on 8.9% assumed asset correlation, we calculate a figure of 9.4% -- quite close to the assumed level. This analysis can be replicated assuming different levels for the true asset correlation. *Figure A3* illustrates the results of this exercise.

13 See Footnote 1.

Figure A3

Error in Estimation of Asset Correlation via Kendall's Tau Approach--Banking

True correlation	Estimate	Error	% error
-8.94%	-9.44%	-0.50%	5.6%
8.94%	9.44%	0.50%	5.6%
17.88%	18.82%	0.95%	5.3%
26.81%	28.08%	1.27%	4.7%

As we observe in *Figure A3*, the methodology typically produces roughly a 6% error in relation to the "true" estimate. Importantly, the error does not change as correlation increases or decreases to negative regions.

The Problem in Applying Kendall's Tau in the Structured Finance Context

In the case of Moody's structured finance DRTM study, we have found that most of the rating co-movement data is concentrated in the last five years. Thus we cannot simply repeat the corporate DRTM exercise, which required the examination of multiple five-year periods, for the structured finance ratings co-movement analysis. Rather, the lack of data across a large span of time required the use of a one-year horizon to measure the structured finance DRTM. Unfortunately for the purpose of analysis, structured finance ratings tend to change very little over a one-year horizon.

To illustrate the problem, the DRTM in *Figure A4* corresponds to the Manufactured Housing sector:

Figure A4

DRTM for Manufactured Housing

	1	0	-1	
1	0.007%	0.600%	0.002%	0.609%
0	0.600%	98.563%	0.120%	99.283%
-1	**0.000%**	0.120%	0.003%	0.123%
	0.607%	99.283%	0.125%	100.0%

The very high joint probability of remaining in the same rating is characteristic of nearly all structured finance sectors. It is explained both by the shorter horizon of analysis in relation to corporates-the probability of a joint rating change over a 1-year horizon is lower than over a 5-year horizon-and in many cases by the greater stability of structured finance asset classes relative to corporates.

We now replicate the sensitivity analysis that we performed for the banking DRTM, but instead apply this to the Manufactured Housing estimates. The results are presented in *Figure A5* below.

Figure A5

Error in Estimation of Asset Correlation Via Kendall's Tau Approach-Manufactured Housing

	True correlation	Estimate	Error	% error
-1	-1.13%	-0.102%	0.010252	-91%
1	1.13%	0.099%	-0.010286	-91%
2	2.25%	0.210%	-0.020444	-91%
3	3.38%	0.326%	-0.030563	-90%

We can easily see that the order of magnitude of the estimation error produces non robust correlation estimates under joint normality (which is the implied assumption in CDOROM.). For any asset class whose rating co-movements give rise to a DRTM like that of Manufactured Housing-i.e., one that cannot support robust asset correlation estimates via Kendall's Tau approach-an alternative technique must then be applied. Although we have illustrated the problem for the Manufactured Housing sector, it is present for virtually all structured finance sectors.

An Alternative Approach for Inferring Asset Correlations from the DRTM when Data is Sparse

The alternative method is to use a parametric estimate calibrated through the joint normal formula by trial and error of the correlation parameter so that the joint normal probability matches the observed DRTM probability.[14] A natural consequence of this alternative parametric approach is that depending on the region of the DRTM selected, the implied correlation could change substantially. A qualitative decision is required to determine a unique final estimate.

For example, again focusing on the MH sector, we see that one can derive rather different estimates by focusing on the cell of the DRTM that represents a joint upgrade, vs. that representing a joint downgrade:

Figure A6
DRTM for Manufactured Housing

	Upgrade	Constant	Downgrade
Upgrade	**0.007%**	0.6%	0.002%
Constant	0.6%	98.563%	0.12%
Downgrade	0.0002%	0.12%	0.0028%

Knowing the marginal probability that any Manufactured Housing credit will be upgraded over a one-year period, we can iteratively solve for asset correlation ($_{ij}$) to reproduce the .007% incidence of joint upgrade. That is,

$$
\begin{aligned}
Pr\left(Z_i < \Phi^{-1}(\alpha_i), Z_j < \Phi^{-1}(\alpha_j)\right) &= \int_{-\infty}^{\Phi^{-1}(\alpha_i)} \int_{-\infty}^{\Phi^{-1}(\alpha_j)} \phi(x, y, \rho_{ij}) dx dy \\
&= \int_{-\infty}^{\Phi^{-1}(\alpha_i)} \int_{-\infty}^{\Phi^{-1}(\alpha_j)} \frac{1}{2\pi\sqrt{1-\rho_{ij}^2}} \exp^{\frac{1}{2(1-\rho_{ij}^2)}\{x^2 - 2\rho_{ij}xy + y^2\}} dx dy \\
&= \int_{-\infty}^{-2.5} \int_{-\infty}^{-2.5} \phi(x, y, \rho_{ij}) dx dy \\
&= 0.007\%
\end{aligned}
$$

The calculated asset correlation is 9%. But the same exercise for the joint downgrade case implies $_{ij}$ = 35%, while the upgrade/downgrade case suggests $_{ij}$ = -13%.

Given this range of possible outcomes, we have chosen the most conservative course, which is simply to pick the highest of the estimates.[15]

14 The joint normal distribution is not the only possible choice here, but is by far the most widely used distribution in the market, is computationally convenient, and is consistent with the normal copula approach in Moody's CDOROM tool.

15 This is certainly the most conservative assumption for the vast majority of rated CDO tranches. Since this may not be true for some unusual structures (e.g., first-to-default transactions), these results should not be applied in such rare circumstances.

Appendix 2: Additive Factors For Sector

Global 1%	*Consumer 2%*	Consumer ABS 3%	Auto Loan and Personal Lease 19% Credit Card 15% Student Loans 13%
		RMBS 1%	First & Second Lien Prime 13% Midprime 15% Subprime 18% Manufactured Housing 38%
			ABS CDOs 12%
	Specific 0%		Tax Lien 29% Mutual Fund Fees 29% Structured Settlements 29% Utility Stranded Costs 29% Big Ticket Lease 29% IP (including Entertainment Royalties) 29% Dealer's Floorplan 29% Tobacco Bonds 99%
	Commercial Real Estate 1%	CMBS 1%	Conduit 8% Credit Tenant Lease 8% Large Loans 8%
		REITS 9%	…… 10%
			Real Estate CDOs 8%
	Corporate related 2%	CDOs 1%	CDO^n exposed to IG 31% CDO^n exposed to HY 20% CDO^n exposed to EM 20% CDO^n exposed to SME/SME Lease 20% Franchise Loan 20%
		Corporates 0%	….. 12%[15]

16 The add-on corresponding to each corporate sector can be 7%, 12% or 17% depending on the sector. See "Moody's Revisits Its Assumptions Regarding Corporate Default (and Asset) Correlations for CDOs," Moody's Rating Methodology, November 2004.

Appendix 3: Definition of "Local/Global" for each Narrow Sector			
Sectors	**Local or Global**	**Narrow Sector add-on if in same region**	**Narrow Sector add-on if in diff. regions**
ABS - Consumer - Consumer ABS - Credit Card	L	15%	0%
ABS - Consumer - Consumer ABS - Auto and Personal Lease	L	19%	0%
ABS - Consumer - Consumer ABS - Credit Card	L	15%	0%
ABS - Consumer - Consumer ABS - Student Loans	L	13%	0%
ABS - Consumer - RMBS - First & Second Lien Prime	L	13%	0%
ABS - Consumer - RMBS - Midprime	L	15%	0%
ABS - Consumer - RMBS - Subprime	L	18%	0%
ABS - Consumer - RMBS - Manufactured Housing	L	38%	0%
ABS - Consumer - ABS CDOs	G	12%	12%
ABS - Specific - Specific - Tax Lien	L	29%	0%
ABS - Specific - Specific - Mutual Fund Fees	L	29%	0%
ABS - Specific - Specific - Structured Settlement	L	29%	0%
ABS - Specific - Specific - Utility Stranded Cost	G	29%	29%
ABS - Specific - Specific - Big Ticket Lease	G	29%	29%
ABS - Specific - Specific - IP (including Entertainment Royalties)	G	29%	29%
ABS - Specific - Specific - Dealer's Floorplan	L	29%	0%
ABS - Specific - Specific - Tobacco Bonds	G	99%	99%
ABS - Commercial Real Estate - CMBS - Conduit	G	8%	8%
ABS - Commercial Real Estate - CMBS - Credit Tenant Lease	G	8%	8%
ABS - Commercial Real Estate - CMBS - Large Loans	G	8%	8%
ABS - Commercial Real Estate - REITs - …	G	10%	10%
ABS - Commercial Real Estate - Real Estate CDOs	G	8%	8%
ABS - Corporate related - CDO - CDO^n exposed to IG	G	31%	31%
ABS - Corporate related - CDO - CDO^n exposed to HY	G	20%	20%
ABS - Corporate related - CDO - CDO^n exposed to EM	G	20%	20%
ABS - Corporate related - CDO - CDO^n exposed to SME/SME Lease	L	20%	0%
ABS - Corporate related - CDO - Franchise Loan	L	20%	0%

Appendix 4: ABS and Corporate sectors list

Sectors
Consumer - Consumer ABS - Auto Loan and Personnal Lease
Consumer - Consumer ABS - Credit Card
Consumer - Consumer ABS - Student Loans
Consumer - RMBS - First & Second Lien Prime (For US RMBS, Weighted Average FICO of 700 or higher)
Consumer - RMBS - Midprime (For US RMBS, Weighted Average FICO between 625 and 700)
Consumer - RMBS - Subprime (For US RMBS, Weighted Average FICO of 625 or lower)
Consumer - RMBS - Manufactured Housing
Consumer - ABS CDOs
Specific - Specific - Tax Lien
Specific - Specific - Mutual Fund Fees
Specific - Specific - Structured Settlement
Specific - Specific - Utility Stranded Cost
Specific - Specific - Big Ticket Lease
Specific - Specific - IP (including Entertainment Royalties)
Specific - Specific - Dealer's Floorplan
Specific - Specific - Tobacco Bonds
Commercial Real Estate - CMBS - Conduit
Commercial Real Estate - CMBS - Credit Tenant Lease
Commercial Real Estate - CMBS - Large Loans
Commercial Real Estate - REITs - Hotel
Commercial Real Estate - REITs - Multi family
Commercial Real Estate - REITs - Office
Commercial Real Estate - REITs - Retail
Commercial Real Estate - REITs - Industrial
Commercial Real Estate - REITs - Healthcare
Commercial Real Estate - REITs - Self-storage
Commercial Real Estate - REITs - Diversified
Commercial Real Estate - Real Estate CDOs
Corporate related - CDO - CDO^n exposed to IG
Corporate related - CDO - CDO^n exposed to HY
Corporate related - CDO - CDO^n exposed to EM
Corporate related - CDO - CDO^n exposed to SME and SME Lease
Corporate related - CDO - Franchise Loans
Corporate related - Corporate - Aerospace and Defense
Corporate related - Corporate - Automobile
Corporate related - Corporate - Banking
Corporate related - Corporate - Beverage, Food and Tobacco
Corporate related - Corporate - Buildings and Real Estate
Corporate related - Corporate - Chemicals, Plastics and Rubber
Corporate related - Corporate - Containers, Packaging and Glass
Corporate related - Corporate - Personal and Non Durable Consumer Products (Manufacturing Only)
Corporate related - Corporate - Diversified/Conglomerate Manufacturing
Corporate related - Corporate - Diversified/Conglomerate Service
Corporate related - Corporate - Diversified Natural Resources, Precious
Corporate related - Corporate - Ecological
Corporate related - Corporate - Electronics
Corporate related - Corporate - Finance
Corporate related - Corporate - Farming and Agriculture
Corporate related - Corporate - Grocery
Corporate related - Corporate - Healthcare, Education and Childcare

Appendix 4: ABS and Corporate sectors list

Sectors
Corporate related - Corporate - Home and Office Furnishings, Housewares, and Durable Consumer Products
Corporate related - Corporate - Hotels, Motels, Inns and Gaming
Corporate related - Corporate - Insurance
Corporate related - Corporate - Leisure, Amusement, Entertainment
Corporate related - Corporate - Machinery (Non-Agriculture, Non-Construction, Non-Electronic)
Corporate related - Corporate - Mining, Steel, Iron and Non Precious Metals
Corporate related - Corporate - Oil and Gas
Corporate related - Corporate - Personal, Food and Miscellaneous
Corporate related - Corporate - Printing and Publishing
Corporate related - Corporate - Cargo Transport
Corporate related - Corporate - Retail Stores
Corporate related - Corporate - Telecommunications
Corporate related - Corporate - Textiles and Leather
Corporate related - Corporate - Personal Transportation
Corporate related - Corporate - Utilities
Corporate related - Corporate - Broadcasting & Entertainment
Corporate related - Corporate - Sovereign & Supranational

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