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DECONSTRUCTING CREDIT VOLATILITY

Credit risk presents an issue for many types of investors. Asset mangers are concerned with return volatility of their portfolios as well as the risk of default. Indexers need to understand credit risk to ensure the best possible benchmark tracking by portfolios that may comprise only a fraction of securities in the index. Insurance companies operating on the book value basis may not be concerned with market volatility at all. For them, risk is a possibility of capital loss after a write-down of an impaired security. The rules for such write-downs vary, but in most cases impairment is driven by an adverse credit rating transition (downgrade or default). All these investors would benefit from a deeper understanding of sources of credit risk, their interaction and relative importance.

Corporate bond returns can be attributed to three sources:

Treasury curve movement
Systematic spread change (common to a particular group)
Idiosyncratic (issuer-specific) spread change

One can argue that to obtain a better handle on special risk one should consider spread changes of bonds that experienced rating transitions separately. The changes in spreads of all other bonds in the peer group can be assumed to be a zero mean random "noise" or "natural" volatility. Intuitively, we can expect the volatility coming from bonds experiencing rating transitions (particularly downgrades) to dominate the idiosyncratic risk. In our recent study[1] we set out to test and quantify this effect in the U.S. investment-grade credit market. To exclude the curve component of systematic risk, we started by using excess returns over duration-matched Treasuries.[2] To eliminate the remaining spread component of systematic risk, we further defined underperformance of downgraded bonds as the difference between their excess return and that of the peer group (defined as a sector/quality/duration bucket). As a result, we were able to concentrate exclusively on risk due to downgrades. We then proceeded to measure historical consequences of adverse rating transitions and to suggest an approach to structuring portfolio that would minimize such risk.

Now we are expanding our analysis of sources of credit risk by studying full excess returns over Treasuries. This allows us to look at all non-term structure components of credit risk: systematic (common to a particular peer group) spread changes, and two components of the idiosyncratic risk: the "natural" volatility of bonds with unchanged ratings, and the volatility associated with upgrades or downgrades.

We define twelve peer groups by dividing the Lehman Credit Index by quality (Aaa-Aa, A, and Baa) and sector (Industrials, Financials, Utilities, and Non-U.S.). Starting at the earliest point for which we have individual security data (August 1988), we perform the following:

[1] *Sufficient Diversification in Credit Portfolios*, Lehman Brothers, May 2002.

[2] *A New Method of Excess Returns Computation*, in *Global Relative* Value, Lehman Brothers, September 2000.

Each month, we "look" forward over the next six months in our time series and divide all cells into three groups:

"Stable"	bonds whose ratings will remain unchanged for the next six months
"Downgrades"	bonds headed for a downgrade
"Upgrades"	bonds headed for an upgrade

Unlike our previous study of credit downgrades where we concentrated only on full letter grade rating changes, this time we consider any change in rating (e.g., Baa1 to Baa2).[3]

Within each of these three groups, we measure the monthly mean and standard deviation of excess return versus Treasuries, as well as the percent of the cell market value formed by each group. We then aggregate this cross-sectional information over time to find the overall mean and standard deviation of excess return for each category. Figures 1 and 2 show the resulting statistics, by sector/quality cell and by quality.

[3] Further, if a bond has a rating change that gets reversed within the same six-month period, we consider only the first event. Consider a bond that gets downgraded in August and has its rating restored in October. In the six months leading up to August (February through July) we consider it a security headed for a downgrade. Of course, starting in April, the October upgrade will also appear in our foresight. This creates a dilemma: how should we treat this security between April and August? We assumed that the market should be anticipating the downgrade, not the subsequent reversal. So, in cases like that, the second rating transition within the same six-month period is ignored. Starting in August, of course, the bond will be reclassified as "headed for an upgrade."

Figure 1. **Excess Return Statistics for the Downgrades, Stable, and Upgrades Groups, by Sector-Quality Cells**
August 1988–September 2001*

	Overall Number of Bonds			**Mean Excess Returns** (bp/year)			**Std Dev Excess Returns** (bp/year)		
Cell	**Down**	**Stable**	**Up**	**Down**	**Stable**	**Up**	**Down**	**Stable**	**Up**
Aaa-Aa Industrials	2,552	24,850	452	-255	15	9	582	289	199
Aaa-Aa Finance	3,101	39,666	897	68	55	-12	380	280	290
Aaa-Aa Utilities	3,801	43,647	60	-21	31	84	294	293	210
Aaa-Aa Non-U.S.	2,273	34,781	439	-14	58	37	422	296	149
A Industrials	9,455	83,359	3,437	-364	26	-17	663	331	355
A Finance	6,183	78,794	7,788	-99	59	4	516	277	261
A Utilities	3,280	52,002	1,588	-202	39	66	609	304	277
A Non-U.S.	1,467	22,937	1,011	-499	48	76	962	308	282
Baa Industrials	6,954	62,420	5,224	-1,054	54	137	1588	441	383
Baa Finance	1,806	21,076	4,818	-816	119	228	1145	406	362
Baa Utilities	2,542	47,511	4,747	-34	56	109	575	357	413
Baa Non-U.S.	659	12,636	806	-1,477	48	291	1886	498	552

* Looking six months forward means that the study actually uses data through March 2002.

Figure 2. **Excess Return Statistics for the Downgrades, Stable, and Upgrades Groups, by Credit Quality Only**
August 1988–September 2001

	Overall Number of Bonds			**Mean Excess Returns** (bp/year)				**Std Dev Excess Returns** (bp/year)			
Quality	**Down**	**Stable**	**Up**	**Down**	**Stable**	**Up**	**All**	**Down**	**Stable**	**Up**	**All**
Aaa-Aa	11,727	142,944	1,848	-47	41	8	34	419	290	239	301
A	20,385	237,092	13,824	-267	42	11	17	642	306	290	343
Baa	11,961	143,643	15,595	-825	64	165	11	1,395	415	397	547

The results in Figure 1 confirm that both the loss and the volatility associated with downgrades increase dramatically for lower qualities. Of course, higher volatility is expected in lower qualities. Yet, the increase in the volatility in the stable group is much less dramatic. For example, the ratio of standard deviation between Baa and Aaa-Aa industrials is 2.7 in the downgrades group versus 1.5 in the stable group. For the non-US debt, this effect is even more pronounced: 4.5 versus 1.7. This may be due to a greater uncertainty about the handling of distressed debt in countries other than U.S. The conclusion one can draw from this is that the group-wide risk is relatively more important in higher qualities. On the other hand, in the lower qualities the event risk dominates. This finding has significant implications for risk management practices. Sector/quality distinctions apparently become much less relevant in lower qualities. Rather, it is "each bond/issuer for itself." Clearly, in that part of the credit spectrum, less attention should be paid to the matching of structural composition of a benchmark. Instead, more effort should be put in diversifying issuer allocation.

Figure 2 provides an aggregate view of this phenomenon. Interestingly, if one looks at the average excess return and excess return volatility in the stable group, there seems to be very little reason to pay up for Aaa-Aa bonds compared to single-A. It is in the downgrades group that the higher quality advantage manifests itself with the mean excess return of -47 bp/year (Aaa-Aa) versus a much more negative -267 bp/year (single-A).

We found it instructive to study the correlations between various groups in our dataset in an effort to better understand the potential cross-influences between bonds experiencing rating transitions and the rest of their peers. For example, we wanted to see whether bonds headed for a downgrade might impact their whole peer group, essentially "dragging" the other bonds down with them. Figure 3 summarizes our findings. We computed correlations between the mean excess return of stable bonds and a variety of other time series. As expected, the mean excess return on stable bonds is nearly perfectly correlated with the mean excess return for the cell as a whole (row B). This is hardly surprising given that stable bonds invariably represent the overwhelming majority of their group. The market value percentage of the downgrades group does not seem to have any effect on the stable bonds. The cross-cell average correlation of market value share of downgraded bonds (row C) with the mean excess return of stable bonds is a mere -0.02. The mean excess return for downgraded

Figure 3. **Correlations Among Different Components of Excess Returns, by Sector-Quality Cells**
August 1988–September 2001

		Aaa-Aa				A				Baa			
	Correlations between	**Ind**	**Fin**	**Util**	**Non-U.S.**	**Ind**	**Fin**	**Util**	**Non-U.S.**	**Ind**	**Fin**	**Util**	**Non-U.S.**
A	Mean excess return of stable bonds **and:**												
B	Mean excess return of the bucket	0.98	0.99	0.99	0.99	0.99	0.99	0.92	0.96	0.97	0.97	1.00	0.98
C	Percent of MV in the downgrade category	0.04	0.01	-0.11	0.08	0.04	-0.09	-0.05	0.07	-0.07	-0.20	0.12	-0.11
D	Mean excess return of downgraded bonds	0.77	0.72	0.51	0.66	0.81	0.88	0.37	0.45	0.55	0.69	0.31	0.50
E	Mean underperf. of downgraded bonds (D - A)	0.43	0.26	-0.31	0.22	0.38	0.50	0.01	0.03	0.28	0.42	-0.14	0.21
F	Mean contrib. of downgrades to underperf. (C x E)	0.47	0.11	-0.32	0.24	0.38	0.44	0.07	0.14	0.33	0.52	0.08	0.28

bonds is correlated fairly highly with the mean excess return for stable bonds (row D). This could be an indication that the "falling angels" do drag their peers down with them. On the other hand, it could merely indicate that all bonds in the cell are reacting to the same systematic spread changes.

To find out, we checked whether the mean returns on stable bonds are correlated with the mean *underperformance* of the downgraded bonds (row E). The results were mixed — some cells do show significant correlations (e.g., 0.43 in the Aaa-Aa industrials, 0.50 in the A Finance), while in other cells the correlations are near zero or even negative (e.g., utilities). Similar results are found when instead of absolute underperformance we looked at the mean *contribution* to underperformance in the downgrades group (row F). Clearly, more analysis in warranted here. These correlations will increase when common market factors cause both increase in the number and severity of downgrades and depress excess returns in the market segment.

Figure 4 presents the correlations among the mean excess returns of stable bonds from different cells. The stable-rating group volatility represents both systematic spread risk and "natural" or random idiosyncratic variation. Particularly in months with significant spread movements, we expect the systematic component to dominate. Indeed, closely related cells tend to exhibit higher correlations. For example, single-A industrials exhibit a correlation of 0.93 with Aaa-Aa industrials and 0.92 with Baa industrials, while the correlations with other sectors range from 0.68 to 0.85.

We also looked at the correlations among the contributions to underperformance from downgrades in different cells (Figure 5). The risk of downgrades is a component of idiosyncratic risk, because it affects a single issuer at a time. As such, one might expect zero correlations between the downgrade risks of the separate cells. In many cases we find this to be true, particularly if we look at different sectors (even within the same quality rating). However, there does seem to be some non-zero correlation of downgrade risk within sectors. For instance, the downgrade risk of single-A industrials has a correlation of 0.44 with Aaa-Aa industrials and 0.52 with Baa industrials.

Our findings about the relative importance of systematic and non-systematic risk in different credit qualities can be expressed more intuitively if we report percent

Figure 4. **Cross-Cell Correlations among the Mean Excess Returns in the Stable Group,** August 1988–September 2001

	Aaa-Aa				**A**				**Baa**			
Cell	**Ind**	**Fin**	**Util**	**Non-U.S.**	**Ind**	**Fin**	**Util**	**Non-U.S.**	**Ind**	**Fin**	**Util**	**Non-U.S.**
Aaa-Aa Industrials	1.00	0.75	0.76	0.67	0.93	0.76	0.77	0.73	0.82	0.60	0.79	0.62
Aaa-Aa Finance	0.75	1.00	0.64	0.74	0.81	0.92	0.65	0.76	0.77	0.82	0.67	0.63
Aaa-Aa Utilities	0.76	0.64	1.00	0.61	0.75	0.66	0.91	0.68	0.70	0.53	0.79	0.61
Aaa-Aa Non-U.S.	0.67	0.74	0.61	1.00	0.68	0.74	0.63	0.81	0.68	0.63	0.60	0.67
A Industrials	0.93	0.81	0.75	0.68	1.00	0.85	0.80	0.81	0.92	0.74	0.83	0.70
A Finance	0.76	0.92	0.66	0.74	0.85	1.00	0.69	0.84	0.85	0.89	0.73	0.72
A Utilities	0.77	0.65	0.91	0.63	0.80	0.69	1.00	0.75	0.78	0.61	0.89	0.66
A Non-U.S.	0.73	0.76	0.68	0.81	0.81	0.84	0.75	1.00	0.82	0.75	0.76	0.85
Baa Industrials	0.82	0.77	0.70	0.68	0.92	0.85	0.78	0.82	1.00	0.81	0.87	0.77
Baa Finance	0.60	0.82	0.53	0.63	0.74	0.89	0.61	0.75	0.81	1.00	0.67	0.74
Baa Utilities	0.79	0.67	0.79	0.60	0.83	0.73	0.89	0.76	0.87	0.67	1.00	0.72
Baa Non-U.S.	0.62	0.63	0.61	0.67	0.70	0.72	0.66	0.85	0.77	0.74	0.72	1.00

contributions to the total variance from the three groups. A simple method of variance decomposition is presented in the Appendix. The results, shown in Figure 6, confirm our previous conclusion. In the Aaa-Aa category, the stable group accounts for 84.7% of the total variance, while the downgrades group—for only 14.6%. In the Baa category, this relationship is dramatically different: the contribution of the stable and downgrades to the total variance are practically equal! To appreciate the true significance of this one should notice (also in Figure 6) that, in the Baa category, the downgrades group accounts for only 7% of all observations, and the stable group for 84%!

The issue of credit risk composition is important to all credit asset managers, albeit for different reasons. Passive managers tracking a broad market index are faced with a problem of selecting a small subset of index securities that will (a) match the index composition along all systematic risk dimensions, and (b) have the minimum possible event risk. While hedging systematic risk is relatively easy, the idiosyncratic risk presents a more serious problem, especially in small portfolios. Our inquiries into the nature of idiosyncratic risk will hopefully make this task more manageable. Other categories of investors may be concerned more with the balance sheet implications of securities in their portfolios (which may be held to maturity) than with the day-to-day market volatility. This is a very different perspective from, for example, that of a total return manager and requires very different risk metrics. While the "natural" spread/return variance of credit securities may be of little importance, the downgrade risk is extremely relevant. Such investors benefit from the ability to separate the downgrade risk from the other components of the non-systematic risk.

Figure 5. **Cross-Cell Correlations of Contributions to Underperformance in the Downgrades Group**
Percent x Peer Group Underperformance, August 1988–September 2001

	Aaa-Aa				A				Baa			
Cell	**Ind**	**Fin**	**Util**	**Non-U.S.**	**Ind**	**Fin**	**Util**	**Non-U.S.**	**Ind**	**Fin**	**Util**	**Non-U.S.**
Aaa-Aa Industrials	1.00	0.04	-0.35	0.23	0.44	0.34	-0.05	0.03	0.31	0.29	-0.04	0.67
Aaa-Aa Finance	0.04	1.00	-0.06	0.14	0.02	0.43	0.00	0.11	0.26	0.09	0.11	0.06
Aaa-Aa Utilities	-0.35	-0.06	1.00	-0.02	-0.17	-0.12	0.02	-0.04	-0.27	-0.09	0.07	-0.23
Aaa-Aa Non-U.S.	0.23	0.14	-0.02	1.00	0.12	0.07	0.00	-0.02	0.12	0.09	-0.04	0.08
A Industrials	0.44	0.02	-0.17	0.12	1.00	0.24	0.29	0.25	0.52	0.36	0.06	0.39
A Finance	0.34	0.43	-0.12	0.07	0.24	1.00	0.03	0.06	0.29	0.33	0.12	0.33
A Utilities	-0.05	0.00	0.02	0.00	0.29	0.03	1.00	0.22	0.09	0.02	0.32	-0.01
A Non-U.S.	0.03	0.11	-0.04	-0.02	0.25	0.06	0.22	1.00	0.13	0.01	0.17	0.19
Baa Industrials	0.31	0.26	-0.27	0.12	0.52	0.29	0.09	0.13	1.00	0.39	-0.01	0.31
Baa Finance	0.29	0.09	-0.09	0.09	0.36	0.33	0.02	0.01	0.39	1.00	-0.06	0.20
Baa Utilities	-0.04	0.11	0.07	-0.04	0.06	0.12	0.32	0.17	-0.01	-0.06	1.00	0.03
Baa Non-U.S.	0.67	0.06	-0.23	0.08	0.39	0.33	-0.01	0.19	0.31	0.20	0.03	1.00

Figure 6. **Variance Decomposition by Credit Quality**
August 1988–September 2001

	Percent of Overall Bonds			Percent of Variance		
Quality	**Down**	**Stable**	**Up**	**Down**	**Stable**	**Up**
Aaa-Aa	7.5	91.3	1.2	14.6	84.7	0.7
A	7.5	87.4	5.1	26.8	69.6	3.7
Baa	7.0	83.9	9.1	46.7	48.4	4.9

Appendix. Total Variance Decomposition

Let us define r_{it} as the excess return of bond i in month t, and N_t as the number of observations (bonds) in month t.

We can compute the mean and variance of the excess returns observed in a particular month t as follows:

$$\mu_t = \frac{SUM_t}{N_t}, \qquad \sigma_t^2 = \frac{N_t SSQ_t - SUM_t^2}{N_t(N_t - 1)}$$

where

$$SUM_t = \sum_{i=1}^{N_t} r_{it}$$
$$SSQ_t = \sum_{i=1}^{N_t} r_{it}^2$$

Similarly, if we sum all of these quantities over time and define

$$N = \sum_t N_t \qquad SUM = \sum_t SUM_t \qquad SSQ = \sum_t SSQ_t$$

then the mean and variance of excess returns of all bonds observed over time are given by:

$$\mu = \frac{SUM}{N}, \qquad \sigma^2 = \frac{N\,SSQ - SUM^2}{N(N-1)}$$

Now let us split the N_t bonds we observed each month into three categories: upgrades, downgrades, and stable. The same statistics can be calculated separately for each category. The quantities that are pure sums are additive within one month and over time:

$$N = \sum_t (N_t^{DG} + N_t^{UG} + N_t^{ST})$$
$$SUM = \sum_t (SUM_t^{DG} + SUM_t^{UG} + SUM_t^{ST})$$
$$SSQ = \sum_t (SSQ_t^{DG} + SSQ_t^{UG} + SSQ_t^{ST})$$

We can then express the overall variance σ^2 calculated above in terms of the statistics for the three categories as follows:

$$\sigma^2 = \frac{N\left(SSQ^{DG} + SSQ^{UG} + SSQ^{ST}\right) - SUM \times SUM}{N(N-1)}$$
$$= \frac{N\,SSQ^{DG} - SUM \times SUM^{DG}}{N(N-1)} + \frac{N\,SSQ^{UG} - SUM \times SUM^{UG}}{N(N-1)} +$$
$$\frac{N\,SSQ^{ST} - SUM \times SUM^{ST}}{N(N-1)}$$

Each of these three terms can be interpreted as the percentage of the total variance, which gives us the desired decomposition.