



## Market Implied Ratings

A simple approach to improve the classification of bonds and produce superior risk forecasts

### Ludovic Breger\*

Manager  
Fixed Income Research  
Barra  
2100 Milvia Street  
Berkeley, CA 94709  
Phone: 510-649-4613  
Fax: 510-848-0954  
ludovic.breger@barra.com

### Lisa Goldberg

Vice-President  
Credit Research  
Barra  
2100 Milvia Street  
Berkeley, CA 94709  
Phone: 510-649-4601  
Fax: 510-848-0954  
lrg@barra.com

### Oren Cheyette

Vice-President  
Fixed Income Research  
Barra  
2100 Milvia Street  
Berkeley, CA 94709  
Phone: 510-649-6425  
Fax: 510-848-0954  
oren.cheyette@barra.com

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## Introduction

In recent years, the growth of the global credit market has been spectacular. From an investor perspective, this has created many new opportunities for higher returns and diversification, but a careful management of risk is more necessary than ever. In this context, measures of credit quality are becoming an increasingly important reference.

Agency ratings are a standard measure of credit quality. The question of capital requirements and the recent collapse of several high-profile large corporations have fueled a vigorous debate about agency ratings. Although not necessarily timely indicators of a company's ability to repay its debt, they are still likely to remain a convenient, widely used reference that can be used across markets and financial institutions (see for instance Basel Committee on Banking Supervision, 1999).

Agency credit ratings are designed to indicate the probability that a given borrower will fail to service its debt, but they serve other purposes. In particular, they are useful as an ingredient to multi-factor risk models. Such models assume that returns of bonds with similar sector and rating will be highly correlated, and use agency ratings to build common factors. In the last thirty years, most attempts to improve on agency ratings have come from a mathematical approach (e.g.

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\* Corresponding author

Merton (1974), Black-Cox (1976)) that generates equity market-based default probabilities, a statistical approach based around conditional default rates (e.g. Duffie-Singleton (1995), Jarrow-Turnbull (1995)), and more recently an hybrid approach (Giesecke (2001), Giesecke-Goldberg (2003)). These approaches result in arguably better credit risk forecasts but do not incorporate agency rating information.

This study differs from most in the literature in two ways. First, we derive price-based equivalent ratings, rather than default probabilities based on firm fundamentals. For many practitioners in the credit area, improving forecasts of default risk has so far been the central concern. This study, in contrast, looks at a market-based approach to classifying bonds, improving spread risk forecasts, and detecting rating anomalies. Finally, in contrast again to typical fundamental models of default, our data come directly from the bond market rather than the equity market.

## From Agency to Market Implied Ratings

Yield spreads between corporate and government bonds compensate investors for risk due to rating changes and defaults, liquidity, and disparate tax treatments. They can be computed as long as a price is available, in particular for non-rated issuers. The link between agency ratings and credit spreads has produced an abundant literature (e.g. West, 1973; Liu and Thakor, 1984; Altman 1989; Kao and Wu, 1990) and the general trend is well identified, with average spreads increasing as credit quality decreases. Individual spreads also vary significantly about their mean (Altman, 1989), and Taylor and Perraudin (2001) have more recently shown the presence of highly persistent inconsistencies between credit ratings and bond yields, even after correction for disparate liquidity and tax effects. Unlike previous studies, our goal is not to understand the origin of such inconsistencies but rather to use them to advantage, incorporating the information they carry into market-based rating revisions. We now illustrate our approach using data from the two largest credit markets.

Figure 1 shows the distribution of average issuer spreads for the US dollar domestic and Euro markets for different rating categories<sup>1</sup>. Corporate bond data are taken from the Merrill Lynch U.S. Corporate/Government Master Index (Merrill Lynch, 2000), and the Salomon Smith Barney EuroBig index (Salomon Smith Barney, 1999). These distributions are based on issuers rather than issues; the spread of an issuer is taken to be the average spread of its outstanding bonds<sup>2</sup>. As expected, average spreads increase with decreasing credit quality. However, there are large overlaps between individual rating sub-distributions. These overlaps make it impossible to unambiguously extract the original rating from the spread. Nevertheless, we can use this observed distribution to build an implied classification, and use it to associate to any issuer an estimate of what its rating *should be*.

In the implied classification, ratings are determined by Option Adjusted Spread (OAS) level<sup>3</sup>. The only question is where the boundaries between classes should be drawn. Our approach to answering this question is based on the assumption that agency ratings are, on average, informative. We create a penalty function that is increased only by a bond whose implied classification differs from its agency classification. The variables in the penalty function are the thresholds between implied rating classes. The values that minimize the penalty function are

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<sup>1</sup> Data limitations lead us to use coarse ratings (AAA, AA etc...) rather than "finer" ratings such as AA+ or BBB-. Standard and Poor's and Moody's reported bond ratings are combined into an average issuer agency rating obtained as described in Appendix A.

<sup>2</sup> US spreads are computed relative to the Treasury yield curve whereas euro spreads are with respect to the swap curve

<sup>3</sup> The credit spread of a bond that includes a call, put or sinking-fund schedule is based on the bond's price corrected for the option value, and referred to as Option Adjusted Spread.

taken to be the implied classification thresholds. Equation 0.1 shows the penalty function for a given threshold vector  $b$ .<sup>4</sup>

$$P(b) = \sum_j \left[ w_j (s_j - b_{i(j)}^+)^+ + w_j (b_{i(j)}^- - s_j)^+ \right] \quad (0.1)$$

$i(j)$  = agency rating index of issuer  $j$

$s_j$  = spread of issuer  $j$

$b_l^-$  = lower threshold for implied rating index  $l$

$b_l^+$  = upper threshold for implied rating index  $l$

$N$  = total number of issuers in the universe

$N_l$  = number of issuers with rating index  $l$

$w_j = \frac{N}{N_{i(j)}}$  weight chosen to equalize the contribution of each rating bucket to the total penalty

function and limit the influence of heavily populated rating categories

The vector of rating thresholds,  $b$  has the following equivalent representations:

$$\begin{aligned} b &= (b_0^+, b_1^+, b_2^+, b_3^+, b_4^+, b_5^+) \\ &= (b_1^-, b_2^-, b_3^-, b_4^-, b_5^-, b_6^-) \\ &= (b_{AAA/AA}, b_{AA/A}, b_{A/BBB}, b_{BBB/BB}, b_{BB/B}, b_{B/CCC}) \end{aligned}$$

Finally, the superscript “+” on the terms in parentheses in the sum indicates that the term contributes only if it is positive.

Thresholds derived from credit spreads observed in the US domestic market and the euro market on May 31, 2001 are presented in Figure 1. Implied boundaries are close to the intersection points of the agency rating sub-distributions, which is precisely what one expects: to a spread level it seems natural to associate the rating of the “highest” sub-distribution.

The differences between the agency and implied ratings can be conveniently displayed in a *reclassification matrix*. This is a matrix whose row  $j$  column  $k$  entry is the fraction of bonds with agency rating  $j$  that have a  $k$  implied rating. The reclassification matrix for the US market on May 31, 2001 is shown in Table A. Roughly 50% of issuers are assigned an implied rating that is different from their original agency rating, but most reclassifications occur within one rating notch. The largest reclassification rates occur in the high yield classes.

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<sup>4</sup> The penalty function is somewhat arbitrary. We experimented with several variants and found that the results were not materially altered.

## Refinements

Bond spreads of course also depend on maturity, yielding a term structure of credit spreads. The market sector of the issuer also has an effect on the average spread observed within a rating category. For instance, the cost of borrowing of telecommunication companies currently exceeds that of other issuers by 20 to several hundred basis points, depending on the rating. Mixing issues of widely different maturities or different industrial sectors could exacerbate the large overlap observed in Figure 1 and produce inaccurate thresholds. In order to estimate the sensitivity of spread thresholds to industrial sectors and duration, we estimated implied ratings for issuers within the same industry, or bonds with comparable durations *separately*. We compare results in Figure 2. Although thresholds do depend on the approach chosen, no dramatic change is observed.

Other ways to build implied ratings from market data are discussed in Appendix B. The ratings presented here have the virtues of simplicity and transparency. We now show that they already constitute a significant improvement over agency ratings when used to explain changes in bond spreads.

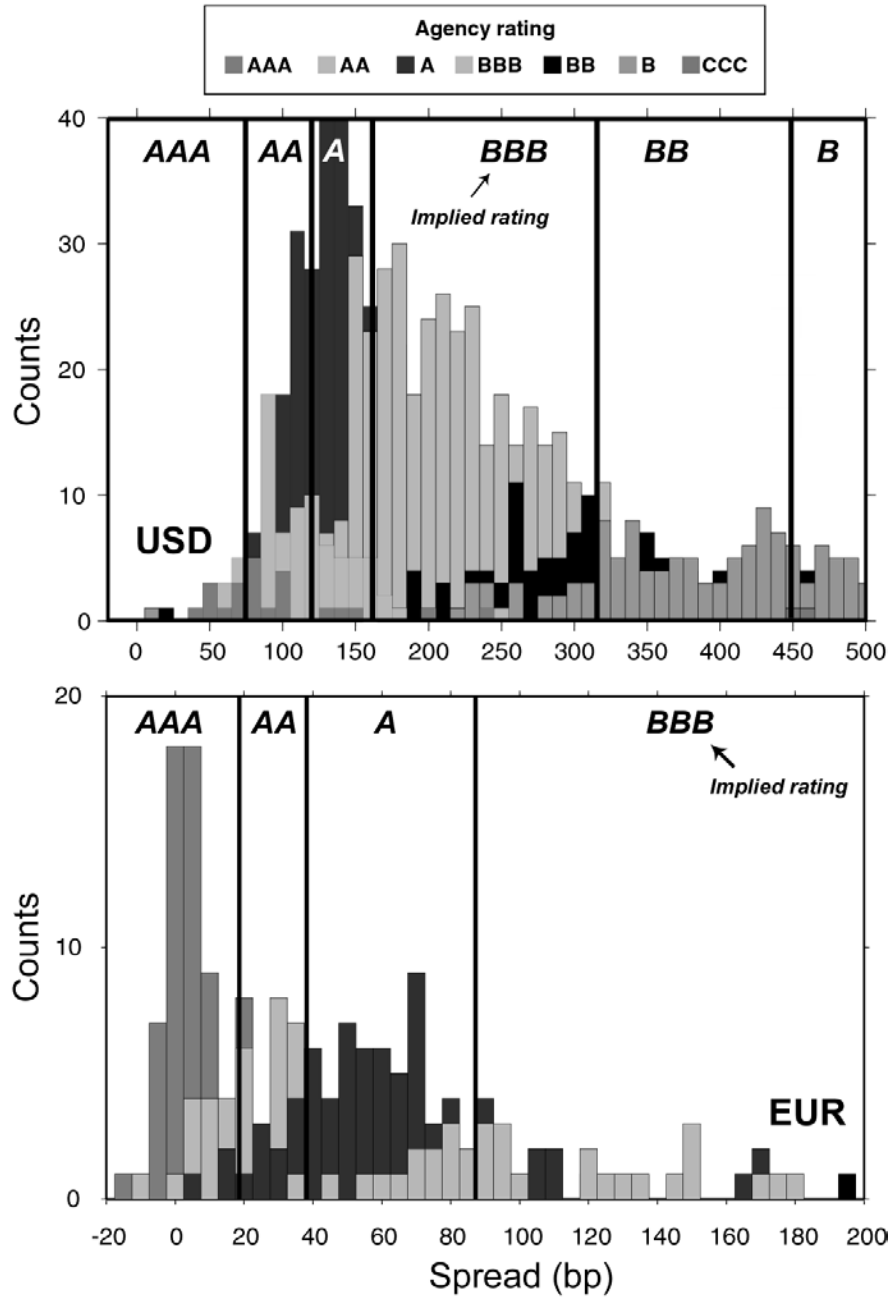


Figure 1. Issuer spreads and spread thresholds for the US dollar and Euro domestic market on May 31, 2001. US dollar spreads are with respect to the US Treasury yield curve whereas euro spreads are computed relative to the swap curve. The spread of an issuer is defined as the average spread of its outstanding bonds. Note how average spreads increase with decreasing credit quality, with large overlaps between individual rating sub-distributions which make it impossible to unambiguously extract the original rating from the spread.

Implied rating (%)

US		AAA	AA	A	BBB	BB	B	CCC
Agency rating	AAA	46	37	10	7	0	0	0
	AA	13	36	47	4	0	0	0
	A	1	11	61	27	0	0	0
	BBB	0	1	22	63	12	2	0
	BB	1	0	1	39	36	21	2
	B	0	0	1	9	36	44	10
	CCC	0	0	0	0	6	59	35

Implied rating (%)

Euro		AAA	AA	A	BBB
Agency rating	AAA	77	23	10	7
	AA	31	47	22	0
	A	3	14	65	18
	BBB	0	3	37	57

Table A. Reclassification matrix for the US domestic (top) and Euro market (bottom) on May 31, 2001 (see Figure 1). Row j column k entry is the fraction of bonds with agency rating j that has a k implied rating. Roughly 50% of issuers are assigned an implied rating that is different from their original agency rating, but most reclassifications occur within one rating notch. Because BB, B and CCC US dollar sub-distributions are wide spread, the largest reclassification rates occur in the high yield classes.

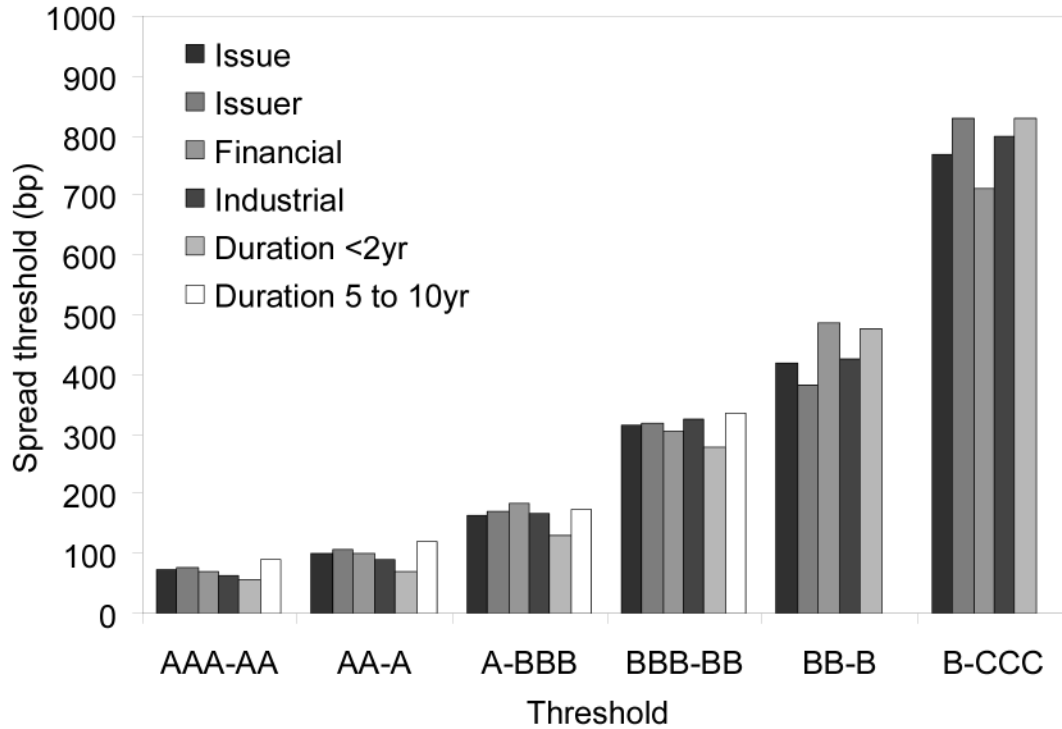


Figure 2: Comparison of US spread thresholds based on bonds, issuers, issuers with the financial or industrial sectors, and bonds with duration less than 2 years or between 5 and 10 years. Thresholds do depend on the approach chosen, but no dramatic change is observed.

### Implied ratings and bond classification

For purposes of risk forecasting, bonds are often grouped according to agency ratings on the empirical fact that returns of bonds with similar ratings will be strongly correlated. We ask whether on average, this correlation increases if we group bonds by implied rather than agency rating. The obvious rationale for this would be that market valuations are a better measure of the drivers of credit spread changes – namely perceived credit quality and risk exposure – than are agency ratings, which typically change with a lag as new information arrives.

To address this question, we decompose the monthly spread return of each bond into a market-wide component and a bond specific component. We model market returns using common factors that explain fluctuations in the average spread of bonds with the same rating and market sector.<sup>6</sup> For instance, the Utility BBB common factor return in the US is the average spread return of bonds issued in US dollars by US BBB-rated utility companies. Sectors and ratings used to construct factors are listed in Table B. The vector of spread returns can then be expressed as:

$$r = X \cdot f + r_{spec}$$

where

$X$  is the matrix of asset exposures  
 $f$  is the vector of factor returns  
 $r_{spec}$  is the vector of asset residual returns not explained by factors, or specific returns  
 idiosyncratic to individual assets

Table B. Sector and ratings used to construct common factors

Euro		US	
Agency	AAA	Canadian	AAA
Financial	AA	Energy	AA
Industrial	A	Financial	A
Pfandbrief	BBB	Industrial	BBB
Sovereign		Supranational	BB
Supranational		Telecoms	B
Utility		Transportation	
		Utility	
		Yankee	
		CCC	

We estimate this multi-factor return model with two choices for factor exposures: the first based on agency ratings and the second based on OAS implied ratings. We then compare the variation in bond spread explained by these models, that is, their  $R^2$ 's (the fraction of variance of spread changes explained by the models). To this end, we examine the residual, or non-systematic return to the bonds  $r_{spec}$ . By definition, this is the component of bond return not explained by the model factors. Lower volatility of residual returns corresponds to higher explanatory power of the common factors, i.e., a better model.

Residual volatilities obtained using agency and implied ratings for the US dollar domestic market are given in Table C. Values are averages of monthly residual volatility over the January 2001 to August 2001 period. For the AAA, AA and CCC rating classes, the explanatory power of the two models is similar. For other ratings however, the specific volatility is substantially lower when factors are built based on implied ratings. In other words, the common factors have more explanatory power. The implied rating model  $R^2$ 's are always at least as good as those of the agency model, and in most cases higher, by as much as 0.28. The average increase in model  $R^2$ 's is 0.11 for the US model and 0.06 for the Euro model (see Table D).

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<sup>6</sup> See Cheyette (2002) for more details on how the model is constructed.

Table C: Average specific return cross-sectional volatility for the US domestic market per rating category, from January 31, 2001 to August 31, 2001.

Rating	Agency ratings (bp)	Implied ratings (bp)	Difference (%)	Statistical significance <sup>9</sup>
AAA	8.39	8.69	3.5	Not significant
AA	10.48	10.35	-1.3	>95%
A	14.38	12.77	-11.9	>99%
BBB	33.48	27.25	-20.5	>99%
BB	84.39	62.8	-29.3	>99%
B	169.96	155.45	-8.9	>99%
CCC	234.9	250.7	6.5	>99%

Table D: Average common factor  $R^2$  for the US dollar and euro market from January 31, 2001 to August 31, 2001.  $R^2$  expresses the fraction of spread return cross-sectional variance explained by common factors. The use of implied ratings rather than agency ratings increases the  $R^2$  significantly for both the US dollar and the euro markets, producing factor models with superior explanatory power.

		Agency ratings	Implied ratings	Difference
US dollar	AAA	0.52	0.67	0.15
	AA	0.47	0.61	0.14
	A	0.44	0.50	0.06
	BBB	0.30	0.30	0
	BB	0.30	0.33	0.03
	B	0.13	0.41	0.28
	CCC	0.12	0.25	0.13
Euro	AAA	0.64	0.70	0.06
	AA	0.37	0.45	0.08
	A	0.21	0.28	0.07
	BBB	0.17	0.20	0.03

Table E: Examples of Euro factor correlations for a euro model based on agency ratings (Top) and implied

<sup>9</sup> Here, the statistical significance indicates the probability that these differences were not obtained by chance, as measured by the F distribution.

ratings (Middle). The correlation between factors corresponding to non-adjacent ratings (i.e. Industrial AAA and Industrial BBB) is clearly less in the model based on implied ratings.

### Agency ratings

	FIN_AA	FIN_A	FIN_BBB		INDUST_AA	INDUST_A	INDUST_BBB
FIN_AAA	0.9	0.8	0.17	INDUST_AAA	0.38	0.21	0.28
FIN_AA		0.89	0.27	INDUST_AA		0.58	0.57
FIN_A			0.28	INDUST_A			0.86

### Implied ratings

	FIN_AA	FIN_A	FIN_BBB		INDUST_AA	INDUST_A	INDUST_BBB
FIN_AAA	0.93	0.78	0.1	INDUST_AAA	0.40	0.33	0.27
FIN_AA		0.85	0.2	INDUST_AA		0.66	0.24
FIN_A			0.33	INDUST_A			0.30

### Agency ratings – Implied ratings

	FIN_AA	FIN_A	FIN_BBB		INDUST_AA	INDUST_A	INDUST_BBB
FIN_AAA	-0.03	0.02	0.07	INDUST_AAA	-0.02	-0.12	0.01
FIN_AA		0.04	0.07	INDUST_AA		0.08	-0.26
FIN_A			-0.05	INDUST_A			-0.56

We next examine the impact of implied ratings on factor correlations. Table E shows examples of factor correlations within the Industrial and Financial sectors for our two models and euro-denominated bonds. The correlation between factors corresponding to non-adjacent ratings (i.e. AAA and A) drops consistently when the model is based on implied ratings. For instance, the correlation between Financial AAA and Financial BBB factors is 0.17 for the “agency” model but 0.1 for the “implied” model. The correlation between the Industrial AA and Industrial BBB decreases by almost 50%. On the other hand, the correlation between factors based on adjacent ratings (i.e. A and BBB) is stable or increases slightly. Our interpretation is that correlations across factors that are separated by more than one rating notch can be artificially large, due to misclassified bonds. Reclassifying bonds according to their implied rating helps separate factors that should a priori be less correlated. This result confirms that, from a risk and return perspective, bonds with the same implied rating are “more alike” than are bonds with the same agency rating.

<sup>10</sup> This assumption underlies the corporate specific risk model.

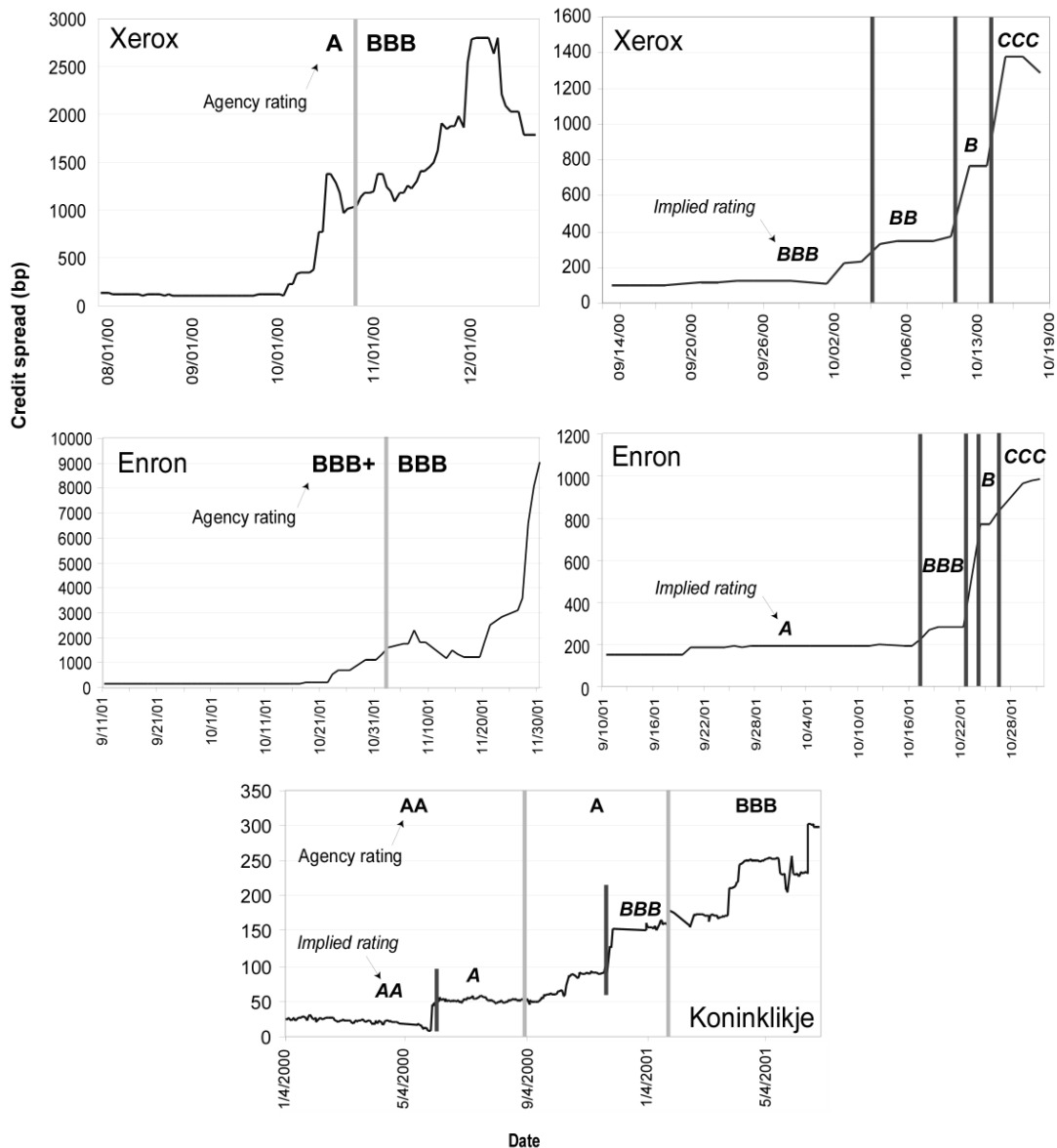


Figure 3. Credit spread and rating for Xerox, Enron and Koninklijke, a less known Dutch Telecom company. Note how the implied rating adjusts immediately to spread changes, and precedes the agency rating by up to 2 to 3 months.

### Monitoring individual issuers

We now illustrate how implied ratings can be used to monitor individual issuers. Implied ratings are easy to interpret and adjust immediately to price changes. We consider some recent examples in Figure 3. The spread of Xerox's 5.25% issue maturing on December 3, 2004 with respect to euro swap rates increased dramatically between October 2, 2000 and October 17, 2001. Xerox's implied rating is already BBB on October 2 and falls to BB over a period of three days. The agency rating was revised from A to BBB only on October 24, 2000, by which time the implied rating was CCC. (Xerox unsecured debt was downgraded by the rating agencies to B+/Ba1 in the spring of 2002.) Similarly, Enron's implied rating followed the drop in its perceived

creditworthiness. The agency rating was only slightly downgraded from BBB+ to BBB on November 1, 2001, and subsequently to D/C at the beginning of December 2001.

Most firms are more difficult to monitor than high profile companies like Xerox and Enron. In Figure 3, we last show the example of Koninklijke, a less known Dutch Telecom company that experienced two consecutive downgrades in 2000-2001. Once again, the implied rating adjusts immediately to spread changes, and precedes the agency rating adjustment by 2 to 3 months.

## **Conclusions**

In recent years, tremendous efforts have been spent trying to improve estimates of default and rating transition probabilities using option theory to link credit risk to market data and ideas originally presented by Merton (1974). While implied ratings are also derived using market bond prices, the motivations behind our work are radically different. Our goal was to improve the classification of obligors and spread risk forecasts, rather than to forecast default probabilities. We explored a simple approach and purposely avoided the relatively heavy machinery of option theory, with its dependence on accounting data.

The implied ratings described in this study already represent an improvement in explaining bond spread changes by reclassifying bonds for both the US dollar domestic and euro market, which is extremely encouraging. We do not claim that our approach is optimal, but we hope to have suggested one avenue for exploration of market-implied ratings.

The number and size of recent defaults has spurred interest in credit risk models and drawn attention to the often-slow response of rating agencies. We have demonstrated that classifying bonds using markets spread data provides a more reliable basis for modeling return relationships than does a classification driven by agency ratings. In this context, implied ratings are a simple, intuitive, and attractive tool.

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## Appendix A – Averaging Agency Ratings

We combine bond ratings reported by Standard and Poor's and Moody's into an issuer rating in the following manner:

- Convert fine letter-based ratings (i.e. AAA, AA-, AA+ etc...) into equivalent integer ratings using equivalences.
- If there are more than one bond ratings, take the (arithmetic) average of all S&P and Moody equivalent integer ratings. If this average is not an integer, round up to the nearest integer. If only one rating is available use that rating.
- Convert the result back into the coarse letter based issuer "average" rating.

## Appendix B – Alternative Schemes for Setting Thresholds

We use average issuer agency ratings as opposed to bond ratings. Average issuer ratings have the advantage of limiting the influence of poor data on the estimated spreads thresholds, but they do not include any information on debt type (e.g. senior, secured, subordinated, etc...). Taking this information into account could help reduce the overlap between rating categories observed in Figure 1.

Simpler approaches could be used to derive spread thresholds. We could group bonds by agency ratings and compute the median OAS of each rating group. The threshold between two adjacent ratings could then be defined as the geometric mean of the ratings' median spreads<sup>11</sup>. This alternative scheme would lead to comparable thresholds. An attractive aspect of the approach presented in this study is that it can be easily refined and fine-tuned. For instance, a more elaborate weighting scheme can be directly incorporated in the penalty function to handle outliers more efficiently.

Ordered-response models can in theory relate spread, sector and duration to rating. Although a detailed discussion of such models is out of the scope of this article, we note that their use is not necessarily straightforward. The random error between the model prediction and the actual response is assumed normally distributed, which is a very strong assumption considering the distributions that we observe for certain markets and rating categories (see Figure 1). The sensitivity of the response to each parameter is also constant, which is unrealistic. A 20 basis point spread change will have the same effect on the log-likelihoods of being rated AA and BB, while the effect should obviously be much stronger on the likelihood of being rated AA. Another complication is that the influence of the sector on spreads strongly depends on the rating. On January 31, 2001 on the US dollar domestic market, the average AA Yankee spread was 120 bp against 150 bp for AA-rated Utilities. However, the average BB Yankee spread is 490 bp, against 290 bp for BB Utilities.

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<sup>11</sup> An anonymous reviewer suggested this approach.