Portfolio Credit Spread Risk

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Spread risk statistics should enable comparisons not only between securities issued by the same firm, but also across different issuers. We present a flexible risk management framework for measuring credit spread risk at the portfolio level. Spread risk factors, such as bond spreads and CDS data, can be drawn directly from the bond and credit markets, and indirectly through prices and implied volatilities from the equity markets. In order to produce a coherent spread risk measure across a portfolio, we outline how spreads can be translated form one market to another.

1 Introduction

Measuring credit spread risk at the portfolio level can be challenging. Credit-related instruments span a significant portion of a portfolio, and include not only corporate bonds and credit default swaps (CDS), but also securities such as synthetic collateralized debt obligations (CDO), CDS options, bank loans, and mortgage backed securities (MBS). For each security, it is useful to assess the compensation investors need for taking on credit risk. The credit risk of a security can be calculated from different spread measures, and each market may have different key credit measures. O'Kane and Sen (2005) provide an excellent survey of credit spread measures and Finger (2005) comments on these credit measures both from the trader's and risk manager's standpoint.

In this note, we build on (Finger 2005) to outline a flexible framework for measuring credit spread risk at the portfolio level. Since the creditworthiness of a firm can be measured from more than one spread measure, it is important to pick credit measures that enable comparisons not only between securities issued by the same firm, but also across different issuers. Two spread measures that allow such comparisons between securities are the option-adjusted spread and CDS fair spread.

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From a risk perspective, a flexible framework is presented for measuring spread risk at the portfolio level, where spread risk factors can be drawn from either the bond, credit, or equity markets. Furthermore, to achieve a coherent portfolio spread risk measure, we describe how spreads can be translated from one market to another.

The outline of this note is as follows. In Section 2, we briefly survey the various spread measures. In Section 3, we discuss how pricing models can be used to translate spreads from one market to another, and in Section 4, we outline how issuer-specific risk for spread-related securities can be calculated from different markets. We provide concluding remarks in Section 5.

2 Credit spread measures

In this section, we describe various credit spread measures. O'Kane and Sen (2005) also present different spread definitions, and comment on their respective advantages and disadvantages. It is important to distinguish the better credit spread measures. O'Kane and Sen (2005) define a good measure of credit risk as one that enables relative comparisons between securities, distinguishing expensive ones from cheaper ones. In addition, a good credit spread measure should enable comparisons between instruments with the same issuer as well as across different issuers. As we will see, coherent credit measures at the issuer level are crucial for analyzing credit risk at the portfolio level.

2.1 Survey of spread-related measures

In this section, we provide definitions for various credit spread measures.

Yield-to-maturity and interpolated spread. The yield-to-maturity (YTM) of a fixed-rate bond is defined as the constant internal rate of return that recovers the price. From this definition, we can define a spread measure by comparing the YTM of a risky bond to that of a hypothetical Treasury bond with the same maturity as the risky bond. This hypothetical Treasury bond's YTM is determined by interpolating on a reference curve that is constructed from benchmark Treasury securities. The interpolated spread (I-spread) is then defined as the difference between the YTM of the bond and the interpolated YTM on a risk-free curve.

Option-adjusted spread. Another credit risk measure for fixed-income securities is the option-adjusted

Table 1

Market spreads

Market	Spread Measures/Risk Factors
Bond	YTM, I-spread, OAS
Credit	CDS fair spread
Equity	Implied spreads (via Merton models) derived from equity price, implied volatility

spread (OAS), which is defined as the constant spread over the base risk-free zero curve that will recover the bond price.[1] In a pricing framework that involves interest rates, it is useful to make the distinction between cashflow generation and discounting. The OAS always impacts pricing through discounting, and sometimes through cashflow generation. We comment more on this distinction in the next section for both corporate bonds and MBS.

CDS fair spread. From the credit markets, the CDS fair spread is the premium paid for default protection on a reference asset. This is an actual payment—and not a discount spread—that is observed in the market. In a CDS contract, a protection buyer makes periodic payments to a protection seller for default protection. When a default occurs, the protection seller compensates the protection buyer by effectively[2] buying the reference asset at par.

Asset swap spreads. In an asset swap, the fixed coupons of a reference bond are swapped (or replaced) with a floating rate plus a spread. The asset swap spread is the spread over Libor paid on the floating leg in such a contract. Similar to the CDS fair spread, this spread is an actual payment.

Implied spreads. Theoretical spreads (both OAS and CDS fair spreads) can be derived from the equity market via Merton-based models such as CreditGrades.[3] The key inputs to these models are the asset volatility and leverage ratio, which are typically estimated from equity volatility and balance sheet information. The asset volatility and leverage ratio may also be inferred from equity option prices. As discussed in Section 3, implied spreads can also be extracted from the bond and CDS markets. For example, an implied OAS can be derived from CDS spreads.

In Table 1, we summarize the spreads discussed in this section along with their corresponding markets.

[1] The OAS was first introduced as a spread statistic for callable bonds, however, the mathematical definition for the OAS equally applies to vanilla bonds. See (O'Kane and Sen 2005).

[2] Both cash and physical settlements exist.

[3] This is structural model that produces risk-neutral probabilities. See (Finger 2002) for more details.

2.2 Which credit measure?

Given that multiple credit spread measures exist in different markets, a natural question is “which credit measure is best?” To answer this, we should keep in mind the criteria that we presented for a desirable credit measure in the beginning of this section:

- Enable comparisons between securities (with different maturities, optionality, coupons, etc.) issued by the same issuer.
- Enable comparisons between different issuers.

Once we identify a key credit measure, a follow-up question is then “can we translate spreads from one market to another to enable comparisons?” Translating spreads from one market to another is useful not only for relative value analysis, but also from a risk perspective, since choosing data from a more liquid market can help in forecasting risk.

There are two key spread measures—the OAS and CDS fair spread—that satisfy these criteria.

2.2.1 Key spread measure—OAS

We highlight some properties of the OAS, and comment why it is a better spread measure than any YTM-based spread measure.

Reinvestment assumption. First, the YTM measure assumes that all coupons will be reinvested at the same rate; that is, the YTM gives the return of a bond if it is held until maturity. Thus, one can only compare bonds that have the same maturity. In contrast, the OAS takes the full term structure of the base curve into effect. As a result, all cashflows are assumed to be reinvested at the base rate plus a constant spread. Thus, future expectations about interest rates are incorporated.

Optionality and sensitivities. In a general pricing framework involving interest rates, it is useful to distinguish between cashflow generation and discounting. We highlight this distinction for corporate bonds and MBS below:

- *Vanilla Corporate Bonds*. In this case, the OAS is independent of any interest rate model and is simply backed out from the price by applying simple discounting.[4] Any OAS-related

[4] See (O’Kane and Sen 2005).

sensitivity will affect only the discounting and not the coupon cashflows. The coupons for a fixed rate bond, by definition, are constant whereas the coupons for a floating are variable and depend on a reference curve. In both cases, the coupons are unaltered whenever the OAS is shifted.

- *Bonds with Optionality*. For a corporate bond with embedded options, the OAS is model dependent, but is still interpreted as the constant spread over the base curve that will recover the price. Spread sensitivities based on the OAS are more realistic than spreads based on the YTM since both cashflows resulting from exercise decisions and discounting are incorporated. Note that the YTM is problematic as a definition for bonds with embedded options since it strictly refers to vanilla bonds. In order to extend the definition of the YTM to say, callable bonds, a date reflecting the likelihood of an early redemption is required. Typically, a date is chosen from the call schedule that results in the lowest yield from the investor's perspective. The YTM of a callable bond is then calculated by replacing the maturity date with the worst-to-call date; that is, it is assumed that the bond will redeem precisely at the worst-to-call date. In contrast, sensitivities derived from the OAS will take into account that the bond may redeem at different dates. For example, a decrease in the OAS of a callable bond can increase the likelihood that an issuer will redeem the bond.[5] Thus, for bonds with embedded options, OAS-related sensitivities and stress tests affect not only discounting but can also alter future cashflows arising from exercise decisions.
- *MBS*. For MBS, a shift in the OAS will typically only influence discounting. In this case, there is a clear separation between cashflow generation and discounting. We can interpret the OAS in the following context. First, from a given interest rate model, we project future interest rate scenarios. Cashflows are determined from these interest rate paths using a prepayment model. For each scenario, we discount cashflows by adding a constant spread to the base rates. The OAS is the constant spread such that the average present value of cashflows is equal to the observed MBS price. Any OAS-based sensitivity will then only apply to discounting and not to the cashflows.

Portfolio Aggregation. Although the above discussions have been based on individual securities, the benefits extend to a portfolio of securities. At the portfolio level, the OAS applies to a broad class of fixed-income instruments, including corporate bonds, sovereign bonds, and MBS, hence OAS sensitivities allow one to measure credit risk across a diverse portfolio of fixed income instruments.

[5] For the same level of interest rates, the bond's intrinsic value at a potential exercise date is higher. A call provision is therefore more likely to be exercised.

2.2.2 Key spread measure—CDS fair spread

The OAS is a discount spread that needs to be calculated from a pricing model. In contrast, the CDS fair spread is model independent since it is the actual premium for default protection that is observed in the credit market. Thus, it is useful to translate CDS spreads into bond spreads to capture the credit risk of an obligor. We explore this idea in the next section.

3 Pricing models and default probability bridges

It is desirable to link data from a particular market to *all* spread-related securities since spreads can be extracted from the bond market, CDS market, and indirectly from the equity market. In order to bridge different markets, we rely on the term structure of risk-neutral default probabilities. All of the pricing models take default probabilities as inputs and provide the price of a security as an output. From prices or spreads in one market, we can reverse the procedure and extract market implied probabilities, which then act as a bridge to price other securities in different markets belonging to the same issuer.

Figure 1 illustrates this procedure, where both fixed income and credit securities can be priced from either the equity, bond, or CDS markets. For instance, we can extract default probabilities from a CDS fair spread curve, and use these to price bonds. Similarly, we can reverse the procedure, extracting default probabilities from the bond market to price a CDS.

Pricing models are thus required in two places: first, for extracting default probabilities from one market, and then for pricing securities in a different one.

3.1 Inputs: Extracting market implied default probabilities

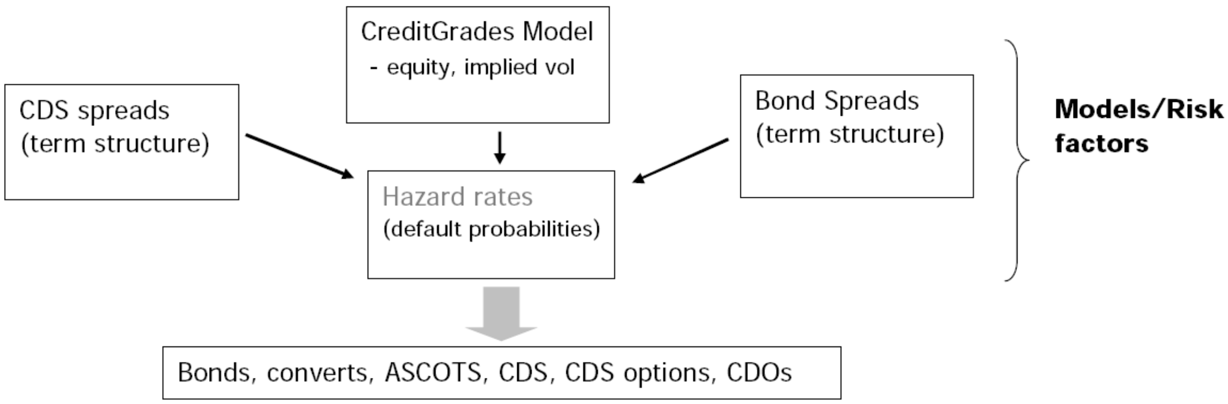
Let us begin with the bond market. Under the Hull-White framework,[6] the price of a risky bond is equal to the price of a risk-free bond minus discounted expected losses:

$$\text{Risky Bond Price} = \text{Risk-Free Bond Price} - \text{Present Value of Expected Losses}. \qquad (1)$$

A standard approach for calculating default probabilities is to bootstrap hazard rates, or conditional probabilities of default. Given a risky yield curve, we assume that hazard rates are piecewise constant,

[6]See (Hull and White 2000).

Figure 1
Hull-White pricing “bridges”



that is, that they are constant between adjacent curve nodes. Using the Hull-White pricing function above, we can iteratively solve for hazard rates. Once the hazard rates are known, we can price bonds or CDS.

Similarly, we can extract hazard rates from CDS data. Under the Hull-White framework, the price of a CDS from a protection seller's viewpoint is[7]

$$\text{CDS Price} = \text{Present Value of Expected Payments} - \text{Present Value of Expected Losses}. \tag{2}$$

From observed market prices (or CDS fair spreads), we can bootstrap a term structure of hazard rates, iterating as above.

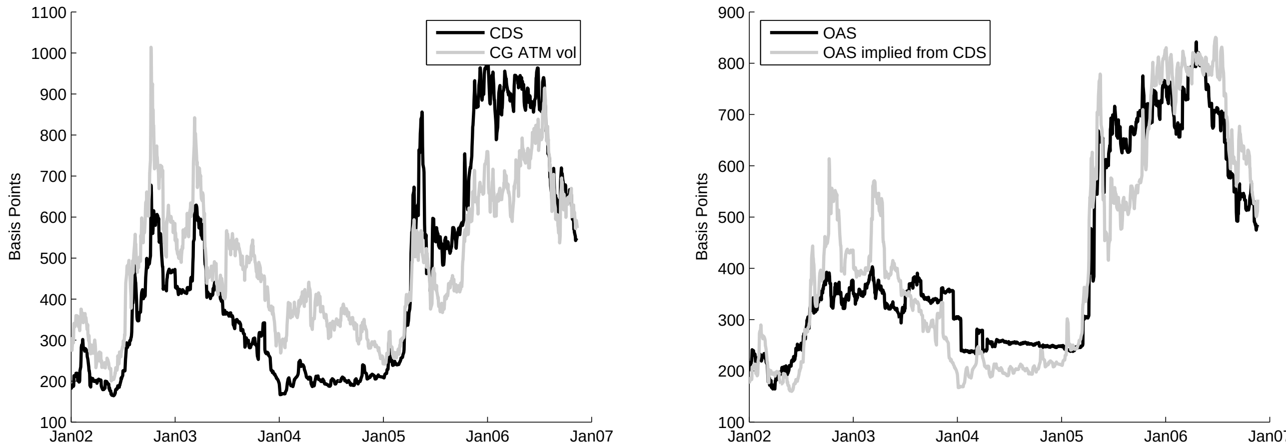
3.2 Outputs: Pricing securities in different markets

We use the Hull-White framework to price securities once hazard rates are known. For example, we might extract default probabilities using CDS data and (2), then apply these in (1) to obtain a CDS-implied bond price. This price will in turn correspond to a CDS-implied OAS. We provide two examples of the default bridge. The left plot in Figure 2 shows an equity-implied five-year CDS fair spread for Ford, and the right plot compares the CDS-implied OAS for Ford to the OAS from Ford bonds.

[7] For example, see (Couderc 2007) for details.

Figure 2

Ford: Implied CDS from equity data (left), implied OAS from CDS data (right)



4 Risk measures involving translational models

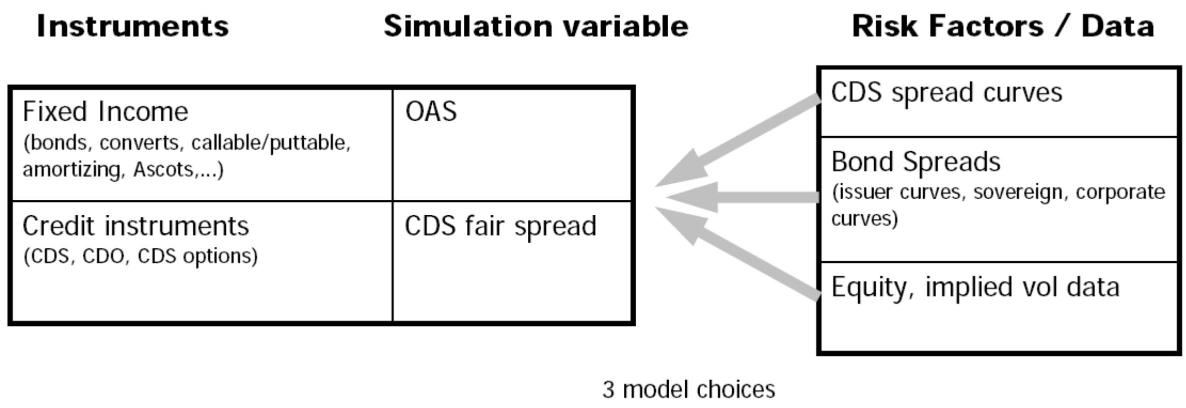
In order to calculate issuer-specific risk, we first need to generate scenarios for spread movements. Given our preference for the OAS and CDS fair spread, we choose these credit measures as our simulation parameters. As shown in Figure 3, the OAS and CDS fair spread can be simulated directly from their corresponding market data, or indirectly from different market data, where the default bridge is used to create an implied history of OAS or CDS spreads. Using the spread scenarios, we can reprice a portfolio, and from many simulations we can compute risk statistics. This section focuses primarily on translational cases, where instruments from one market are priced from data from another market.

4.1 Simulating OAS from CDS curve data

First, consider simulating corporate bonds prices from CDS data. Under the Hull-White framework, the price of a risky bond is equal to the price of a risk-free bond minus discounted expected losses. For a bond (possibly containing optionality), we can simulate as follows:

- First, identify an equivalent risky vanilla bond with the same base OAS as the original bond.

Figure 3
Spread VaR Simulations



- Generate simulations for the CDS fair spreads, and use (2) to convert these to hazard rate simulations.
- Reprice the risky vanilla bond using the simulated hazard rates using (1).
- From the risky vanilla bond price simulations, back out simulated OAS values.
- Reprice the original risky bond using the simulated OAS.

This mechanism allows us to calculate risk statistics such as VaR.[8]

4.2 Simulating CDS fair spreads from bond data

Likewise, we can simulate fair spreads from bond spread data. As we simulate bond spreads, we bootstrap hazard rates which then are inputs used to price the CDS through (2).

[8]The procedure outlined for simulating bond prices from CDS data also applies for bonds priced from equity data via Merton-based models. The only difference is that the source of default probabilities comes from equity data.

Table 2
Sample sensitivities

Positions	Present Value	Notional (MM)	Interest Rate (1 bp)	Effective Duration	Credit Spread (1 bp)	Spread Duration	Equity (-1%)
Trade Group	188,199		-31		-53		789
• CCL 04/29/2033	682,674	1	-31	0.53	-96	1.40	-4,115
• Equity	-490,432						4,904
• CDS 06/20/2008	-492	0.285	0		42		
Floating Rate Bond	972,435	1	-2	0.03	-616	6.34	

4.3 Risk examples involving translational methods

Example 1: Sensitivity report

Table 2 shows an example of a sensitivity report. The first three positions represent hypothetical trades involving Carnival Corporation. The three positions are: a convertible bond which is trading at a premium; a short equity position; and a CDS position. This group of positions represent an equity-hedged convertible bond position with credit default protection. The last position is a floating rate bond, which can be viewed as either belonging to the same issuer or to a different one.

For each of the positions, we calculate various sensitivities: interest rate sensitivities (interest rate shift and effective duration), credit-related sensitivities (credit spread shift and spread duration), and equity sensitivity. The two duration statistics are defined as the numerical derivative with respect to a parallel shift in interest rates (or credit spread, either OAS or CDS fair spread) divided by the present value of the bond. The two shifts represent the difference in value arising from a movement of one basis point in interest rates (or credit spreads).

In Table 2, we note that an increase in the OAS will decrease the values of the convertible bond and the floating rate bond since discounting has increased. In addition, the CDS value will increase as the fair spread increases. These observations are consistent with an overall deterioration in credit for the reference issuer. We now focus on the effective and spread duration statistics. First we note that for a regular fixed rate bond, the effective and spread durations are the same since a shift in the OAS is equivalent to a parallel shift of the base curve. However, as we move to other securities, such as floating rate and convertible bonds, the spread duration is no longer a redundant statistic. Although the convertible pays a fixed coupon, this security also contains an embedded equity option that appreciates as interest rates rise. Thus, the option sensitivity counteracts the bond-like discounting sensitivity to interest rates. For spreads, no such balance exists, making the spread sensitivity large. Similarly, the effective and spread durations differ significantly for the floating rate bond, since the former statistic includes changes in coupon cashflows, whereas the latter does not.

Example 2: Total VaR using translational methods

In this example, we use a single source of market data to forecast the spread risk for a group of positions belonging to the same issuer. In Table 3, we consider a hypothetical basis trade involving a CDS that is long default protection and a bond position, both on Ford. We consider a fixed-rate bullet bond with a notional of $1 million, a semiannual coupon rate of 10%, and a maturity of 8 September 2016. The CDS has the same notional and maturity. VaR at a confidence level of 95% is computed in three different ways; in each case, the risk of the issuer for all of the positions is driven by a single market.[9]

From the sample report in Table 3, we observe that VaR, both at the group and security level, is comparable under the three different choices for data. This highlights the correlation between bond spreads, CDS fair spreads, and equity prices, which is also illustrated in Figure 2. In Table 4, we see that the standard deviations for bond spread and fair spread returns are similar.

Table 3

Total VaR from translational models at 95% confidence interval

Positions	Bond Spreads	CDS Spreads	CreditGrades
Total	4820	3950	3300
Ford Bond	9940	9680	11270
Ford CDS	9510	8390	9120

[9]The volatility of risk factor returns was computed using an exponentially weighted estimate with a decay factor of 0.94 and an analysis date of 28 November 2006. Similar results were found by computing historical VaR, which we do not include in this report.

Table 4

Annualized Standard Deviations of Risk Factors for Ford Data

Risk Factor	5 Year Node	10 Year Node
CDS Fair Spread Return	32%	31%
Bond Spread Return	33%	32%

Table 5

VaR Drilldown at 99% confidence level using GE Data

	VaR		
Positions	IR Market Risk	issuer-specific Risk	Total
Bond Spread Model	6,016	129	6,174
• GE Bond	**5,955**	**1,754**	**6,140**
• GE CDS	62	2,239	1,797
CDS Spread Model	5,543	233	5,489
• GE Bond	5,511	990	5,772
• GE CDS	**34**	**1,090**	**1,084**
CreditGrades Model	5,215	1,767	5,408
• GE Bond	5,098	3,184	5,687
• GE CDS	118	1,388	1,404
Basis Trade	5,989	2,414	6,192
• GE Bond	**5,955**	**1,754**	**6,140**
• GE CDS	**34**	**1,090**	**1,084**

Example 3: VaR decomposition into interest rate and issuer-specific factors

In this example, we decompose VaR into interest rate and issuer-specific portions. We consider bond and CDS positions that are long protection on GE, and present the results in Table 5. The interest rate risk is defined as the risk arising from the base curve—the US Treasury curve in this example—while holding spreads constant. On the other hand, issuer specific is defined as the risk arising from spreads while holding interest rates constant.

The first observation, from Table 5, is that market risk contributes most to the overall risk of the grouped positions. For example, under the CDS spread model, issuer-specific VaR is 233 while interest rate VaR is 5543. This observation across all three models is not surprising since this pair represents a hedged credit position. At the security level, interest rate risk is the major component of risk for the bond whereas issuer-specific risk is the major component of risk for the CDS.

Comparing, for each security, the total risk to the sum of the interest rate and issuer-specific risks gives us a loose sense of the correlation between the two risk sources. The correlation appears low in all cases, and even negative in some. This is in fact a common observation. See (Berd and Ranguelova 2003) for further information.

Finally, to assess a basis trade, a relative value investor might use multiple risk factors for the same issuer. The last group of positions in Table 5 use both the issuer yield curve and CDS fair spread data to calculate VaR. We observe that the issuer-specific VaR is greater than the translational models since bond spreads and fair spreads in this case do not determine each other through one of our bridges. In this example at least, the impact of modeling two distinct sources of issuer risk is negligible.

5 Concluding remarks

The creditworthiness of an issuer can be measured from different notions of credit spreads. Two spreads which allow relative comparisons between securities are the option-adjusted spread and CDS fair spread. The former is a consistent measure of credit risk across different fixed income securities while the latter is an actual default premium observed in the credit market.

In this note, we outlined a flexible framework for measuring spread risk at the portfolio level where spread risk factors can be drawn from either the bond, credit or equity markets. In addition, this note described how spreads can be translated from one market to another in order to produce risk statistics. In particular, we outlined how market implied default probabilities could serve as a bridge across markets.

Extracting spreads from different market data sources is useful from both a relative value and risk perspective. For long only investors, a single risk factor from the most liquid market to express the credit risk of an issuer has the advantage of reducing the dimensionality of risk factors and increasing computational efficiency for risk calculations. At the other extreme, relative value investors will use multiple risk factors for the same issuer.

References

Berd, A. and E. Ranguelova (2003). The co-movement of interest rates and spreads: Implications for credit investors. *Lehman Brothers High Grade Research*.

Couderc, F. (2007). Measuring risk on credit indices: On the use of the basis. *RiskMetrics Journal 7*(1).

Finger, C. C. (Ed.) (2002). *CreditGrades Technical Document*. RiskMetrics Group.

Finger, C. C. (2005, November). Spread values. *RiskMetrics Group Research Monthly*.

Hull, J. and A. White (2000). Valuing credit default swaps I: No counterparty default risk. *The Journal of Derivatives 8*(1), 29–40.

O'Kane, D. and S. Sen (2005). Credit spreads explained. *Journal of Credit Risk 1*(2), 61–78.