CHAPTER 8

Long-Term Expected Credit Spreads and Excess Returns

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8.1 Introduction

Expected credit spreads and excess returns of corporate bonds over government bonds could be used by investors to construct client portfolios. In this chapter, we estimate long-term expected credit spreads and excess returns for a variety of US corporate bond ratings and maturities. The long-term expected credit spreads and excess returns are estimated using an extension of the risk-neutral valuation model of Fons (1994). The model is calibrated on long historical data over the 1919–2014 period, a sample period that is much longer than used in most other papers analyzing credit spreads and excess returns.

The shape of the credit spread term structures (CSTS) has been shown to depend on the credit rating of the issuer. While the CSTS of high-quality corporate bonds could either be upward-sloping or hump-shaped, those for low credit quality corporate bonds are downward sloping; see

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Merton (1974) and Duffie and Singleton (1999). The shapes of the term structure of credit spreads have been confirmed by the empirical work of Sarig and Warga (1989), Fons (1994), and Bohn (1999).[1]

Investors in corporate bonds require a premium for default risk, referred to as the "default spread". It is well known that the default spread is only a small fraction of total spread (or the "corporate bond basis"); this is referred to as the "credit spread puzzle". Huang and Huang (2012) and De Jong and Driessen (2012) show that the corporate bond basis is related to liquidity effects, and Elton et al. (2001) show that a substantial part of the corporate bond basis can be explained by tax effects. Since long-term investors are expected to earn the corporate bond basis, we therefore include the basis in our estimation of the spread in our risk-neutral valuation model.

We find that investors require a higher default spread for investment grade (IG) corporate bonds than of high-yield (HY) corporate bonds for the same amount of default risk. This may be because investors appear to be more risk-averse when investing in IG corporate bond compared to HY bonds as investors: the risk-neutral default probabilities of IG- (HY-) rated bonds are 2.3 times (1.4 times) higher than their physical probabilities. These findings are similar to the existing literature; see, for example, Giesecke et al. (2011) and Driessen (2005).

We show that the shapes of the calibrated long-term (LT) expected CSTS are in line with the existing literature (Merton 1974; Duffie and Singleton 1999; Sarig and Warga 1989; Fons 1994). The shapes of the calibrated LT-expected CSTS are (1) upward-sloping for high credit ratings ranging from the AAA to BBB ratings, (2) humped-shaped for the BB and B middle-graded ratings, and (3) downward sloping for the CCC speculative rating. Furthermore, we find that the calibrated LT-expected CSTS are in line with the historical average CSTS over the 1988–2014 period and capture the positive skewness in the historical distribution of CSTS.

Table 8.1 presents the expected annualized buy-and-hold excess credit returns of ten-year corporate bonds in percentage and their corresponding par credit spreads, following the approach of De Jong and Driessen (2012) and Bongaerts et al. (2011). These estimates for the expected credit excess returns are in line with the findings of Hull et al. (2005) and Giesecke et al. (2011). Our expected excess returns for IG bonds are approximately 0.4% higher than historical average credit excess returns as documented by Ng and Phelps (2011) and Ilmanen (2011). The difference between the LT-expected buy-and-hold and historical average credit excess return for

IG bonds can largely be explained by the periodic rebalancing of constituents in the corporate bond benchmark as the result of rating upgrades and downgrades. Ng and Phelps (2011) show that relaxing the requirement of rebalancing gives 0.4% additional return for IG benchmark, which is approximately the documented difference between the LT-expected and historical average excess returns.

This chapter contributes to the existing literature in the following ways. First, the model is calibrated on much longer historical data sample. Second, we introduce a risk-neutral valuation model including the corporate bond basis, which captures the main stylized facts of CSTS and excess-return term structures and can straightforwardly be applied to determine expected credit spreads and excess returns for other regions than the US. Third, we extend the findings of the long-term expected credit spread and excess returns of Giesecke et al. (2011) by estimating the spreads and excess returns for multiple ratings and maturities. Fourth, our model can straightforwardly be applied to estimate the LT-expected credit spreads and excess returns for other regions than the US. These results have many uses for portfolio managers, for example, to construct efficient portfolios for long-term investors.

In the remainder of this chapter we provide more detail on these results. Section 8.2 introduces a risk-neutral model to calibrate long-term credit spreads and excess returns for multiple ratings and maturities. Section 8.3 outlines the data that is used to calibrate the risk-neutral model. Section 8.4 describes the calibration methods of the risk-neutral model. In Sect. 8.5, discusses the calibration results of the long-term expected credit spreads and excess returns for the US market. Finally, Sect. 8.6 concludes.

8.2 Risk-Neutral Valuation Model

8.2.1 *Defaultable Zero-Coupon Bond Excluding the Bond Basis*

The price of a default-free zero-coupon bond is equal to the discounted face value. Under the assumption of arbitrage-free and complete markets, the price of default-free zero-coupon bond with unit face value and maturity T at time t, $P(t, T)$, is given by

$$P(t,T) = \mathbb{E}_t^{\mathbb{Q}}\left[\frac{B(t)}{B(T)}\right] = B(t)\mathbb{E}_t^{\mathbb{Q}}\left[\exp\left(-\int_t^T r(s)\,\mathrm{d}s\right)\right],$$

where $\mathbb{Q}$ is the risk-neutral probability measure, $r(t)$ the instantaneous short-rate at time t, $B(t)$ is the money savings-account at time t. We define the initial money savings-account, $B(0)$, to be equal to 1.

The price of a defaultable zero-coupon bond is the sum of defaultable discounted face value plus the recovery value of the bond at an uncertain moment in time only when the issuer goes into default before the maturity of the bond. Under the assumption of fractional recovery of face value, Lando (1998) shows that the price of a defaultable zero-coupon bond with credit rating indexed by i, unit face value and maturity T at time t, $D_i(t, T)$, is given by

$$D_i(t,T) = \mathbb{E}_t^{\mathbb{Q}}\left[\frac{B(t)}{B(T)}1_{(\tau>T)}\right] + \int_t^T \mathbb{E}_t^{\mathbb{Q}}\left[\frac{B(t)}{B(s)}R(s)\lambda_i^{Q}(s)\mathrm{d}s\right], \tag{8.1}$$

where τ is the time-of-default, $\lambda_i^{Q}(t)$ the instantaneous risk-neutral hazard rate of rating i at time t and $R(t)$ the recovery rate at time t.[2]

Next, we make the common assumptions as in O'Kane (2010) that the short rate process and hazard rate process are independent of each other and that the recovery rate is an exogenously given constant. Using these assumptions, we can write Eq. 8.1 as

$$D_i(t,T) = P(t,T)Q_i(t,T) + \bar{R}\int_t^T P(t,s)\lambda_i^{Q}(s)\mathrm{d}s, \tag{8.2}$$

where $\bar{R}$ is the expected recovery rate and $Q_i(t, T)$ the cumulative risk-neutral default probability of rating i up to time T. This expression assumes that investors are only compensated for interest rate and credit risk.

8.2.2 *Defaultable Zero-Coupon Bond Including the Bond Basis*

We include a maturity independent bond basis in our model by discounting corporate bond cash flows with an adjusted discount factor following Longstaff et al. (2005), which allows the model to capture any liquidity or other non-default-related components in corporate bond prices. We assume a maturity independent bond basis for simplicity and because there is at the moment no consensus in the literature whether liquidity premia are higher or lower for short-maturity compared to long-maturity corporate bonds.[3] We assume that the continuously compounded bond basis is an exogenously given constant depending on the rating *i*, defined as l_i^c. The expression of the defaultable bond price in Eq. 8.2 including the bond basis then becomes

$$D_i(t,T) = P(t,T)Q_i(t,T)Z_i(t,T) + \bar{R}\int_t^T P(t,s)Z_i(t,s)\lambda_i^Q(s)\mathrm{d}s,$$

with

$$Z_i(t,T) = \exp\left(-\int_t^T l_i^c \mathrm{d}s\right) = \exp\left[-l_i^c(T-t)\right],$$

where the continuously compounded bond basis l_i^c can be expressed in terms of *f*-frequency compounded bond basis l_i^f as follows:

$$l_i^c = f\log\left(1 + \frac{l_i^f}{f}\right). \tag{8.3}$$

8.2.3 Modeling Default Probabilities

To model the physical and risk-neutral default probabilities of a reference entity, we use the first jump of a Poisson process with time-inhomogeneous intensities as in O'Kane (2010). The physical and risk-neutral probability that the reference entity with rating *i* survives up to time *T* at time *t*, $W_i(t, T)$, and $Q_i(t, T)$, respectively, are equal to

$$W_i(t,T) = \mathbb{E}_t^{\mathbb{P}}\left(1_{(\tau>T)}\right) = \exp\left(-\int_t^T \lambda_i^P(s)\mathrm{d}s\right),$$

$$Q_i(t,T) = \mathbb{E}_t^{\mathbb{Q}}\left(1_{(\tau>T)}\right) = \exp\left(-\int_t^T \lambda_i^Q(s)\mathrm{d}s\right),$$

where $\mathbb{P}$ is the physical probability measure and $\lambda_i^P(t)$ is the physical hazard rate of bond with rating *i* at time *t*.

The physical and risk-neutral default hazard rates are connected to each other through the Radon–Nikodym derivative, which allows us to change equivalent martingale measure $\mathbb{P}$ into $\mathbb{Q}$:

$$\Lambda_i^{\mathbb{P}\to\mathbb{Q}}(t) = \left.\frac{\mathrm{d}\mathbb{Q}}{\mathrm{d}\mathbb{P}}\right|_i = \exp\left[\int_0^t \left(\lambda_i^P(s) - \lambda_i^Q(s)\right)\mathrm{d}s\right].$$

For simplicity, we assume that the risk-neutral hazard rates are a constant multiple of the physical hazard rates, such that

$$\lambda_i^Q(t) = \theta_i \lambda_i^P(t),$$

where θ the price of risk parameter. With this assumption, the expression of the risk-neutral survival probability becomes,

$$Q_i(t,T) = \exp\left(-\theta_i \int_t^T \lambda_i^P(s)\mathrm{d}s\right) = W_i(t,T)^{\theta_i}. \tag{8.4}$$

8.2.4 *Defaultable Coupon-Paying Bond*

A defaultable coupon-paying bond can be decomposed as the sum of defaultable zero-coupon bonds. The price of a defaultable f-frequency coupon-paying bond with rating i, unit face value, annualized compounded coupon as percentage of the face value $c_i^f(T)$, and payment schedule[4] $T_1, \ldots, T_n$ at the time of the bond issuance $T_0 = t$, $V(t, T)$ is

$$\begin{aligned} V_i(t,T) = P(t,T)Q_i(t,T)Z_i(t,T) + c_i^f(T)\sum_{k=1} fP(t,T_k)Z_i \\ (t,T_k)Q_i(t,T_k) + \bar{R}\int_t^T P(t,s)Z_i(t,s)\lambda_i^Q(s)\mathrm{d}s, \end{aligned} \tag{8.5}$$

where $f = n/T$ is the accrual fraction equal to the coupon period of the bond such that $f = \frac{1}{2}$ denotes semi-annual coupons. Note that we assume that accrued coupons are not recovered. Substituting Eq. 8.4 in Eq. 8.5, we end up with the price of the defaultable coupon-paying bond

$$V_i(t,T) = P(t,T)W_i(t,T)^{\theta_i} Z_i(t,T) + c_i^f(T)\sum_{k=1}^{n} fP(t,T_k)Z(t,T_k)W_i(t,T_k)^{\theta_i} + \bar{R}\int_t^T P(t,s)Z_i(t,s)\theta_i\lambda_i^P(s)\mathrm{d}s. \tag{8.6}$$

The par coupon, $c_i^f(T)$, is defined as the coupon of a bond that equals the face value of the bond, that is, $V(t, T) \equiv 1$. We define the par coupon as the sum of the liquid default-free coupon, $r^f(T)$, and the par credit spread of the illiquid defaultable bond, $s_i^f(T)$. The par coupon is given by,

$$c_i^f(T) = r^f(T) + s_i^f(T) = r^f(T) + l_i^f + d_i^f(T), \tag{8.7}$$

where the par credit spread is decomposed into the bond basis l_i^f and par default spread $d_i^f(T)$.

8.3 Data

8.3.1 Raw Data

From exhibit 32 of Moody's default report (Ou 2015), we obtain historical global cumulative default probabilities for AAA, AA, A, BBB, BB, B, and CCC rated bonds for maturity from 1 to 20 years over the 1920–2014 period. Using exhibit 20 and 21 of the Moody's default report, we obtain annual average recovery rates of all bonds and senior unsecured bonds over the 1982–2014 period.

As a proxy for risk-free interest rates, we extract the monthly average of daily yields on US government bonds from the Federal Reserve Board's (FED) Selected Interest Rates H.15 statistical release for the three-month (3 M) and 6 M treasury bills and one-year (1Y), 2Y, 3Y, 5Y, 7Y, 10Y, 20Y, and 30Y constant maturities from April 1953 to December 2014. We extend the bond yields of all maturities except the 20Y and 30Y maturities further to April 1941 using GlobalFinancialData (GFD) and the 3 M and 10Y maturities further to January 1919.[5] We also obtain the monthly average yield on the composite of long-term government bonds with a maturity over ten years from the FED from January 1925 onward and from January 1919 to January 1925 from GFD. Using GFD, we follow Giesecke et al. (2011) and further extend the long-term composite government bond yield from March 1857 to December 1918 with yields on high-grade New England municipal bonds from March 1857 to December 1914 and the yield of high-grade Bond Buyer municipal bonds from January 1915 to December 1918. Finally, we extract the monthly weighted average life (WAL) maturity of the composite long-term government bond index from Bank of America Merrill Lynch (ML) from December 1988 to December 2014.[6]

The monthly average yields on Moody's US long-term corporate bond benchmarks of the four individual IG ratings are obtained from GFD over the period of January 1919 to December 2014. Using GFD, we follow Giesecke et al. (2011) and further extend the AAA corporate bond yield from March 1857 to December 1918 with the yield on long-term high-quality railroad bonds. From December 1988 to December 2014, we extract the monthly average yield and WAL maturity for the individual and composite US IG and HY ratings for multiple non-overlapping maturity bucket benchmarks (1–3Y, 3–5Y, 5–7Y, 7–10Y, 10–15Y, and 15Y+), the 10Y+ maturity bucket benchmark, and the combination of all-maturities bucket benchmarks from ML. From ML, we also obtain the option-adjusted credit spreads for the composite and individual IG and HY rating benchmarks and all the described maturity buckets from December 1996 to December 2014.

For historical measures of the bond basis of multiple ratings, we rely on the papers of Huang and Huang (2012), Chen et al. (2014), and De Jong and Driessen (2012) who quantify the bond basis. As an alternative measure for the bond basis, we calculate the average historical difference between the option-adjusted credit and credit default swap (CDS) spreads. As indicated by Ilmanen (2011), CDSs are more liquid and present a more generic view of a firm's default risk than corporate bonds. Therefore, we extract 5Y CDS spreads from Barclays Capital IG index and HY index that are available from March 2004 and September 2005 to December 2014, respectively.

8.3.2 Smooth Marginal Default Probabilities

The historical annual marginal default probabilities are not monotonous with term, in contrast to the popular assumption in the literature (see Duffie and Singleton 1999). For example, the marginal default probability of the AAA and AA ratings is higher in years 2–8 than for years 9–15. To prevent using data that do not conform to that commonly assumed in the theoretical literature we follow, we adjust the marginal default probabilities by fitting a smooth function through the raw data.

The estimation of smooth marginal default probabilities is set up as follows. A fully specified one-year Markov transition matrix is estimated by minimizing the weighted sum of the squared differences between the fitted and historical cumulative default probabilities. The weight assigned to each time period is the ratio of the largest cumulative default probability across all ratings and horizons divided by the cumulative default probability of a specific rating and horizon to ensure that each cumulative is relatively equally important in the minimization.[7]

$$
\begin{aligned}
&\min_{\Gamma} && \sum_{I=1}^{i-1}\sum_{j=1}^{H}\frac{d_{I-1,H}}{d_{i,j}}\left(\Gamma_{i,I}^{(j)}-d_{i,j}\right)^2 && \\
&\text{s.t.} && 0\le \Gamma_{k,l}\le 1, && k,l=1,\dots,I \\
& && \sum_{k=1}^{I}\Gamma_{i,k}=1, && k=1,\dots,I \\
& && \Gamma_{I,k}=0, && k=1,\dots,I-1 \\
& && \Gamma_{I,I}=1, &&
\end{aligned}
\qquad (8.8)
$$

where $d_{i,j}$ is the historical j-year cumulative default probability of rating i, H the maximum horizon in years, I the number of ratings, and Γ the one-year Markov transition square $I \times I$-matrix. The rating letters correspond to rating numbers as follows: {AAA, AA, …, CCC, D(efault)} = {1, 2, …, 7, 8}. The last row of Γ is enforced to equal [0…0 1] which reflects the absorbing state of default.

The R^2 of the fitted marginal and cumulative default probabilities with respect to the original values per rating are reported in Table 8.2. The fitted cumulative default probabilities are close to the original ones as the R^2 is above 0.95 for each rating, indicating that our smoothed estimates do not greatly distort the overall pattern of default probabilities. The use of our smoothed estimates, however, has the advantage that it ensures that we obtain smooth CSTS.

8.3.3 Recovery Rates

There are only small differences between the average recovery rates of senior unsecured bonds and all bonds from 2000 onward. The average recovery rate of senior unsecured bonds across different ratings is around 38%, though it takes a few years to obtain the recovery. Including the delay in recovery, the discounted recovery rate is 35% for all senior unsecured ratings.

8.3.4 Government Bond Yields and Term Structure

We describe the risk-free yield term structure in a particular month using the Nelson–Siegel (NS) functional form:

$$y_t(T) = \beta_{1,t} + \beta_{2,t}\left(\frac{1-\exp^{-\lambda_t T}}{\lambda_t T}\right) + \beta_{3,t}\left(\frac{1-\exp^{-\lambda_t T}}{\lambda_t T} - \exp^{-\lambda_t T}\right), \qquad (8.9)$$

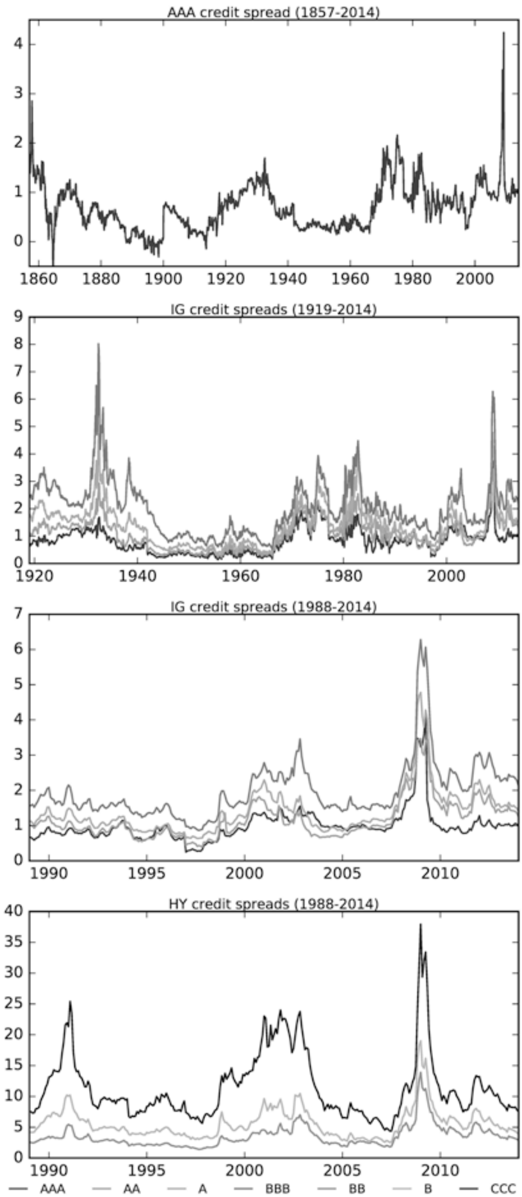
where $y_t(T)$ the yield at time t for maturity T in years, $\beta_{i,t}$ latent dynamic factor i at time t and λ_t the exponential decay rate at time t. Following Diebold and Li (2006), we assume a fixed and exponential decay rate equal to $\lambda = 0.7308$. We estimate Eq. 8.9 in a particular month using all available constant maturities yields with ordinary least squares. The NS fitted yields are reported in Table 8.3. The fit of the NS term structures is generally high with an average (median) cross sectional R^2 of 0.92 (0.97) from 1941 onward.

8.3.5 Credit Spreads

8.3.5.1 Extended Sample of Option-Adjusted Credit Spreads

The most accurate measure of the credit spread is the option-adjusted spread (OAS) of ML as it is duration-matched and corrected for optionality. The ML OAS is available from December 1996 onward, and we extend the series up to December 1988 for all the available ML corporate bond maturity bucket benchmarks using the following estimation procedure inspired by Giesecke et al. (2011). In a particular month, we calculate the difference between the yield of the ML corporate bond maturity bucket benchmark and government bond yield that is estimated with Eq. 8.9 by using the WAL maturity of the corporate bond benchmark. For the 10Y+ and 15Y+ corporate bond maturity bucket benchmarks, we use the yield of the composite long-term government bond index as it better matches the duration of these maturity buckets than the government bond yield that corresponds to its WAL maturity. For the IG ratings, we obtain the longest available history of the OASs of the Moody's long-term corporate bond benchmarks by subtracting the LT composite government bond yields from the Moody's long-term corporate bond yields (as suggested by using Giesecke et al. 2011). Descriptive statistics of the constructed credit spread series are reported in Table 8.4, and Fig. 8.1 shows a graphical representation of the series.

Fig. 8.1 Graphical presentation of the credit spreads of the individual IG and HY rating for different sample periods



Credit spreads are positively skewed, such that average spreads are higher than median spreads. The average credit spreads of the A and BBB ratings are almost the same over the longest available sample compared to the 1988–2014 sample period, whereas the average credit spreads for the AAA and AA are lower for the 1998–2014 sample. The average of the average AAA and BBB credit spreads over 1919–2014 equals 144 bps, which is in line with Giesecke et al. (2011) who find an average credit spread of 153.3 bps over 1866–2008.

The average WAL maturities of the IG 10Y+ maturity bucket benchmarks are about 25 years over 1988–2014, whereas the WAL maturities of the HY all-maturity benchmarks range from 9 for BB to 7 for CCC. Although we do not have direct information of the WAL maturities regarding the corporate bond benchmarks before 1988, we examine the WAL maturity of the LT composite government bond index with maturities over ten years to get an indication for the WAL maturities of the IG corporate bond benchmarks before 1988. To get an indication of the WAL maturity of the LT composite government bond index before 1988, we compare the average yield of the LT government bond index with the average yield of the constant maturities indices using Table 8.3. Although the WAL maturity of the LT government bond index is above 20 years from 1988 onward, the average yield of the LT government bond index seems closer in line with the average yield of the 15-year constant maturity index for longer historical sample periods. Therefore, this might also suggest that the WAL maturities of the IG corporate bond benchmarks before 1988 are close to 15 years.

8.3.5.2 Credit Spread Term Structures

We construct NS CSTS for all individual corporate bond rating benchmarks from December 1988 to December 2014 in the same manner as for the government bonds in Eq. 8.9. For each rating, we take the credit spreads of all the available corporate bond non-overlapping maturity bucket benchmarks and their corresponding WAL maturities in a particular month and estimate the NS parameters using ordinary least squares. The cross-sectional explanatory power of the fitted CSTS is high with an average (median) R^2 of roughly more than 0.75 (0.80) for all individual ratings except for the AAA rating. The lower R^2 of the AAA rating might be caused by the fact that this rating contains the least number of issuers compared to all other individual ratings, especially for some particular maturity buckets. Although we do not use these constructed average

CSTS in the calibration of the pricing model of Sect. 8.2, we take them as reference to compare them with the LT-expected CSTS we construct in the remainder of this chapter.

8.3.6 *Bond Basis*

There are some papers that quantify the bond basis. Huang and Huang (2012) find that credit risk accounts only for about 20–30% of the observed credit spreads of IG bonds, whereas the fraction is higher for high yield spreads. Chen et al. (2014) document comparable results for the small fractions of pure default risk for IG bonds and higher fractions for HY bonds. De Jong and Driessen (2012) quantify that the liquidity risk premium of long-term IG and HY bonds is 60 bps and 150 bps, respectively. In Table 8.5, we summarize the main findings of Huang and Huang (2012), De Jong and Driessen (2012), and Chen et al. (2007) regarding the quantification of the bond basis. Based on the results of Huang and Huang (2012), De Jong and Driessen (2012), and Chen et al. (2007), the average bond basis is approximately 60, 66, 78, and 97 bps for the AAA, AA, A, and BBB ratings, respectively.

We compare these findings of the bond basis with an estimate for the bond basis that is calculated as the average difference between the 5Y spread of the credit default swap (CDS) index and 5Y credit spread of the corresponding composite corporate bond benchmark. We estimate an IG bond basis of 95 bps based on the average CDS-credit spread difference. As the composite IG benchmark is tilted to the A and BBB ratings, our estimate for the A and BBB bond basis of 78 and 97 bps, respectively, is in line with the alternative CDS-credit spread estimate of the IG bond basis.

8.4 Methodology

8.4.1 *Model Parameters*

Based on the historical data analysis, we assume some of the model parameters of the defaultable corporate coupon-paying bond in Eq. 8.6, namely:

1. We use the smoothed cumulative default probabilities estimated in Sect. 8.3.2 in place of the physical cumulative default probabilities $W_i(t, T)$.
2. The expected constant recovery rate $\overline{R}$ of 35% (see Sect. 8.3.3).

3. The par yields of 3 M, 10Y, and 20Y maturities of the risk-free interest rate term structure equal to 3.55%, 4.95%, and 5.95%, respectively. The risk-free par yield of 3 M and 10Y maturities is based on the historical average over the 1919–2014 period. The 20Y–10Y term spread is assumed to be 0.2%, which is in line with the longest available historical sample. With the assumptions of the three par yields, we solve the three NS β-parameters of Eq. 8.9 and determine the risk-free par yields $r^f(T)$ for all other maturities. The risk-free zero yields, required in $P(t, T)$, are obtained by bootstrapping the risk-free par yield term structure assuming annual coupons.
4. The par credit spreads $s_i^1(T)$ of 0.80%, 1.05%, 1.40%, and 2.05% of annual (f = 1) coupon-paying defaultable corporate bonds with AAA, AA, A, and BBB ratings, respectively, and a corresponding maturity of T = 15 years. The assumed par credit spreads of the individual IG ratings are based on the historical averages over the maximum overlapping sample from 1919 to 2014 and rounded to multiples of 0.05%. The assumption of the maturity of 15 years is based on paragraph 3.5.1.
5. The par credit spreads $s_i^1(T)$ of 3.50%, 5.55%, and 11.35% for annual coupon-paying defaultable corporate bonds with BB, B, and CCC ratings, respectively, and corresponding maturity of T = 9, 8, and 7 years, respectively. The assumed par credit spreads of the individual HY ratings are based on the historical averages over the maximum overlapping sample from 1988 to 2014 and again rounded to multiples of 0.05%. We assume that the individual HY average credit spreads over the 1988–2014 period would be approximately the same over the 1919–2014 period. This assumption is based on the observation that the average credit spreads of the A and BBB ratings are approximately the same measured over 1919–2014 and 1988–2014 sample periods. The assumptions of the WAL maturities are based on the historical average over the 1988–2014 period and rounded to whole years.
6. The par bond bases l_i^1 of 0.6%, 0.7%, 0.85%, 1.10%, 1.40%, 1.15%, and 1.00% for annual coupon-paying defaultable corporate bonds with AAA, AA, A, BBB, BB, B, and CCC ratings, respectively. These assumptions are based on the average bond basis of Huang and Huang (2012) and L. Chen et al. (2007) from Table 8.5 and rounded to 0.05%. We do not directly consider De Jong and Driessen (2012) as they do not report rating varying bond bases, although our assumptions for the bond basis of the aggregate IG

and HY benchmarks are in line with their results. With the assumed par bond bases l_i^f, we can calculate the continuously compounded bond basis l_i^c using Eq. 8.3 and $Z_i(t, T)$ discount factors.

Table 8.6 summarizes the model assumptions.

8.4.2 Calibration Credit Spread Term Structures

In order to calibrate the term structure of annual coupon-paying ($f = 1$) par credit spreads $s_i^1(T)$ per rating following Eq. 8.7, we only require information regarding the default spread $d_i^1(T)$ as we assume maturity independent bond bases per rating l_i^1 in Sect. 8.4.1. For every rating i, we assume a par credit spread $s_i^1(T)$ of the annual coupon-paying defaultable corporate bond for one particular maturity T. For the IG ratings, we made an assumption for the par credit spreads $s_i^1(T)$ for the $T = 15$-year maturity and we made par credit spreads assumptions for a maturity of $T = 9$, 8, and 7 year for the BB, B, and CCC ratings. Adding the par credit spread $s_i^1(T)$ to the assumption of the liquid default-free par coupon $r^1(T)$ gives to total par coupon $c^1(T)$ following Eq. 8.7. So, the total par coupon is assumed to be known for one particular maturity per rating and the other maturities have to be calibrated. In Sect. 8.4.1, we discussed assumptions regarding the prices of risk-free zero-coupon bonds $P(t, T)$, physical default probabilities $W_i(t, T)$, recovery rate $\bar{R}$, and additional discount factors $Z_i(t, T)$ so that we only need to calibrate the price of risk parameter θ_i before we can calibrate the full term structure of par default and credit spreads.

The price of risk parameter θ_i is calibrated as follows for a particular rating i. For every rating i, we assume the total par coupon $c^1(T)$ for one particular maturity T to be known. With this assumption and the other assumptions regarding $P(t, T)$, $Z_i(t, T)$, $W_i(t, T)$, and $\bar{R}$, only the price of risk parameter θ_i is the unknown parameter in the expression of the par bond price of the defaultable corporate bond of Eq. 8.6. We first discretize this expression of the par bond price of Eq. 8.6 with the trapezoidal rule as follows

$$
\begin{aligned}
V_i(t,T) &= P(t,T)W_i(t,T)^{\theta_i} Z_i(t,T) + c_i^1(T)\sum_{k=1}^{n} P(t,T_k)Z_i(t,T_k)W_i(t,T_k)^{\theta_i} \\
&\quad + \bar{R}\sum_{k=1}^{n} \frac{P(t,T_k)Z_i(t,T_k) + P(t,T_{k-1})Z_i(t,T_{k-1})}{2}\begin{bmatrix} W_i(t,T_{k-1})^{\theta_i} \\ -W_i(t,T_k)^{\theta_i} \end{bmatrix} \\
&= 1.
\end{aligned}
$$

We calibrate θ_i such that this expression equals 1.

With the calibrated θ_i, we calibrate the default spreads $d^1(T)$ for all other maturities using Eq. 8.7. The only unknown parameter for the corporate bond with particular maturity T is the par default spread $d_i^1(T)$. So, for every maturity T, we calibrate $d_i^1(T)$ such that the bond price equals 1. Adding the calibrated par default spread to the par bond basis gives the par credit spread.

8.4.3 Expected Credit Excess Returns

To estimate the expected excess returns of corporate bonds over government bonds, we follow the procedure of De Jong and Driessen (2012) and Bongaerts et al. (2011). The method works as follows. First, we approximate an annual coupon-paying defaultable bond with maturity T and rating i by a defaultable zero-coupon bond that has the same duration U as the coupon-paying defaultable bond. The price of the defaultable zero-coupon bond with maturity U equals

$$D_i(t,U) = P(t,U)Z_i(t,U)\left[Q_i(t,U) + \bar{R}\left(1 - Q_i(t,U)\right)\right] = \frac{1}{\left(1 + y_{iU}\right)^U},$$

where y_{iU} is the annual compounded yield of the defaultable bond with rating i and maturity U. This expression assumes that default losses are incurred at maturity. We express the price of the liquid default-free zero-coupon bond with maturity U as

$$P(t,U) = \frac{1}{\left(1 + y_{gU}\right)^U},$$

where y_{gU} is the annual compounded yield of the default-free government bond with maturity U. The expected real-world cumulative return of holding the defaultable zero-coupon bond at time t up to maturity U is

$$\left(1 + y_{iU}\right)^U\left[W_i(t,U) + \bar{R}\left(1 - W_i(t,U)\right)\right]. \tag{8.10}$$

Next, we annualize the expected cumulative return in Eq. 8.10 and subtract the annual expected return of the default-free zero-coupon government bond. This gives the annual expected real-world excess return of the defaultable zero-coupon bond with rating i and maturity U, $\mathbb{E}_t^{\mathbb{P}}\left(r_{iU}\right)$, as follows:

$$\mathbb{E}_t^{\mathbb{P}}\left(r_{iU}\right)=\left(1+y_{iU}\right)\left[W_i\left(t,U\right)+\bar{R}\left(1-W_i\left(t,U\right)\right)\right]^{1/U}-\left(1+y_{gU}\right). \quad (8.11)$$

Note that these are expected excess return for a buy-and-hold strategy of corporate bond investments. Portfolio rebalancing following upgrades and downgrades are not incorporated in these expected excess returns.

8.5 Results

8.5.1 Credit Spread Term Structures

The calibrated price of risk parameters θ_i per rating, reported in Table 8.7, is 4.44, 2.18, 2.36, 2.22, 1.54, 1.39, and 1.29 for the AAA, AA, A, BBB, BB, B, and CCC ratings, respectively.[8] Our calibrated price of risk parameters of the IG bonds is in line with the existing literature. Giesecke et al. (2011) find a price of risk parameter of 2.04 for the composite of IG bonds based over a 1866–2008 sample, and Driessen (2005) reports price of risk parameters of 1.83, 2.61, and 2.37 for AA, A, and BBB rated bonds, respectively, based on the 1991–2000 sample. The calibrated price of risk parameters indicates that investors in IG bonds are more risk-averse than for HY bonds.

Graphical presentations of the calibrated LT-expected par CSTS are shown in Fig. 8.2 and compared to the historical ones. The calibrated LT-expected par CSTS are (1) upward-sloping for high credit ratings ranging from AAA to BBB, (2) humped-shaped for the BB and B middle graded ratings, and (3) downward sloping for the CCC speculative rating. The shapes of these LT-expected par CSTS are consistent with the literature (Merton 1974; Duffie and Singleton 1999; Sarig and Warga 1989; Fons 1994). In addition, the historical CSTS have the same shape as the long-term expected CSTS for the IG and CCC ratings. On the other hand, the downward sloping shapes of the historical CSTS, containing both credit and basis components, of the BB and B ratings are

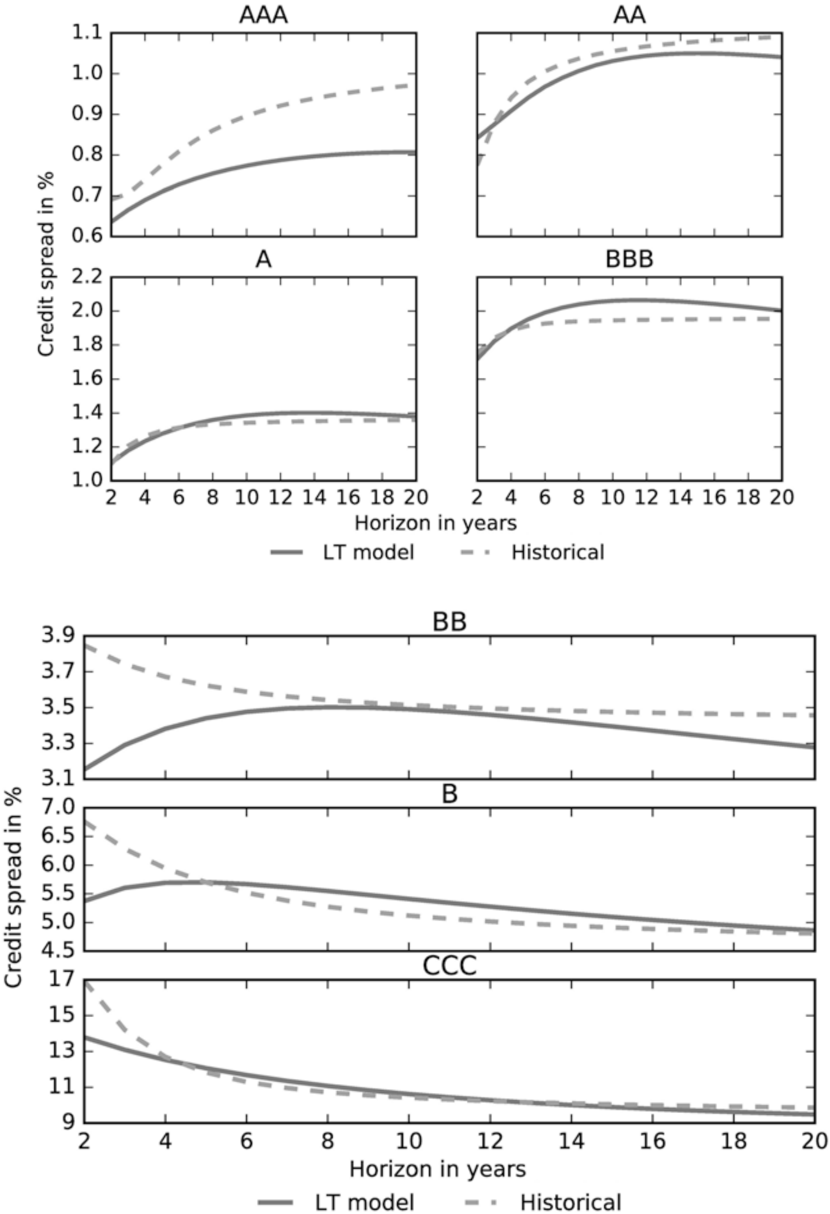


Fig. 8.2 A graphical presentation of the long-term (LT) model expected CSTS of the individual IG and HY ratings from Table 8.7

not in line with the theoretical hump-shape. This might be influenced by the liquidity of short-term BB and B bonds or the sample period that contain two crisis periods. Overall, we conclude that the shapes of the calibrated long-term expected par CSTS are in line with the literature and historical data.

In addition to the comparison with the literature, we also compare the shapes of the calibrated LT-expected par credit spread curves with the average historical CSTS of Sect. 8.3.5.2 in terms of correlation between the credit spreads for the 2–20-year maturities of both CSTS. We find high correlations above 0.95 for the individual IG ratings, which indicates that the shapes of the LT-expected and historical IG CSTS are strongly in line with each other. We observe lower correlations for the individual HY ratings, especially for the BB rating that shows a correlation of 0.40 between the LT-expected and historical average CSTS. On the other hand, the correlation between the LT-expected and historical average credit spreads for the CCC rating is high and equal to 0.93. The lower correlations for the BB and B ratings are mainly due to the differences between the shape of the short-end of the CSTS as seen earlier in this paragraph. Overall, we conclude that the calibrated LT-expected CSTS are in line with the estimated historical average CSTS.

Furthermore, we make a comparison between the LT-expected CSTS and the historical distribution of CSTS in Fig. 8.3. Although the figures show that the historical distribution of CSTS has a wide variation, the historical average CSTS are generally close to the 60%-percentile of the historical distribution which confirms that the historical distribution of CSTS has a positive skewness. The calibrated LT-expected CSTS are also generally close to the 60%-percentile of the historical distribution of CSTS, except for the AAA rating that is closer to the 40%-percentile of the historical distribution. This exception for the AAA rating is caused by the difference in sample means between 1988–2014 and 1919–2014 that we used for the calculation of the historical average CSTS and the calibrated one. Whereas the average historical BB and B CSTS is downward sloping, it is humped-shaped between the 40% and 60% percentiles of the historical distribution which is better in line with the theoretical and empirical literature. Overall, we conclude the calibrated LT-expected CSTS capture the positive skewness in the historical distribution of CSTS and are generally close to historical average CSTS.

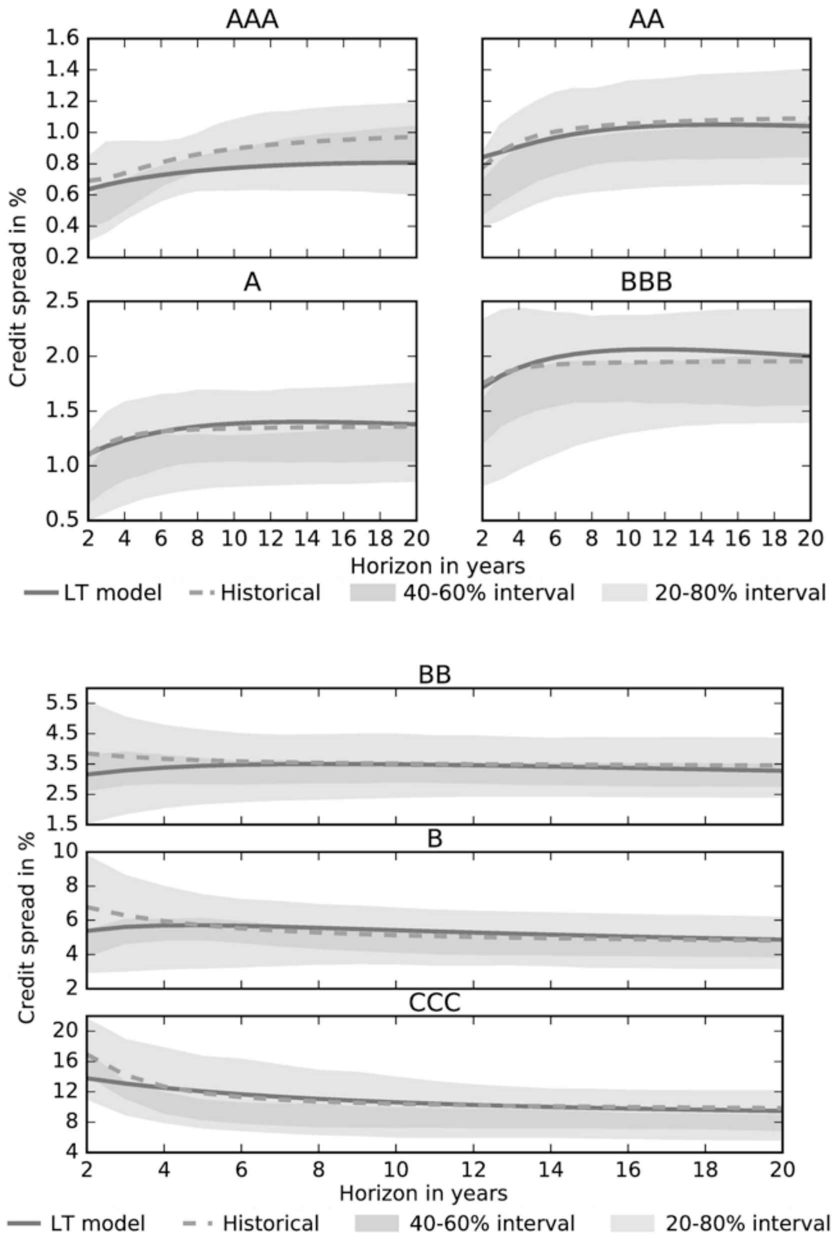


Fig. 8.3 A graphical presentation of the long-term (LT) model expected CSTS of the individual IG and HY ratings from Table 8.7, with confidence intervals

As a robustness check, we calibrated the LT-expected par CSTS over the same sample as the historical average CSTS in order to get a fairer comparison between both. Therefore, we calibrate the risk-neutral model on the 2000–2014 period by using different assumptions for the risk-free interest rates and credit par spreads. Based on unreported results (available upon request), we obtain almost the same historical average and LT-expected par CSTS if we calibrate the LT-expected par CSTS over the same sample that is used for the calculation of the historical average. This means that the LT-expected CSTS that we calibrate on the 1919–2014 sample is a good indication of the historical average CSTS over this period. So, our findings are robust to different model assumptions.

8.5.2 *Credit Excess Returns*

The calibrated LT-expected annualized buy-and-hold credit excess returns following the approach in Eq. 8.11 are reported in Table 8.8. We find that the LT-expected annual excess gross returns of ten-year coupon-paying corporate bonds of the AAA, AA, A, BBB, BB, B, and CCC ratings are 0.74%, 0.89%, 1.18%, 1.67%, 2.19%, 2.44%, and 3.23%, respectively. Our calibrated LT-expected excess returns are in line with the existing literature. For example, our findings generally only show differences with Hull et al. (2005) in the order of 0.05% for IG bonds and 0.2% for HY bonds.[9] Furthermore, Giesecke et al. (2011) find a long-term expected excess return of roughly 1% for IG bonds over the 1900–2008 period, which is close to the average of 1.1% of the calibrated LT-expected excess returns of the four individual IG ratings.[10]

In addition to the comparison with the literature, we compare the calibrated LT-expected excess returns with historical average excess returns. Ng and Phelps (2011) report historical arithmetic average excess net returns of about 0.7% (3%) for IG (HY) bonds over the 1990–2009 period and similar average returns are found by Ilmanen (2011) for longer historical periods. The historical average excess returns are about 0.4% lower (higher) than our calibrated LT-expected excess returns of IG (HY) bonds. Possible explanations for the difference in expected and historical average excess returns could be related to (a combination) of the following effects: more/less historical defaults than expected using our model; difference the actual and expected recovery rates; transaction costs that we do not incorporate in our model. The first two possible explanations for the difference between historical and expected defaults are probably more important for HY bonds than IG bonds as the default probability of HY bonds is higher than IG bonds. Our LT-expected credit excess return assumptions are derived for buy-and-hold investments, whereas typical corporate bond benchmarks are periodically rebalanced by removing constituents that no longer reflect the rating category of the benchmark as the result of rating upgrades and downgrades. Ng and Phelps (2011) show that relaxing the requirement of selling downgraded bonds for corporate bond benchmarks of IG ratings gives approximately 0.4% additional return compared to constrained indices. So, it seems that we can explain large part of the difference between the LT-expected and historical average excess returns of IG bonds to this rebalancing effect. Overall, we conclude that our calibrated LT-expected excess returns are generally in line with the historical average returns.

We observe a consistent increasing pattern in the expected credit excess return and the quality of the credit rating for every maturity. For every maturity, the AAA rated bond has the lowest expected credit excess return, followed by the AA rating, and so on. Within a rating category, we observe that the term structure of expected credit excess returns follows the shape as the term structure of par credit spreads. The expected credit excess returns of the individual IG ratings are within 1% of each other for all maturities which is approximately the same as the difference in expected par credit spreads. There are small differences of about 0.2% between the expected credit excess returns for the BB and B ratings. Depending on the maturity, the CCC rating has expected excess returns that are about 0.6–1.7% higher than that of the B rating. Overall, long-term investors could expect higher returns when investing in HY bonds compared to IG bonds though this coincides with higher risks.

8.6 Conclusion

In this chapter, we estimated LT-expected credit spreads and excess returns for multiple US corporate bond ratings and maturities using a risk-neutral model that is calibrated on historical data over the 1919–2014 period. The risk-neutral model incorporates the well-known credit spread puzzle by the addition of a maturity-independent constant that varies per rating.

We find that investors appear more risk-averse when investing in IG corporate bonds compared to HY bonds. In addition, we show that the shapes of the calibrated LT-expected CSTS are in line with the existing literature. The shapes of the calibrated LT-expected CSTS are (1) upward-sloping for high credit ratings ranging from the AAA to BBB ratings, (2) humped-shaped for the BB and B middle-graded ratings, and (3) downward sloping for the CCC speculative rating. Furthermore, we find that the calibrated LT-expected CSTS are in line with the historical average CSTS and capture the positive skewness in the historical distribution of CSTS.

We show that the expected annual excess gross corporate bond returns are in line with the empirical literature of expected credit excess returns of buy-and-hold investments. Our expected excess returns for IG (HY) bonds are approximately 0.4% higher (lower) than historical average credit excess returns. For HY, this difference could be due to a combination of effects. For IG, the difference could be related to benchmark construction. We obtain the returns of buy-and-hold benchmarks, whereas historical benchmarks are periodically rebalanced following rating upgrades and downgrades of constituents within a benchmark. Ng and Phelps (2011) show that relaxing the requirement of rebalancing gives 0.4% additional return for IG benchmark, which is approximately the documented difference between the LT-expected and historical average excess returns.

We extend the findings of Giesecke et al. (2011) for long historical average credit excess returns by determining the credit excess returns for ratings and maturities. Furthermore, we document two interesting patterns in the LT-expected credit excess returns. First, we find a consistent increasing pattern in the expected credit excess return and the quality of the credit rating for every maturity. So, long-term investors could expect higher returns when investing in HY bonds compared to IG bonds, though this coincides with higher risks. Second, we observe that within a rating category, the term structure of expected credit excess returns follows the same shape as the term structure of par credit spreads. Our findings are robust for different assumptions.

Acknowledgments I thank Alex Boer, Bert Kramer, and Martin van der Schans for very helpful comments and suggestions. Any remaining errors are my own.

Appendix

Table 8.1 The estimated long-term expected credit spreads and excess returns

Rating	*Credit spread*	*Excess return*
AAA	0.77	0.74
AA	1.03	0.89
A	1.39	1.18
BBB	2.06	1.67
BB	3.49	2.19
B	5.41	2.44
CCC	10.62	3.23

Source: Author calculations

Table 8.2 The R^2 of the marginal and cumulative default probabilities of the original Moody's data and the estimated model values from optimization of Eq. 8.8

Rating	*Marginal*	*Cumulative*
AAA	0.07	0.95
AA	0.63	1.00
A	0.89	1.00
BBB	0.87	1.00
BB	0.96	1.00
B	0.99	1.00
CCC	0.97	0.99

Source: Ou (2015) and author calculations

Table 8.3 The Nelson–Siegel fitted average of the US government bond yields of particular maturities for multiple samples

Sample	*3 M*	*1Y*	*5Y*	*10Y*	*15Y*	*20Y*	*30Y*	*LT (10Y+)*
1857–2014								4.70
1919–2014	3.55			4.96				5.03
1941–2014	4.00	4.32	5.13	5.41	5.51	5.56	5.61	5.48
1953–2014	4.60	4.97	5.81	6.07	6.17	6.22	6.26	6.08
1976–2014	4.95	5.32	6.38	6.79	6.93	7.01	7.08	6.93
1988–2014	3.29	3.51	4.63	5.18	5.40	5.50	5.61	5.7 (20.9)
2000–2014	1.90	1.96	3.16	3.89	4.18	4.32	4.47	4.36 (20.0)

In addition, we report the historical average yield of the long-term (LT) government bond index with a maturity over ten-years (10Y+). The weighted average life maturity of the LT government bond index is reported between parentheses

Source: GobalFinancialData, Federal Reserve Board and author calculations

Table 8.4 Descriptive statistics of the individual IG 10Y+ and HY all-maturity (all) rating benchmark for two sample periods

	AAA	*AA*	*A*	*BBB*	*BB*	*B*	*CCC*
Panel A: Descriptive statistics monthly credit spreads (1919–2014)							
Statistic	(10Y+)	(10Y+)	(10Y+)	(10Y+)	(All)	(All)	(All)
Mean	0.82	1.06	1.40	2.03			
Stdev	0.46	0.56	0.73	0.99			
Skew	1.43	0.78	1.09	1.40			
Kurt	8.83	3.85	5.10	7.14			
Min	0.14	0.23	0.32	0.51			
0.25	0.44	0.56	0.79	1.26			
0.50	0.82	1.03	1.33	1.93			
0.75	1.06	1.40	1.80	2.54			
Max	4.24	3.47	4.78	8.02			
Autocorr (1)	0.96	0.97	0.98	0.98			
Autocorr (12)	0.69	0.77	0.74	0.72			
Panel B: Descriptive statistics monthly credit spreads (1988–2014)							
Statistic	(10Y+)	(10Y+)	(10Y+)	(10Y+)	(All)	(All)	(All)
Mean	0.99	1.16	1.40	1.98	3.48	5.57	11.36
Stdev	0.46	0.54	0.64	0.81	1.74	2.45	5.40
Skew	3.54	1.80	2.46	2.51	2.57	2.14	1.74
Kurt	21.46	7.66	11.72	12.39	12.71	10.13	6.55
Min	0.25	0.39	0.63	0.86	1.41	2.54	4.37
0.25	0.78	0.80	1.01	1.52	2.44	3.92	7.71
0.50	0.93	1.01	1.22	1.70	3.03	4.93	9.60
0.75	1.07	1.40	1.60	2.35	4.09	6.60	13.25
Max	4.24	3.47	4.78	6.28	13.90	19.00	37.94
Autocorr (1)	0.96	0.97	0.98	0.98	0.96	0.96	0.96
Autocorr (12)	0.69	0.77	0.74	0.72	0.40	0.31	0.34
WAL maturity	25.2	24.2	23.9	23.5	9.2	7.5	6.8

The mean, standard deviation (stdev), skewness (skew), kurtosis (kurt), minimum (min), maximum (max), 25%, 50%, and 75% percentiles and monthly (1) and annual (12) autocorrelation (autocorr). In addition, we show the weighted average life (WAL) maturity for the 1988–2014 sample

Source: GobalFinancialData, Merrill Lynch and author calculations

Table 8.5 The findings of three papers that have quantified the liquidity premium in % of ten-year corporate bonds for different ratings

Number	*Paper*	*AAA*	*AA*	*A*	*BBB*	*BB*	*B*	*CCC*
1	Huang and Huang (2012)	0.53	0.77	1.00	1.38	1.28	0.82	
2	Chen et al. (2014)	0.63	0.63	0.76	0.93	1.22		
3	De Jong and Driessen (2012)	0.60	0.60	0.60	0.60	1.50	1.50	1.50
Mean	1 & 2	0.58	0.70	0.88	1.15	1.25		
Mean	1 & 3	0.57	0.68	0.80	0.99	1.39	1.16	
Mean	2 & 3	0.61	0.61	0.68	0.77	1.36		
Mean	1, 2 & 3	0.59	0.66	0.78	0.97	1.33		

The liquidity premium of Huang and Huang (2012) is taken from Table 8.2 of the paper by computing the difference between the ten-year maturity calculated credit spread and yield spreads. The liquidity premium of H. Chen et al. (2014) is taken from Table 8.5 of the paper by calculating the average difference between the credit spread and pure default spread of the bad (B) and good (G) state. Although De Jong and Driessen (2012) differentiate for the liquidity premium for different ratings, they do not report the actual numbers. Therefore, we decide to take the numbers they report

Source: Huang and Huang (2012), Chen et al. (2014), De Jong and Driessen (2012), and author calculations

Table 8.6 The assumptions for the par yield $c_i^f(T)$ of the defaultable corporate bond with annual, $f = 1$, coupon payments, rating i, and maturity T

i	T	$c_i^1(T)$	$r^1(T)$	$s_i^1(T)$	l_i^1	$d_i^1(T)$	$\frac{d_i^1(T)}{s_i^1(T)}$
AAA	15	5.88	5.08	0.80	0.60	0.20	25.0%
AA	15	6.13	5.08	1.05	0.70	0.35	33.3%
A	15	6.48	5.08	1.40	0.85	0.55	39.3%
BBB	15	7.13	5.08	2.05	1.10	0.95	46.3%
BB	9	8.41	4.91	3.50	1.40	2.10	60.0%
B	8	10.40	4.85	5.55	1.15	4.40	79.3%
CCC	7	16.14	4.79	11.35	1.00	10.35	91.2%

The par coupon is split into the risk-free par yield $r^f(T)$ and par credit spread $s_i^f(T)$. The par credit spread is decomposed into the bond basis l_i^f and default spread $d_i^f(T)$ assumptions of Eq. 8.7. In the last column, we report the par default spread as a percentage of the par credit spread

Source: Author calculations

Table 8.7 The long-term expected par credit spreads $s_i^1(T)$ of Eq. 8.7 for maturities T 1–10 years (panel A) and 11–20 years (panel B), and rating i

Panel A: $s_i^1(T)$ for maturities 1–10 years											
Rating i	θ_i	T=1	2	3	4	5	6	7	8	9	10
AAA	4.44	0.60	0.64	0.67	0.69	0.71	0.73	0.74	0.75	0.76	0.77
AA	2.18	0.80	0.84	0.87	0.91	0.94	0.97	0.99	1.01	1.02	1.03
A	2.36	1.01	1.11	1.18	1.23	1.28	1.31	1.34	1.36	1.37	1.39
BBB	2.22	1.57	1.72	1.82	1.90	1.95	1.99	2.02	2.04	2.05	2.06
BB	1.54	2.95	3.15	3.29	3.38	3.44	3.48	3.50	3.50	3.50	3.49
B	1.39	4.87	5.37	5.61	5.69	5.70	5.67	5.62	5.55	5.48	5.41
CCC	1.29	14.65	13.79	13.09	12.53	12.06	11.68	11.35	11.07	10.83	10.62
Panel B: $s_i^1(T)$ for maturities 11–20 years											
Rating i	ρ_i	11	12	13	14	15	16	17	18	19	20
AAA	0.99	0.78	0.79	0.79	0.80	0.80	0.80	0.80	0.81	0.81	0.81
AA	0.97	1.04	1.04	1.05	1.05	1.05	1.05	1.05	1.05	1.04	1.04
A	0.97	1.39	1.40	1.40	1.40	1.40	1.40	1.39	1.39	1.38	1.38
BBB	0.96	2.06	2.06	2.06	2.06	2.05	2.04	2.03	2.02	2.01	2.00
BB	0.40	3.48	3.46	3.44	3.42	3.40	3.37	3.35	3.32	3.30	3.28
B	0.66	5.34	5.28	5.21	5.15	5.10	5.04	4.99	4.95	4.90	4.86
CCC	0.93	10.44	10.27	10.13	10.01	9.89	9.79	9.70	9.62	9.55	9.48

In addition, we show the calibrated price of risk parameter θ_i of Eq. 8.4 per rating i in panel A. Finally, we calculate the correlation ρ_i between the 2–20 year maturities of the calibrated CSTS and the historical average CSTS over the 1988–2014 period from Sect. 8.3.5.2 for each rating i

Source: Author calculations

Table 8.8 The expected credit excess returns over government bonds based on Eq. 8.11 for maturities T 1–10 years (panel A) and 11–20 years (panel B)

Panel A: Expected credit excess returns for maturities 1–10 years										
Rating	1	2	3	4	5	6	7	8	9	10
AAA	0.60	0.63	0.65	0.67	0.69	0.70	0.71	0.72	0.73	0.74
AA	0.76	0.77	0.79	0.81	0.83	0.85	0.86	0.87	0.88	0.89
A	0.94	1.00	1.04	1.07	1.10	1.12	1.14	1.16	1.17	1.18
BBB	1.35	1.43	1.49	1.54	1.57	1.60	1.62	1.64	1.65	1.67
BB	1.93	2.00	2.05	2.09	2.12	2.14	2.16	2.17	2.18	2.19
B	2.15	2.29	2.36	2.40	2.42	2.43	2.44	2.44	2.44	2.44
CCC	3.85	3.71	3.60	3.51	3.45	3.39	3.34	3.30	3.26	3.23
Panel B: Expected credit excess returns for maturities 11–20 years										
Rating	11	12	13	14	15	16	17	18	19	20
AAA	0.75	0.76	0.76	0.77	0.77	0.78	0.78	0.79	0.79	0.79
AA	0.90	0.91	0.91	0.92	0.92	0.92	0.93	0.93	0.93	0.94
A	1.19	1.20	1.21	1.21	1.22	1.22	1.23	1.23	1.23	1.24
BBB	1.68	1.68	1.69	1.70	1.70	1.71	1.71	1.72	1.72	1.72
BB	2.20	2.20	2.21	2.21	2.21	2.22	2.22	2.22	2.22	2.22
B	2.43	2.43	2.42	2.42	2.41	2.41	2.41	2.40	2.40	2.40
CCC	3.21	3.18	3.16	3.15	3.13	3.12	3.11	3.10	3.09	3.08

Source: Author calculations

Notes

1. Helwege and Turner (1999) generated controversy with their findings of an upward-sloping credit spread term structure for low credit quality issuers. These findings have, however, been contradicted by Bohn (1999).
2. The assumption of fractional recovery of face value assumption is supported by empirical evidence; see Bakshi et al. (2001).
3. There exists considerable evidence of a short-term liquidity premium in the US sovereign debt market. See, for example, Nagel (2016) and the references therein.
4. Note that $T_n \equiv T$ with T equal to the bond maturity.
5. The historical interest rates obtained from GFD before April 1953 are based on Homer and Sylla (1996).
6. The yields of the composite of long-term government bonds index of Merrill Lynch are almost identical to the ones from the FED.
7. In our case, this is the 20-year cumulative default probability of the CCC rating.
8. Note that the price of risk parameter has no unit as it is a multiplication factor between the physical and risk-neutral hazard rates. For example, if the price of risk parameter is 4 then this means the risk-neutral investors perceive the risk-neutral default probabilities 4 times larger than the physical default probabilities.
9. Hull et al. (2005) find expected annualized excess returns of 0.81%, 0.86%, 1.12%, 1.58%, 2.03%, 1.36%, and 3.07% for the AAA, AA, A, BBB, BB, B, and CCC ratings, respectively. The authors define these excess returns over the swap rate.
10. Giesecke et al. (2011) report an expected annualized excess return of about 0.8%, which is based on a recovery assumption of 50%, an average credit spread of 1.53%, and average default loss rate of 1.5% measured over the period 1866–2008. However, the authors find that the annual default loss rate decreases by half to roughly 0.75% for the 1900–2008 period, which is a period that better corresponds to our 1919–2014 sample. Taking their finding of an average credit spread of 1.53% and default losses of 0.75% and our recovery assumption of 35% gives an expected excess return of 1.04%.

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