THE BAA CORPORATE CREDIT SPREAD: ESTIMATION AND DETERMINANTS

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ABSTRACT

The purpose of this paper is to estimate the Baa corporate bond spread and identify its four determinants: a default risk premium, a tax premium, an illiquidity premium, and an excess risk premium. Especially important is the modeling of the default risk premium which is the product of the probability of default and one minus the recovery rate. Both these two parameters are assumed to be stochastic. But, since an analytical joint distribution for them is difficult to find, the paper resorts to Monte Carlo simulation. Although the number of obligor names is limited in bond portfolios the paper argues that time diversification, which arises from holding a bond portfolio for the long run, can reduce substantially the uncertainty and the negative skew in mean bond returns. The paper finds that the Baa spread of 144 basis points can be decomposed into a tax premium of 39 basis points, an illiquidity premium of 4 basis points, a default risk premium of 41 basis points, leaving 60 basis points for the excess risk premium. The paper concludes by that there is little evidence for a bond spread puzzle.

JEL Classification Codes: E43, E47, C22

INTRODUCTION

The purpose of this paper is to estimate the spread of the US Baa corporate bond yield relative to the yield of the US 10-year Treasury-bond, and to decompose this spread into its determinants. There are four determinants recognized in the literature (Elton et al., 2001; Dick-Nielsen et al., 2012). These compensate for default risk, differential taxes, and illiquidity, with the rest being an excess risk premium. The identification of the bond spread and its determinants is an important topic that is and should be of interest to practitioners like bond portfolio managers, and to theoreticians like academicians specializing in corporate finance. Policymakers, especially central bankers, are also among those who monitor the movements in the spread and its determinants. Finally, credit risk management and regulatory requirements necessitate the recognition of the components of this spread.

A specific issue is whether the default risk premium is high enough, or, equivalently, whether the bond excess risk premium is too large, and whether its magnitude is a puzzle (Amato and Remolona, 2003) akin to the puzzle of the excess equity return (Mehra and Prescott, 1985; Chen et al., 2009), and, finally, whether it is due to systematic or idiosyncratic risk (Amato and Remolona, 2003; Chen et al., 2009; Hull, 2012a, 2012b). This paper argues that, although bond yields are known to be heavily negatively skewed, and that diversification is limited because of default contagion and the small number of different bond issuers, diversification can still be highly possible if one takes into consideration time diversification. Time diversification comes about when the investor holds the bond portfolio for many years, and not just for one year. This means that the bond excess premium in the long run will mostly be due to systematic risk. This paper finds that the implied Baa corporate bond beta, which is a measure of systematic risk in the Capital Asset Pricing Model (CAPM), is estimated to be as small as 0.082, a figure which is highly realistic. Second, and as is stated in Amato and Remolona (2003), incremental taxes, even if rather low, do induce a sizeable tax premium, because taxes are levied on the *level* of the bond yield, and not on the credit spread.

This paper has the distinctive feature of assuming that the probability of default and the recovery rate are both stochastic, and that they are negatively related to each other with a correlation coefficient of -0.7, which is retrieved from statistical data in Moody's (2009). This negative correlation arises because defaults usually happen during the lows of the business cycle, at a time when bond sales are likely to be fire sales since in such times demand is deficient. In many parts of the literature the recovery rate is taken to be a constant, although the evidence for a stochastic recovery rate, for its pro-cyclicality, and for a negative correlation with the probability of default are now strong (Altman et al., 2003, 2004, 2005; Moody's, 2009; Bruche and González-Aguado, 2010). For example, Hull (2012a, 2012b) assumes a recovery rate for Baa bonds to be a constant of 40%. Dionne et al. (2010) initially assume a constant recovery rate of 49.42% for Baa bonds, but they find later that random recovery rates add some 5 basis points to the default risk premium, and make the latter more uncertain. Kitwiwattanachai (2012) relaxes the assumption of a constant recovery rate and relates this rate to a measure of industry distress. However, few of these references use the powerful tools of Monte Carlo simulation to generate the default premium and its distribution. Dionne et al. (2010) is an exception, but the simulation and estimation approaches they adopt are totally and materially different and much more complex than the methodology of this paper.

THE THEORETICAL MODEL

The theoretical model borrows from Portait and Poncet (2012). The gross return on a bond is comprised of two terms: (1) a promised return of $1+k$, with a probability $(1-p)$, where p is the probability of default conditional on no previous default, and where k is the promised yield-to-maturity and the promised coupon, and (2) a return of $\alpha(1+k)$ with a probability p, where α is the recovery rate. The expected return is therefore:

$$(1+k)(1-p)+\alpha(1+k)p = 1+r+\pi+\rho+t \qquad (1)$$

In the RHS of equation (1) r is the risk-free rate, π is the excess risk premium, ρ is the illiquidity risk premium, and t is the tax premium. Since $(1+k)=(1+s+r)$, where s is the credit spread, then it can be proven that the spread s is equal to:

$$s = \frac{\pi+\rho+t+p(1-\alpha)+rp(1-\alpha)}{1-p(1-\alpha)} \approx \pi+\rho+t+p(1-\alpha) \qquad (2)$$

The same result is obtainable by a different method. Suppose the expected cash flows are:

(1) $(1-p)^i k + (1-p)^{i-1} p\alpha(1+k)$ for period i

(2) $(1-p)^N (1+k) + (1-p)^{N-1} p\alpha(1+k)$ for the last period N

And if the gross discount rate is $(1+r+\pi+\rho+t)$, then equations (2) are similarly obtained, by equalizing the discounted expected cash flows to +1, i.e. the bond is priced at par, and by noting that a price at par implies that the net adjusted discount rate is equal to the expected interim cash flow (the final cash flow being +1):

$$\left(\frac{1+(r+\pi+\rho+t)}{1-p}\right)-1 = k + \frac{p\alpha(1+k)}{(1-p)} \qquad (3)$$

THE CALIBRATION

In order to undertake a Monte Carlo simulation the probability distributions of the Baa corporate bond spread, of the default probability, and of the recovery rate must be established. Starting with the distribution of the probability of default, the 20-year cumulative probability of default for a Baa corporate bond is taken from Moody's (2009, Exhibit 38, p. 31) to be 13.228%. The implied mean hazard rate or the mean default probability, conditional on no previous default, is calculated as follows (Hull, 2012a, 2012b):

$$-\frac{\ln(1-0.13228)}{20} = 70.9431\,\text{basis points} \qquad (4)$$

The standard deviation of the Baa default rate is 43.7 basis points (Moody's, 2009, Exhibit 36, p. 29). Since in this exhibit there are 89 years considered, from 1920 to 2008, then the standard error of the hazard rate is 43.7/√89 basis points. This is the estimate that is adopted. As for the mean recovery rate, in Moody's (2009, Exhibit 27, p. 25) it is estimated to be 42.68%. This compares with a rate of 49.42% in Dionne et al. (2010), and with a rate of 43.5% in Davydenko et al. (2012). Bruche and González-Aguado (2010) estimate a standard deviation of the recovery rate of around 24% for 1124 firms, while Altman et al. (2003, 2004) report an estimate between 24.38% and 24.87% for this standard deviation, and Davydenko et al. (2012) estimate this standard deviation to be 22.7% for 175 firms. Hence the standard error of the recovery rate adopted in this paper is approximated by the figure 0.24/√1124 taken from the first former reference. Finally the probability distributions of the hazard rate and the recovery rates are generated in order to ensure a correlation coefficient of -0.7 between them (see the R-Squares in Moody's, 2009, Exhibit 9, p. 10).

The data for the monthly Baa corporate bond yield and for the monthly 10-year constant-maturity US Treasury bond yield are taken from the web site of the Federal Reserve Bank of Saint Louis, and spans the period between June 1, 1953 and November 1, 2013. As for the probability distribution of the Baa corporate bond spread it is inferred from an error-correction multiple regression, (Engle and Granger, 1987), on the change in the Baa corporate bond yield (Table 1). First it is ascertained that this change in yield has a statistically insignificant intercept (Table 1, 2nd column). Then the error-correction model is estimated (Table 1, 3rd column).

Table 1
REGRESSION RESULTS WITH THE CHANGE IN THE Baa CORPORATE BOND YIELD (Δ(Baa) AS THE DEPENDENT VARIABLE. THE MODEL IN THE LAST COLUMN IS:

$$\Delta(Baa) = c(1)*\Delta(TB) + c(2)*\Delta(baa(-1)) + c(3)*(Baa(-1) - c(4) - c(5)*TB(-1))$$

Variable	Estimate	Estimates
Constant	0.002380	
	(0.208759)	
c(1)		0.522804
		(19.20560)
c(2)		0.291654
		(6.541107)
c(3)		-0.022378
		(2.699517)
c(4)		1.443028
		(2.464843)
c(5)		1.080634
		(13.04743)
-1/c(3)		44.68735
		(2.699517)
c(5)-1		0.080634
		(0.973561)
c(1)/(1-c(2))		0.738064
		(12.80810)
(c(1)/(1-c(2)))-1		-0.261936
		(4.545552)
Adjusted R-Square		0.646599
Ljung-Box Q-statistic:		
k=6	0.000	0.093
k=12	0.000	0.098
k=24	0.000	0.125
Ljung-Box Q^2-statistic:		
k=6	0.000	0.209
k=12	0.000	0.000
k=24	0.000	0.000
Jarque-Bera normality test:	0.000000	0.000000
Breusch-Godfrey serial correlation LM test with 12 lags of the residual:	0.0000	0.0349

Notes: TB stands for the 10-year constant-maturity US Treasury bond yield. Δ is the first-difference operator. The symbols c(1) to c(5) stand for slope regression coefficient estimates. In parenthesis are absolute t-statistics. The Ljung-Box Q-statistics and the Ljung-Box Q^2-statistics are on the residuals, and the squared residuals respectively. The actual p-values for the Ljung-Box Q-statistics and the Ljung-Box Q^2-statistics, for the Jarque-Bera normality test, and for the Breusch-Godfrey test are reported. Heteroscedasticity and autocorrelation robust standard errors and covariance are applied (Newey and West, 1987), with the lags selected by minimizing the Akaike information criterion, and with a Newey-West automatic bandwidth and lag length. The sample period is monthly, from June 1, 1953 to November 1, 2013, i.e. 726 observations after adjustments.

The empirical results are extremely concordant with the theory. The adjustment factor is negative, as expected, and implies that adjustment to the long run takes around 44.69 months (t-statistic: 2.699517), a figure which is reasonable. Second, the coefficient on the first lagged value of the 10-year constant-maturity Treasury bond is 1.080634 (t-statistic: 13.04743), and this coefficient is statistically insignificantly different from +1 with a t-statistic of 0.973561. This implies that in the long run the Baa corporate bond yield varies proportionately with the Treasury bond yield, as expected theoretically. Although the total short run effect of the Treasury bond yield on the Baa corporate bond yield is close to +1, taking the value 0.738064, it is nevertheless statistically significantly different from +1 with a t-statistic of -4.545552. Finally, the average spread premium is estimated to be 144.3028 basis points, with a standard error of 58.5444 basis points. This average spread compares with the value of 132.8 basis points in Dionne et al. (2010), of 140 basis points in Luu and Yu (2011), of 160 basis points in Benzschawel and Assing (2012), and 169 basis points in (Hull, 2012a, 2012b). However average credit default swap (CDS) spreads are somewhat lower, at 127 basis points in Schneider et al. (2010), and at 79.27 basis points in Kitwiwattanachai (2012). Hence, in the Monte Carlo simulation, the Baa corporate credit spread is modeled to have a mean of 144.3028 basis points, and a standard error of 58.5444 basis points.

THE SIMULATION RESULTS

The Monte Carlo simulation starts by generating the fundamental variables, i.e. the spread, the default probability, the recovery rate, and the default premium, all according to their probability distributions as set in the previous section. Initially the excess return is defined as the difference between the spread and the default premium. In fact this excess return is equal to the sum of a tax premium, an illiquidity premium, and an excess risk premium. The tax premium is assumed to be the product of a tax rate of 4.875% and the mean Baa corporate bond yield (Elton et al., 2001). Since the sample mean corporate bond yield is 7.966236%, the tax premium is fixed at 38.84 basis points. The illiquidity premium is set at 4.35 basis points (Dick-Nielsen et al., 2012). Hereafter the analysis is on the spread, the default premium, and the excess return. Later the excess return is decomposed into its three determinants.

The number of simulation runs is 10,000, and these runs are repeated a hundred times. The figure of 10,000 may be thought of as gigantic. However it corresponds to a portfolio of 200 bonds held for 50 years, or 250 bonds held for 40 years, or even 334 bonds held for 30 years. Amato and Remolona (2003) write in their paper that collateralised debt obligations (CDOs) may not have more than 200 obligor names. This corresponds here to a holding period of 50 years.

The simulation results are presented in Table 2. The grand mean spread is estimated to be 144.3768 basis points with a mean standard deviation of 58.55393, while it is simulated to have a mean of 144.3028 basis points and a standard error of 58.5444 basis points. The difference is hence trivial. The grand mean has a standard error of 0.620646 basis points which is a bit higher than the expected standard error of $58.55393/\sqrt{10000}$, or 0.585539 basis points. Anyway the spread is statistically highly significantly different from zero in the long run with a t-statistic of 232.623. In Table 2 there are other statistics on the distribution of the standard deviation of the spread, of the t-statistics for the null that the spread is zero, and their associated p-values, and also on the distributions of the maxima and the minima. For example the highest t-statistic for the spread is 2.5103 and the minimum is 2.4208. The highest upper-tailed p-value is 0.007744 and the smallest is 0.006032. The maximum of the maxima of the spread is 442.2518, and the minimum of the minima is -128.9690 basis points. The maximum of the minima is -50.37500, and the minimum of the maxima is 332.4383 basis points, while the 95% confidence interval is between 29.6110 and 259.1425 basis points. All statistics follow a normal distribution except for the distribution of the maxima for which the p-value of the Jarque-Bera normality test is extremely low, rejecting normality at any conventional marginal significance levels. These results are confirmed in Table 3 with additional normality tests. There is no theoretical reason for the distribution of the maxima to be normal.

Table 2
DESCRIPTIVE STATISTICS ON THE DISTRIBUTIONS WITHIN THE SAMPLE OF THE 100 REPETITIONS OF THE 10,000 SIMULATION RUNS.
THE SAMPLE SIZE IS THEREFORE 100 FOR ALL STATISTICS.

statistic	Baa spread	Credit default premium	Excess return=Baa spread- credit default premium
Grand mean	144.3768	40.68484	103.5990
Grand median	144.3260	40.68699	103.6188
Grand maximum	145.8680	40.76771	105.2950
Grand minimum	142.8796	40.61211	102.2951
Standard deviation	0.620646	0.035273	0.612504
Normality test	0.497746	0.245998	0.754755
Standard deviation:			
Mean	58.55393	3.252217	58.65266
Median	58.55523	3.252503	58.68830
Maximum	59.40672	3.301616	59.63468
Minimum	57.51121	3.193714	57.35622
Normality test	0.774893	0.345285	0.233911
t-statistic:			
Mean	2.465724	12.51032	1.766383
Median	2.463909	12.51006	1.767367
Maximum	2.510292	12.75205	1.810095
Minimum	2.420751	12.32673	1.726351
Standard deviation	0.018357	0.075174	0.014522
Normality test	0.916565	0.124119	0.301581
p-value of t-statistic:			
Mean	0.006843	0.000000	0.038681
Median	0.006859	0.000000	0.038583
Maximum	0.007744	0.000000	0.042142
Minimum	0.006032	0.000000	0.035141
Standard deviation	0.000351	NA	0.001215
Normality test	0.859036	NA	0.454662
Maximum:			
Mean	369.0305	53.43288	329.7135
Median	365.3179	53.28941	328.7424
Maximum	442.2518	57.12609	382.8578
Minimum	332.4383	51.68501	299.7367
Standard deviation	19.03105	1.050870	16.22681
Normality test	0.000000	0.000000	0.000192
Minimum:			
Mean	-83.24963	28.36754	-119.6399
Median	-81.21745	28.57507	-116.9005
Maximum	-50.37500	29.95607	-94.49000
Minimum	-128.9690	24.44315	-163.2110
Standard deviation	17.40945	0.978568	17.00032
Normality test	0.147336	0.000025	0.029390

Notes: The normality test is the Jarque-Bera test for which the actual p-values are reported. All statistics are obtained with the use of the EViews 8 (2013) statistical software. NA stands for “not available.” The spread is simulated to follow a normal distribution with mean 144.3028 and standard error 58.5444. The probability of default is simulated to have a normal distribution with mean 70.9431 and standard error $47.3/\sqrt{89}$. The recovery rate is simulated to have a normal distribution of 0.4268 and standard error $0.24\sqrt{1124}$. The probability of default and the recovery rate are simulated to have a correlation coefficient of -0.70. All figures are in basis points except for those corresponding to the t-statistics and their p-values.

The default premiums, which are the product of the simulated probabilities of default and one minus the simulated recovery rates, has a grand mean of 40.6848 basis points, and a mean standard deviation of 3.2522 basis points. This high precision implies very high t-statistics, higher than 11, for the null hypothesis of a zero mean, and very low corresponding p-values.

The maximum of the maxima of the default premium is 57.126, and the minimum of the minima is 24.443 basis points. The maximum of the minima is 29.956, and the minimum of the maxima is 51.685 basis points, while the 95% confidence interval is between 34.311 and 47.059 basis points. All statistics follow a normal distribution except for the distribution of the maxima and of the minima for which the p-values of the Jarque-Bera normality test are extremely low, rejecting normality at any conventional marginal significance levels. These results are confirmed in Table 3 with additional normality tests. Theoretically there is no reason for the maxima and the minima to be distributed normally.

Table 3
TESTS FOR NORMAL EMPIRICAL DISTRIBUTIONS. ACTUAL P-VALUES ARE REPORTED. THE NULL HYPOTHESIS IS A NORMAL DISTRIBUTION.
ALL VARIABLES ARE BASED ON 100 REPLICATIONS OF 10,000 SIMULATION RUNS.

Variable	Lilliefors (D)	Cramer-von Mises (W2)	Watson (U2)	Anderson-Darling (A2)
Means:				
Spread	0.0579	0.2323	0.2489	0.3486
Default premium	> 0.10	0.0657	0.0532	0.0772
Excess return	> 0.10	0.6900	0.6365	0.7203
Standard deviations:				
Spread	> 0.10	0.7402	0.6928	0.6664
Default premium	> 0.10	0.6112	0.6781	0.6010
Excess return	> 0.10	0.2297	0.2154	0.2527
t-statistics:				
Spread	> 0.10	0.3203	0.2899	0.3418
Default premium	> 0.10	0.6253	0.7621	0.5172
Excess return	> 0.10	0.7388	0.7167	0.6609
p-values of t-statistics:				
Spread	> 0.10	0.5215	0.4822	0.4777
Default premium	NA	NA	NA	NA
Excess return	> 0.10	0.7728	0.7346	0.7317
Maxima:				
Spread	0.0160	0.0008	0.0020	0.0003
Default premium	0.0001	0.0001	0.0003	0.0000
Excess return	> 0.10	0.0543	0.1152	0.0085
Minima:				
Spread	> 0.10	0.0585	0.0887	0.0692
Default premium	0.0049	0.0012	0.0024	0.0011
Excess return	0.0736	0.0066	0.0137	0.0027

See notes under Table 2.

Finally the statistics of the distribution of the excess return are analyzed. The grand mean of the excess return is 103.599 basis points, with a mean standard deviation of 58.653 basis points. The grand mean compares with an estimate of 101 basis points in Hull (2012a, 2012b). Hence the different methodology of this paper obtains nevertheless quite exact figures. However the estimates of the excess return are not statistically significantly different from zero. The highest t-statistic is 1.8101 and the smallest is 1.7264. The highest upper-tailed p-value is 0.04214, and the smallest is 0.03514. However holding a portfolio of bonds for a substantial amount of time reduces the standard deviation to 0.6125, while it is expected to be 0.5865.

Anyway in this latter case the average t-statistic becomes huge at 169.140, implying an extremely high likelihood of obtaining a positive excess return in the long run.

The maximum of the maxima of the excess return is 382.858, and the minimum of the minima is -163.211 basis points. The maximum of the minima is -94.490, and the minimum of the maxima is 299.737 basis points, while the 95% confidence interval is between -11.360 and 218.558 basis points. All statistics follow a normal distribution except for the distribution of the maxima for which the p-value of the Jarque-Bera normality test is relatively low, rejecting normality at a 1% two-tailed marginal significance level. These results are confirmed in Table 3 with additional normality tests, although some of the normality tests in Table 3 show low p-values for the distribution of the minima, implying that the distribution of the minima is non-normal. In fact, there is no theoretical reason for the distributions of the maxima and the minima to be normal.

Since the tax premium is fixed at 38.84 basis points and the illiquidity premium is set at 4.35 basis points, then an estimate of the mean risk premium of the Baa corporate bond is 60.41 basis points, lower than the estimate in Elton et al. (2001) of 74.40 basis points. Since the historical mean equity risk premium is estimated to be 6.18%, (Mehra and Prescott, 1985), then the beta, or systematic risk, of a Baa corporate bond is just 0.098 according to an application of the CAPM. Including more recent observations for the equity risk premium reduces further down the beta of the Baa corporate bond. Brealey et al. (2014) report an average equity risk premium of 7.4% since the year 1900. This implies a beta for the Baa corporate bond of just 0.082, a figure which is highly reasonable. Based on all the above it is apparent that the Baa corporate bond risk premium is not at all too large, and, hence, one cannot describe this premium as a puzzle.

CONCLUSION

This paper has the purpose of estimating the Baa corporate bond yield spread and to identify its four determinants: a default risk premium, a tax premium, an illiquidity premium, and an excess risk premium. Especially important is the modeling of the default risk premium, which is commonly equated to the bond yield spread (Portait and Poncet, 2012; Hull, 2012a, 2012b). The default risk premium is the product of the default probability and the loss given default (LGD). In turn the LGP in percent is equal to one minus the recovery rate. It is no longer acceptable to assume that the default probability and the recovery rate are non-stochastic. However if these two parameters are indeed stochastic, then an analytical solution for their joint distribution is complex, if not impossible. This justifies resorting to Monte Carlo simulation. This is the approach adopted in this paper. The results show that the Baa corporate bond spread of around 144 basis points can be decomposed into a tax premium of 39 basis points, an illiquidity premium of 4 basis points, a default risk premium of 41 basis points, and this leaves 60 basis points as the excess risk premium. This implies a Baa bond beta, which is a measure of systematic risk under the CAPM, of around 0.08, which is quite reasonable. In addition, the paper argues that, although diversification among obligor names is limited, and although bond returns are heavily negatively skewed, time diversification can reduce substantially the uncertainty in the mean return of a portfolio of bonds, ensure normality of mean bond returns, and explain the excess risk premium as mainly systematic, instead of being considered as idiosyncratic. Time diversification arises when the bond portfolio is held for the long run. The major conclusion is that there is little evidence for a credit spread puzzle because an excess risk premium of 60 basis points is adequate when the volatility of the level of the Baa bond yield is 2.95%, which represents around 15% of the volatility of a portfolio of stocks.

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