The Term Structure of Credit Spreads and Credit Default Swaps – an Empirical Investigation

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Abstract

We investigate the term structure of credit spreads and credit default swaps for different rating categories. It is quite well-known that for issuers with lower credit quality higher spreads can be observed in the market and vice versa. However, empirical results on spreads for bonds with the same rating but different maturities are rather controversial. We provide empirical results on the term structure of credit spreads based on a large sample of Eurobonds and domestic bonds from EWU countries. Further we investigate maturity effects on credit default swaps and compare the results to those of corporate bonds. We find out that for both instruments a positive relationship between maturity and spreads could be observed for investment grade debt. For speculative grade debt the results are rather ambiguous. We also find that spreads for the same rating class and same maturity exhibit very high variation.

Key words: Credit Spreads, Credit Default Swaps, Maturity Effects, Reduced Form Models.

1. Introduction

Investing in bond markets always bears the potential risk of the loss of interest rate or principal payments, due to the fact that the issuer of the bond might not be able to meet his obligations. The probability of this scenario affects investment decisions for all market participants. This leads to the necessity of the development of reliable credit risk models, which support various decision-makers in the estimation and management of credit risk as well as in the pricing of financial instruments dealing with credit risk.

The main focus of the present paper is not on the pricing of assets subject to credit risk, but on theoretical implications and empirical evidence regarding credit spreads. The credit spread is defined to be the additional amount of interest payed by a risky asset over the yield of a risk-free investment. In this context the term risky represents the credit risk, to which the asset is exposed through the probability of the issuer not being able to meet his obligations. This can be caused by insolvency, bankruptcy and further reasons leading to a delay or loss of promised payments and is referred to as the default of the obligor.

What kind of behavior for the credit spreads would be expected with varying maturity of the exposure, holding credit quality constant? The answer to this question still seems to be controversial. Some empirical studies and observations result in a split behavior of credit spreads. They presume, that for high-grade bonds the credit spreads increase with maturity as for low-grade bonds they decrease, resulting in a downward-sloping risk structure. A brief summary of empirical studies can be found in section 1.

At a first glance the split behavior of credit spreads appears to be counterintuitive, but an early approach to explain this effect has been undertaken by Johnson [10] and has become known as the "crisis-at-maturity-hypothesis". It is argued, that speculative-grade companies with low credit quality, in his context identified as those having a high leverage-ratio, may face severe problems of refinancing as their short term debt matures. In consequence the risk of not being able to

meet the obligations and thus the probability of default in the short term is quite high. Once those companies have overcome their problems and survived a certain period of time without a default, they face a lower risk in the long run. For currently large and solid firms, the outlook in the short term is very stable with a low risk of default, whereas the forecast of credit quality over longer periods is less certain.

Is such a behavior reproducible by theoretical pricing models and can empirical evidence from market prices be found supporting these considerations? These questions are now examined in this paper which can be outlined as follows. First a few credit risk models and their implications for the term structure of credit spreads are presented in section 2. Although empirical work is very limited in this field, three former studies dealing with maturity effects of credit spreads are covered in section 3. Subsequently own empirical results based on a large sample of Eurobonds denominated in and domestic bonds from EWU countries are presented.

The importance of questions concerning the measurement, hedging and trading of credit risk has provided the foundation for a strong development of the market for credit derivatives. One of the derivative instruments, the Credit Default Swap, is designed to extract and transfer the pure default risk of a certain obligor and thus a strong relation to the default risk expressed in bond spreads is given. Therefore the presumed maturity effects are expected to appear in the market for credit default swaps as well. Section 4 examines this question and is followed by a conclusion of the presented work.

2. Credit Risk Models and their Implications for the Credit Spread

2.1. Merton-Model

Based on the equilibrium theory of option pricing, developed by Black and Scholes [2], Merton has built up a pricing theory for corporate liabilities in general [15]. The main idea behind his proceeding is the interpretation of corporate liabilities as options on the firm value.

He derives an explicit solution for the credit spread, which can be used to analyze the dependencies of the structure of credit spreads according to several factors. Concerning time to maturity $T - t$ Merton highlights, that the change in the credit spread can be either sign, depending on d, which is referred to as the "quasi"-debt-to-firm-value ratio $d = Be^{-r(T-t)}/V$, where r is the riskless rate of interest, B is the outstanding debt and V is the value of the firms assets. He shows, that for $d \geq 1$ the change of the premium will be negative, for $d < 1$ it will be first positive, than negative, resulting in a so-called hump-shaped graph.

In two following notes, first Lee [12] and later Pitts and Selby [17] refined especially the graphical depiction of these dependencies, removing some inaccuracies incorporated in Merton's paper. Despite this, using the "quasi"-debt-to-firm-value ratio d as an indicator for credit quality, a split behavior in terms of the relationship between credit spreads and maturity is derived.

2.2. Fons (1994)

In 1994 Jerome S. Fons published an article [6] addressing the term structure of credit spreads, which can be seen as one of the first reduced-form models. This model class does not rely on the value of the firm as an explanatory variable, but uses external processes to represent occurring defaults. The only source of information included in the model are historical default probabilities, rating information and an estimate for the recovery rate μ.

The cumulative probability cpd of default for a specific rating category R and a time horizon of t years reflects the probability, that an issue defaults up to year t after holding the rating R. The marginal default probability mpd in year t after holding credit rating R is defined to be the difference in cumulative probabilities of year t and $t - 1$. The forward probability of default fpd represents the conditional probability of defaulting in year t after holding the rating, given that default has not occurred up to time $t - 1$. To simplify the representation in sub-

sequent formulas, the cumulative survival rate should be introduced, calculated simply as $S_R(t) = 1 - cpd_R(t)$.

Now this data is used to develop a model for corporate bond pricing and the credit spread S in this setting is obtained as

$$s = -\frac{1}{T}\ln(\sum_{t=1}^{T} S_R(t-1)fpd_R(t)\mu Be^{-r(t-T)} + S_R(T)) .$$

(1)

As a result of the spread calculation according to his model, Fons discovers an almost strictly upward slope for the credit spreads for bonds in investment-grade classes. The so-called hump-shaped behavior, which already was proposed by the model of Merton, can be observed for the rating BB. Credit spreads are increasing up to a maturity of 5 years and decrease afterwards. For the rating class B a strictly downward slope has been calculated.

The examination of market spreads of roughly 2850 U.S. corporate bonds for one refer-ence date matches the model predictions. Although the required statistical significance is lacking in some cases, for rating classes AA and A and BBB a positive and for rating classes BB an B a negative slope coefficient for a linear regression is found.

Comparing the theoretical results with the market spread it has to be mentioned, that spreads received from the pricing equation are basically and essentially lower than market spreads. This is in particular true for investment-grade rating classes, whereas calculated spreads in the speculative-grade classes more closely fit observable market spreads.

2.3. Jarrow, Lando, Turnbull (1997)

The model developed by Jarrow, Lando and Turnbull [9] in 1997 belongs to the class of intensity models and incorporates the probabilities of rating transitions into the valuation process. An expression for the credit spread in terms of the spot rates, depending on the recovery rate μ and the martingale rating transition probabilities $\tilde{q}$ is obtained as

$$r^R(t) - r'(t) = -\log(1 - (1-\mu)\tilde{q}_{iK}(t,t+1)) .$$

(2)

From the empirical results presented in the article, a few important effects can be ob-served. For issues rated AAA, AA or A, a strictly upward sloping credit spread curve is derived. Within a time horizon of 30 years, BBB rated issues are the first, for which a hump-shaped curve is obtained. While BB rated issues are showing a comparable behavior, the curve for class B de-creases starting with the second year. Finally for rating class CCC a strictly negative spread-maturity relationship can be observed. The extraordinary high spreads in the subinvestment cate-gories and the fact, that the spread curve for class CCC even falls below the curve for class B im-ply inconsistencies. Nevertheless this model is able to generate the split behavior of credit spreads with respect to maturity as well.

Starting from the basic concepts introduced in the reduced-form models, the development of this model class is still going on[1].

3. Evidence from the Bond Markets

3.1. Former Empirical Studies

Having laid the theoretical foundations for the analysis of maturity effects in credit spreads, a few empirical studies should be presented.

Sarig and Warga [19] investigate the term structure of credit spreads for a set of pure dis-count-bonds and discuss the findings in relation to the theoretical behavior suggested in the firm value approach by Merton [15]. The sample covers the time period from February 1985 to Sep-

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[1]For a detailed survey of standard reduced-form and structural credit risk models and their extensions refer to [24].

tember 1987 and consists of 137 corporate zero-bonds, issued by 42 different companies. The average of yield spreads for the bonds in a given month is calculated and afterwards averaged across time. The authors retrieve a downward-sloping term structure of credit spreads for bonds rated B or C, a hump-shaped behavior for rating class BB and an upward-slope for the investment grade classes. These results are now compared with the theoretical behavior of credit spreads according to the structural model by Merton and are interpreted as a confirmation. To apply the argumentation proposed in the theoretical model, a negative correlation between rating and "quasi"-debt-to-firm-value ratio d has to be assumed.

Another study, providing a different thesis regarding maturity effects in credit spreads, was conducted by Helwege and Turner in 1998. The argumentation of Helwege and Turner [7] is based on an assumed selection bias, evolving from the fact, that issuers with the same credit rating are treated equally. They argue that, especially for the subinvestment-grade classes, credit quality within one rating class varies significantly. Assuming, that the more creditworthy issuers within one rating class tend to issue debt with longer maturities, the credit yield curve will be biased downward for this rating category.

The sample includes 64 straight public U.S. subinvestment-grade bond offerings and 163 bonds from 1977 to 1994, ranked equally in the priority structure. Only so-called "matched cases", that is groups of bonds from the same obligor, issued on the same day are examined. In the first step of the analysis, for every single issuer the credit spread of the bonds issued at the same day, is examined. Regardless of the absolute difference of the spread or of the maturity it is observed, if the spread rises or decreases with maturity. While 77 % of the matches are strictly upward sloping, the positive spread-maturity relation for the subinvestment-grade classes is supported by the non-parametric Wilcoxon signed rank test as well as the t-test.

One further study dealing with credit spreads and credit quality as their only explaining factor is a publication of Jeffrey Bohn [3]. Covering the time period between June 1992 and January 1999 data from more the 24000 bonds denominated in U.S.–$ and more than 1700 issuers results in a sample size of almost 600000 observations.

The key difference in the proceeding of Bohn is the classification of issues according to credit quality. While usually the credit rating is used to group issues with comparable credit quality, Bohn additionally uses the Expected Default Frequency. This measure for the probability of default over a specific time horizon is provided by KMV corporation and can be seen as one practical implementation of a structural firm value model in the spirit of Merton. The one-year EDF as well as the geometric mean of all one to five year EDF's is used to classify the issues according to credit quality. One major advantage of EDF's instead of credit ratings is the fact, that they can be calculated for each date of the sample period. Therefore they reflect current credit quality more precisely than credit ratings, which are adjusted not that frequent.

Using data from June 1992 to January 1999, monthly medians of credit spreads for each maturity bucket and credit quality class are calculated and averaged across time. The spread curves generated from this analysis show a comparable behavior to those presented by Sarig and Warga [19]: A positive slope for the investment-grade classes and a hump-shaped or downward-sloping term structure for issues of currently low credit quality. Even though the sample includes a large number of observations, a few anomalies like the crossing of spread curves representing different credit quality, can be observed. This effect becomes exceedingly evident in the case where a snapshot at a specific point of time is examined.

Reflecting the results of the former studies, in particular the controversial observations and the overall heterogeneity of data, the question might arise, if default risk is really the main factor determining the credit spread of an issue. Liquidity, tax effects and market risk factors may have significant influence on spreads. Those questions are examined in an empirical study of Delianedis and Geske [4] as well as by Elton, Gruber, Agrawal and Mann [5]. Both conclude, that especially in the investment-grade rating classes default risk is outweighed by those factors, whereas with a decline in credit quality the contribution of default risk to the credit spread rises.

3.2. Empirical Results for the Term Structure of Bond Spreads

3.2.1. A First Glance at Conditional Probabilities of Default

After discussing the theoretical background, models from different classes dealing with credit risk and the presentation of former empirical studies, several proprietary results should be outlined. In the first step historical default rates as reported by rating agencies are examined. The source of data for the analysis in this step is a publication from Standard & Poor's [22], where cumulative average default rates are provided, covering time period of 1981-2003. Based on these rates, the average forward default rates are calculated and presented in Table 1.

Table 1

Average forward default rates [%] 1981-2003

Rating	Time Horizon (years)									
	1	2	3	4	5	6	7	8	9	10
AAA	0.00	0.00	0.04	0.03	0.05	0.09	0.1	0.18	0.07	0.07
AA	0.01	0.03	0.07	0.09	0.13	0.15	0.2	0.17	0.15	0.18
A	0.05	0.1	0.15	0.2	0.25	0.26	0.28	0.26	0.34	0.33
BBB	0.37	0.69	0.75	1.06	1.03	1.03	0.87	0.81	0.74	0.96
BB	1.45	2.97	3.76	3.71	3.45	3.73	3.15	2.86	3.06	2.45
B	6.59	9.04	8.74	7.75	6.36	5.81	5.59	5.52	3.91	4.35
CCC	34.14	15.08	11.57	10.33	12.85	6.68	2.8	1.83	9.3	8.59

A graphical representation of the behavior of forward-pd's with respect to time horizon is given in Figures 1 and 2.
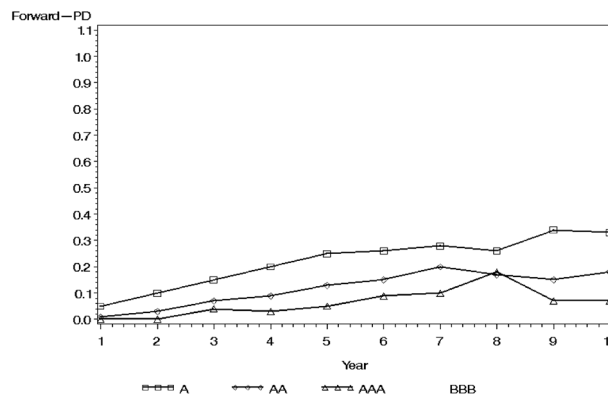

Fig.1. Forward-pd's for investment-grade rating classes

For the three rating categories AAA, AA and A an obvious increase of the forward-pd can be determined, whereas for rating class BBB, BB and B a hump-shaped progression can be observed. For issues rated CCC the shape of the term structure is decreasing from the first year. The split behavior of forward-pd's, which is suggested by the considerations of the "crisis-at-maturity-hypothesis" can be identified. This can be seen as a first indication for credit spreads behaving in a similar manner, which should be investigated in the following chapter.
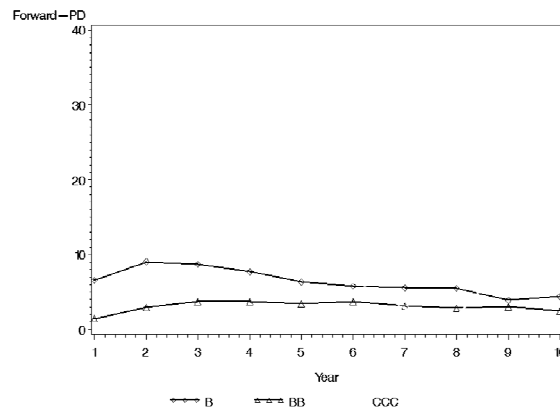
Fig. 2. Forward-pd's for subinvestment-grade rating classes

3.2.2. Description of the Bond Sample

The Reuters Eurobond pages and the national pages from EWU countries were the main source of information, where only issues denominated in have been extracted. One internal database of a major German bank, including a comprehensive sample of about 800 -denominated bond issues, a publication of JPMorgan [11] and the search function of onvista1 have been used to obtain additional assets. In the next step static information like coupon, coupon frequency, maturity, optional features, rating and several further characteristic attributes have been extracted from Reuters as well as from Bloomberg. This data has then been cross-checked to eliminate erroneous information. After eliminating all floating rate notes, a set of 2400 bonds remained, for which historical price and yield information has been obtained from Bloomberg. Comparable to the former studies and to assure sufficient quantity of data especially for longer maturities, issues with a time to maturity between 0.5 and 10.5 years were included in the evaluation. Furthermore this assures an equal length of each time interval while grouping the assets to integer maturity ranges. Subsequently the sample has been restricted to bonds paying annual, constant coupon rates. Likewise all issues incorporating any kind of optional feature like callability, putability or convertibility have been excluded from further research. Depending on the availability of a price and yield information for the desired reference date, approximately 2000 bonds are available for examination.

Table 2

Correlation and regression for bondspreads as of February 11th, 2004

	n	ρ	b	t-stat.	p-value	R^2
AAA	707	0.101	0.003	2.7	<0.0001	0.010
AA	426	0.188	0.009	3.93	<0.0001	0.035
A	595	0.253	0.018	6.37	<0.0001	0.064
BBB	334	0.231	0.039	4.34	<0.0001	0.054
BB	46	0.316	0.139	2.21	<0.0001	0.099
B	40	0.328	0.192	2.14	0.039	0.108

3.2.3. Risk-Free Term Structure and Spread Calculation

The yields of German and French government securities, provided by Bloomberg, are used to generate a term structure of interest rates, which can be referred to as being risk–free. Lin-

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[1]http://anleihen.onvista.de/suche-vergleich/unternehmen.html.

ear interpolation is carried out to calculate risk-free quotes for 3 month, 6 month, 1, 2, …, 10, 15, 20 and 30 years on a daily basis. Once this risk-free term structure is provided, the spread calculation for every single asset and reference day can be accomplished. Equipped with the historical yield information for every asset on a daily basis, the observable market credit spread is obtained as the difference between the asset's yield and the corresponding risk-free rate. Again a linear interpolation is applied, as maturities of the assets usually do not equal the integer time horizons for which risk-free quotes are available.

3.2.4. Results as of February 11th, 2004

February 11th, 2004 is chosen as the reference date for the examination of market spreads. Figures 3 to 8 show the spreads based on the single issues and classified according to the different rating classes. For each rating class the Pearson correlation coefficient ρ and the parameters of a linear regression model are provided in Table 2.

Although the slope coefficients are positive and significantly different from zero for all rating categories, the overall fit of the regression is very low, as indicated[1] by the value of R^2. For AAA-rated issues two properties are immediately observable. First, a maturity effect can almost not be identified. This contradicts theoretical predictions, but corresponds with the empirical results of Fons. Considering the findings, that especially in the high rating classes the default risk might account only for a smaller fraction of the credit spread, the observed results can be justified. The second remarkable observation is the occurrence of negative credit spreads. This heavily depends on the choice of the risk-free reference. Generally LIBOR is known to be comparable to a AA-rated security. Therefore a negative spread between LIBOR and AAA-rated government or corporate bonds can be expected. Nevertheless in the present case, where AAA-rated government securities are used to create the risk-free structure, this should not occur. The question is, if the German and French securities are appropriate benchmarks for the examined bond sample and to which extend the linear interpolation causes inconsistent results. Although the occurrence of the negative spreads should not be neglected, the overall number of issues showing this behavior is small compared to the sample size.
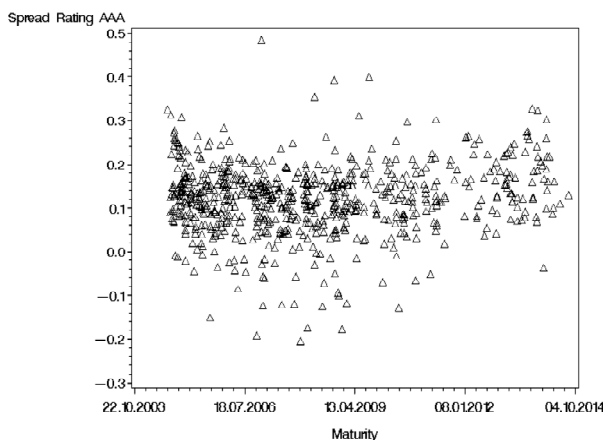

Fig. 3. Bondspreads as of February 11th, 2004 for AAA-rated issues

AA-rated issues exhibit a higher credit spread and the number of negative spreads further decreases. Supported by a higher slope coefficient of the regression, a positive relationship between maturity and spread can be observed, although the overall variation is extraordinary high and interpretation of the maturity effect and further implications seem to be questionable. The

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[1] For a discussion of problems of using the R^2 –statistic as a measure of fit for a regression model, refer to section 3.

same holds for A- and BBB- rated issues, although the positive spread-maturity relationship be-comes more apparent. Caused by a lack in data quantity, conclusions become even more vague for BB-and B-rated issues. Although the correlation indicates a positive relationship as well, it is ob-vious, that a small number of data points has a major influence on all results and the robustness of all results is very low. Nevertheless the results do not provide any indication for the existence of a downward-slope in the term structure of credit spreads.
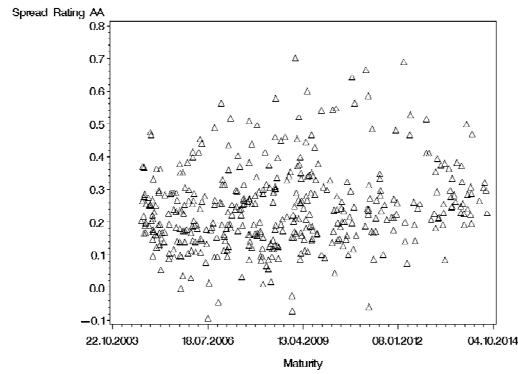

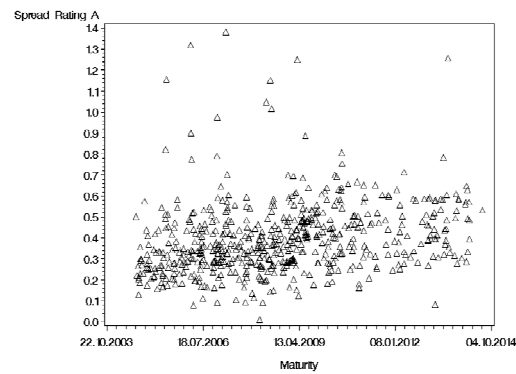Fig. 4. Bondspreads as of February 11th, 2004 for AA-rated issues

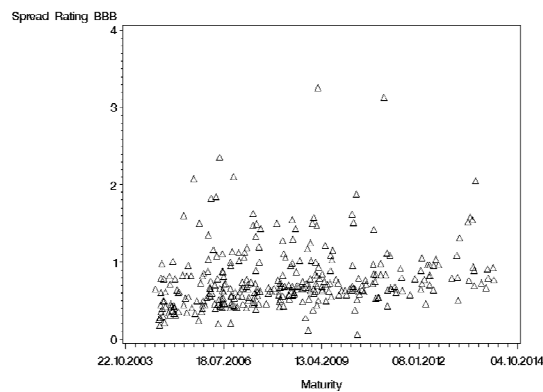Fig. 5. Bondspreads as of February 11th, 2004 for A-rated issues

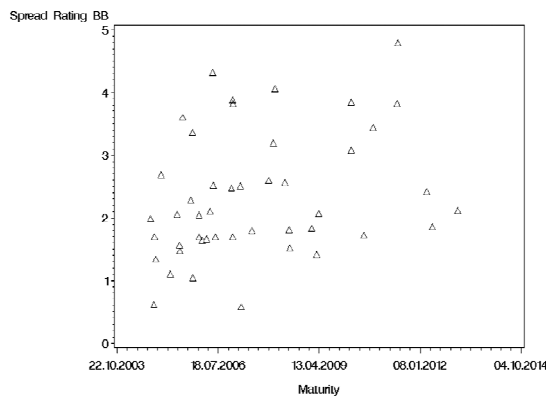Fig. 6. Bondspreads as of February 11th, 2004 for BBB-rated issues

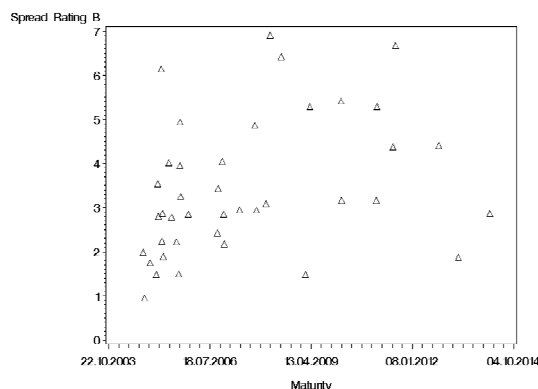Fig. 7. Bondspreads as of February 11th, 2004 for BB-rated issues

Fig. 8. Bondspreads as of February 11th, 2004 for B-rated issues

In the next step, the raw data is aggregated to highlight some of the key results. The assets are grouped to integer maturity buckets, where all assets with a time to maturity between 0.5 and 1.5 years are subsumed to maturity 1, all assets between 1.5 and 2.5 years to maturity 2 etc. The average spread for the different rating classes is represented in Figure 9 for investment-grade and in Figure 10 for subinvestment-grade rating classes.

The general tendency of a positive spread-maturity-relationship for the investment-grade rating classes is supported by this representation, whereas the noisiness of the results becomes in particular obvious for BB-and B-rated issues. In Table 3 the correlation and regression results for the average bondspreads are presented, confirming these considerations. For the investment-grade rating categories a significantly positive slope coefficient is obtained, along with reasonable high values of the R^2-statistic between 47% and 87%.

In Table 6, mean, standard deviation and coefficient of variation ane presented for every rating class and maturity bucket. By measuring the variability of the spreads for each rating class and maturity bucket via the coefficient of variation, additional observations can be interpreted. In general the overall heterogeneity of the data sample is supported, whereas the spreads for AAA-rated issues exhibit a high relative variation in particular. Again the quantity of data for the subinvestment-grade rating classes prevents a detailed inspection.
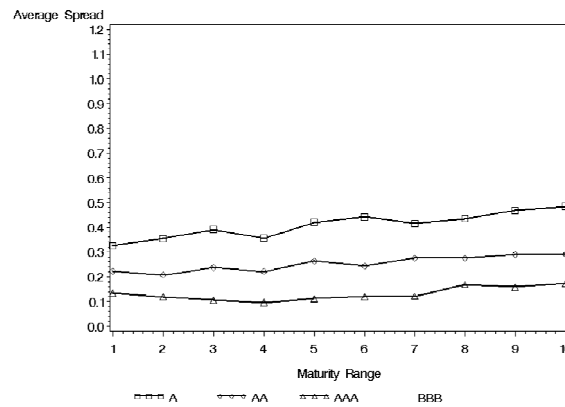
Fig. 9. Average bondspreads as of February 11th, 2004 for investment-grade rated issues
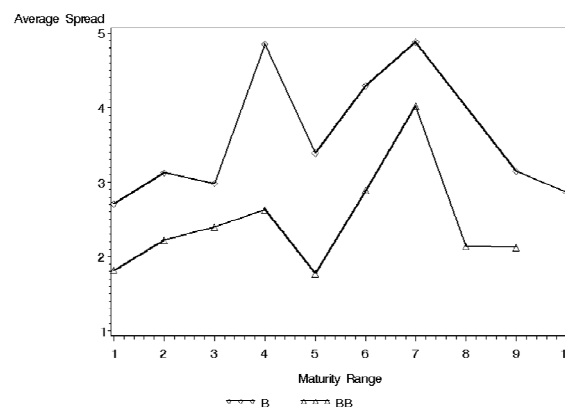

Fig. 10. Average bondspreads as of February 11th, 2004 for subinvestment-grade rated issues

Table 3

Correlation and regression results for maturity buckets of bondspreads as of February 11th, 2004

	n	ρ	b	t-stat.	p-value	R^2
AAA	10	0.692	0.006	2.71	0.0001	0.479
AA	10	0.924	0.009	6.85	0.0001	0.854
A	10	0.937	0.016	7.60	<0.0001	0.878
BBB	10	0.689	0.032	2.69	<0.0001	0.475
BB	9	0.297	0.075	0.82	0.438	0.088
B	9	0.133	0.037	0.35	0.733	0.018

A further issue of the examination of bondspreads deals with the comparison of observed market spreads and calculated spreads, based on the forward-pd's. For this purpose the expected spreads are derived according to the formula presented by Fons in section 2. The assumption of a flat term structure is relaxed and the given term structure is used instead. With r_t being the non–stochastic risk-free rate for an investment with time to maturity t, the formula for the spread calculation becomes

$$ s = -\frac{1}{T}\ln(\sum_{t=1}^{T} S_R(t-1)\,fpd_R(t)\mu Be^{-r_t t + r_T T} + S_R(T)) \cdot \qquad (3) $$

The question of the appropriate recovery rate is addressed as follows. With the available information for the bonds regarding priority in capital structure, it was possible to identify 1175 senior secured, 909 senior unsecured and 71 junior issues. To assure a sufficient quantity of data in all rating classes and for all maturities, the sample is not split, but a weighted average recovery rate is calculated. Based on the historical, value-weighted recovery rates as reported by Moody's [16], a value of $\mu =0.486$ is obtained. The results of the spread calculation are shown in Table 4 and a graphical representation is given in Figures 11 and 12.

All the before mentioned considerations and theoretical predictions regarding maturity effects, are illustrated. The positive slope for the investment-grade rating categories, a hump-shaped progression starting with class BBB and the strictly negative slope for the lowest rating class is obvious. By comparing the calculated spreads with the market spreads it is observable, that for the investment-grade rating categories the calculated spreads are far below the market spreads, whereas they match more closely in the subinvestment-grade rating categories. These findings are consistent with the results of Fons. One possible reason for this behavior is the fact, that the probability of default may only account for a smaller fraction of the credit spread in the investment–grade rating categories, as it has been discussed in section 1. In a subsequent step, the calculated spreads are used as the explanatory variable for the observed market spreads in a regression model. The results are given in Table 5. Statistically significant results are obtained for rating classes AAA, AA and A. The explanatory power of the regression as indicated by R^2 lies between 50% and 84%. Both a positive intercept and a positive slope coefficient reflect the fact, that the market spreads are higher than the calculated spreads.
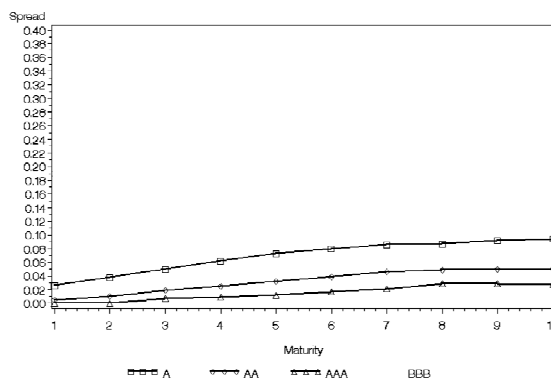
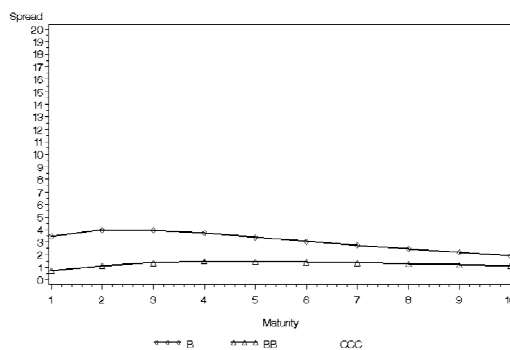Fig. 11. Calculated bondspreads for February 11th, 2004

Fig.12. Calculated bondspreads for February 11th, 2004

Table 4

Calculated spreads [%], based on forward-pd's, for February 11th, 2004

Rating	Time Horizon (years)									
	1	2	3	4	5	6	7	8	9	10
AAA	0	0	0.007	0.009	0.012	0.017	0.021	0.029	0.029	0.028
AA	0.005	0.01	0.019	0.025	0.032	0.039	0.046	0.049	0.05	0.051
A	0.026	0.038	0.05	0.062	0.073	0.08	0.086	0.087	0.092	0.094
BBB	0.19	0.271	0.302	0.352	0.373	0.382	0.371	0.355	0.335	0.328
BB	0.748	1.128	1.362	1 513	1.43	1 423	1 355	1.27	1.2	1 103
B	3 446	3.971	3.955	3 717	3 369	3 042	2 748	2 486	2.19	1 947
CCC	19 295	12.543	9.468	7 627	6 548	5 402	4 381	3 563	3.11	2 686

Table 5

Regression of bond market spreads on calculated spreads for February 11th, 2004

	n	ρ	a	t-stat.	p-value	b	t-stat.	p-value	R^2
AAA	10	0.713	0.105	9.59	<.0001	1 703	2.88	0.021	0.509
AA	10	0.914	0.2	21.58	<.0001	1 620	6.36	0.0002	0.835
A	10	0.922	0.271	12.44	<.0001	2 015	6.71	0.0002	0.849
BBB	10	0.561	0.367	1.59	0.151	1 339	1.92	0.091	0.315
BB	9	0.409	0.883	0.66	0.53	1 038	1.19	0.275	0.167
B	9	0.048	3 408	2.40	0.048	0.056	0.13	0.903	0.002

Table 6

Statistical indicators for bondspreads as of February 11th, 2004

	Time Horizon (years)									
	1	2	3	4	5	6	7	8	9	10
	AAA									
μ	0.14	0.12	0.11	0.1	0.11	0.12	0.12	0.17	0.16	0.17
σ	0.07	0.08	0.08	0.09	0.08	0.09	0.07	0.07	0.06	0.08
σ/μ	0.52	0.64	0.78	0.92	0.74	0.72	0.56	0.43	0.38	0.47
n	137	107	101	86	87	53	44	22	41	29
	AA									
μ	0.22	0.21	0.24	0.22	0.26	0.24	0.27	0.28	0.29	0.29
σ	0.09	0.12	0.11	0.13	0.14	0.13	0.16	0.15	0.1	0.08
σ/μ	0.39	0.56	0.48	0.57	0.53	0.52	0.6	0.56	0.33	0.27
n	60	57	53	65	59	35	31	19	24	23
	A									
μ	0.32	0.35	0.39	0.36	0.42	0.44	0.42	0.44	0.47	0.48
σ	0.16	0.17	0.18	0.18	0.16	0.14	0.13	0.14	0.18	0.13
σ/μ	0.5	0.49	0.46	0.5	0.38	0.33	0.32	0.31	0.39	0.26
n	63	76	85	89	92	66	40	27	38	19
	BBB									
μ	0.55	0.76	0.77	0.75	0.83	0.75	0.88	0.81	1.12	0.8
σ	0.27	0.45	0.38	0.29	0.46	0.38	0.52	0.17	0.45	0.1
σ/μ	0.49	0.6	0.49	0.38	0.55	0.5	0.59	0.21	0.4	0.13
n	46	54	54	43	50	26	25	17	13	6

Table 6 (continuous)

	1	2	3	4	5	6	7	8	9	10
	BB									
μ	1.82	2.22	2.4	2.63	1.78	2.89	4.02	2.14	2.12	-
σ	0.84	0.92	1.18	0.93	0.33	1.08	0.7	0.4	0	-
σ/ μ	0.46	0.41	0.49	0.35	0.19	0.37	0.17	0.19	0	-
n	10	11	7	6	3	3	3	2	1	-
	B									
μ	2.71	3.12	2.98	4.85	3.39	4.29	4.88	0	3.15	2.87
σ	1.39	1.23	0.68	1.84	2.7	1.6	1.48	0	1.8	0
σ/ μ	0.51	0.39	0.23	0.38	0.8	0.37	0.3	0	0.57	0
n	12	6	6	5	2	2	4	0	2	1

The same analysis is conducted for a second reference date (August 11th, 2003) and is available upon request.

3.3. Stable Effects in the Distribution of Regression Residuals

While interpreting regression results and the R^2-statistic as a measure of fit, the distribution of the residuals, that is the difference between observed and predicted values, has to be considered. In the standard setting of a regression model, the residuals are assumed to be normally distributed. If this is not the case, R^2 might not reflect the fit of the regression appropriately. A large number of residuals of small and several residuals of high absolute value suggest a heavy-tailed distribution. The α-stable distributions constitute a class of distributions allowing the modelling of skewness and heavy tails. They are characterized by the parameter vector $\Theta = (\alpha, \beta, \sigma, \mu)$, with $\alpha \in (0,2]$ being the index of stability, the skewness parameter $\beta \in [-1, 1]$, the scale parameter $\sigma \in R_+$ and the location parameter $\mu \in R$. For $\alpha < 2$ the distributions exhibits peakedness and heavy tails. Currently a large amount of research is carried out in the field of stable distributions. One example for advanced literature dealing with stable distributions and their applications to finance is Rachev, Mittnik [18].

The regression residuals of bond market spreads on maturity for February 11th, 2004 are used to estimate the parameters of an α-stable distribution. The results are given in Table 7 and Figures 13 to 17 illustrate the fact, that the distribution of the residuals matches more closely the α-stable than the normal distribution.

Table 7

Parameters of an α-stable distribution for regression residuals of bondspreads

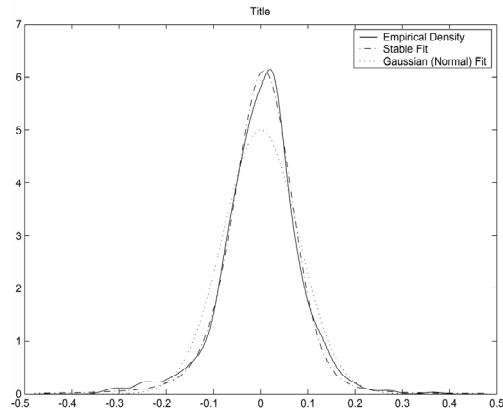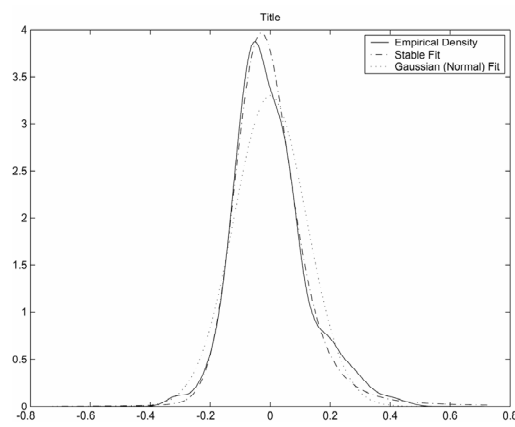| Rating	Time horizon (years)				
	n	α	β	σ	μ
AAA	707	1.7061	-0.2790	0.0464	-0.0006
AA	426	1.6655	0.7874	0.0712	0.0087
A	595	1.7412	0.9755	0.0869	0.0032
BBB	334	1.3084	0.8894	0.1377	0.0861
BB	46	1.6243	10.000	0.5804	0.1366

Fig.13. α-stable fit of the regression residuals for rating AAA

Fig. 14. α-stable fit of the regression residuals for rating AA
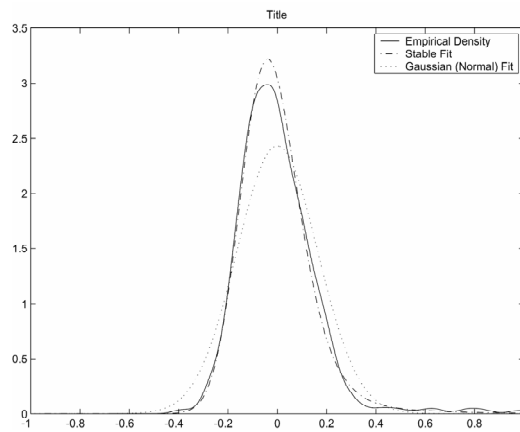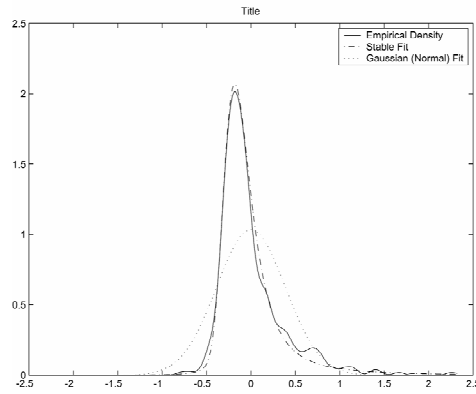

Fig.15. α-stable fit of the regression residuals for rating A

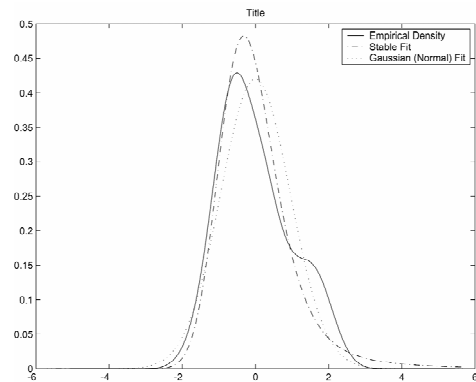Fig. 16. α-stable fit of the regression residuals for rating BBB

Fig.17. α-stable fit of the regression residuals for rating BB

4. Credit Derivatives

4.1. The Market for Credit Derivative Products

Credit derivative products are designed to isolate specific aspects of credit risk from one or more underlying assets. They are used to transfer these risks between the contract partners, which allows to actively trade and hedge credit risk. The major credit derivative products are Total Return Swaps (TRS), Credit Spread Options (CSO), Collateralized Debt Obligations (CDO), Credit Linked Notes (CLN) and Credit Default Swaps (CDS). A detailed explanation of those contracts can be found for instance under http://www.creditderivatives.cc, whereas it has to be mentioned that the market for credit derivatives is extraordinary innovative and the development of new products permanently continues.

4.1.1. Credit Default Swap (CDS)

A Credit Default Swap is a financial contract, where the protection buyer pays a periodical fee on the notional amount of the reference underlying. In return the protection seller is committed to effect a default payment, in case a credit event with respect to the underlying reference entity occurs. In a single name CDS this underlying will usually be one specific bond, whereas in a basket CDS the underlying consists of a portfolio of credit risky assets. The protection buyer still faces the risk of a change in credit quality and market value of the underlying, whereas the risk of default is isolated in this contract and transferred to the protection seller. Therefore it is intuitive to compare the CDS premium, expressed in basis points per year, with the credit spread on the market of the underlying. Figure 18 shows the setting of a theoretical risk-free trade, where the inves-

tor has perfectly hedged the default risk. For simplicity it is assumed, that the asset is issued at par and the credit spread is obtained as the difference of the coupon and the risk–free rate r. From no-arbitrage considerations the CDS premium P should equal the credit spread S. Based on this argumentation the so-called basis, $P - S$, consequently equals zero. As in the market a basis different from zero can be observed, various factors causing the divergence between CDS spread and credit spread need to be considered. A detailed examination of this question can be found in a publication by Lehman Brothers [13].

As it is probably the most important factor affecting the basis, only the counterparty default risk should be mentioned explicitly. Unlike in bond markets, where the transaction between the issuer and the investor does not involve any other credit risk factors apart from the obligor's default risk, a new dimension of credit risk is implied on the CDS market. The derivative contract is established with a protection seller, who himself can default. The issue of default correlation between the issuer of the underlying of the CDS and the protection seller needs to be considered. Generally the concern is on the side of the protection buyer, who will demand a reduced CDS premium for taking the additional risk of default of the protection seller. The result will be a decrease in the basis.
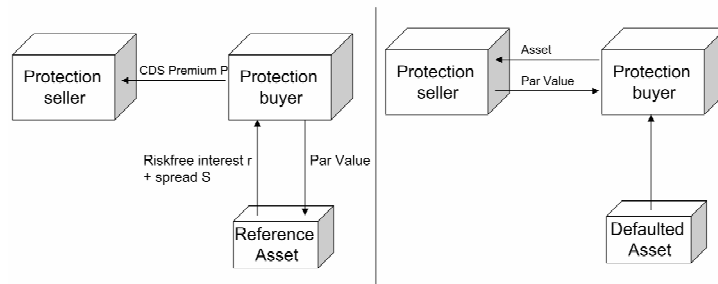

Fig.18. Payment structure of a CDS before and in the event of default

4.2. Empirical Results from the CDS Market

4.2.1. Description of the Sample

The data source for the CDS sample is a database, where Credit Default Swap indicators are collected. These indicators are bid and ask quotes provided by various market participants and do not necessarily represent real trades. In the further discussion the arithmetic mean between bid and ask, called the mid quote, is examined. The maturity of the contract, the underlying company, the credit rating, currency and various other static information complete the sample. The time horizon between January 2001 and March 2004 is covered, where in the beginning of the sample period only about 200, later up to 3000 quotes per trading day are available. The major part of the sample are single name corporate CDS quotes denominated in U.S.–$ and consequently the analysis has been restricted solely to those contracts. Credit Default Swaps are OTC-contracts usually equipped with integer maturities, where the 5-year CDS is by far the most common specification, followed by maturities of 1, 3, 7 and 10 years.

4.2.2. Results across Time

In a first step the behavior of the CDS-quotes over the whole sample period should be examined. Figures 19 and 20 show the average mid-quotes of the whole sample for different maturities, classified according to the credit rating. Note that all quotes during the following analysis are given in basispoints, following the market convention for the quotation of the CDS premium. For the investment-grade rating classes a clear positive relationship between CDS-quote and maturity is observable. Furthermore it is remarkable, that the quotes for AAA-and AA-rated reference entities are very close, where for the 5-year maturity AAA- even exceed the AA-quotes. Apart from this anomaly, the 5-year quotes exhibit a noticeable behavior in the course of the whole analysis. Representing the point with the highest liquidity, they constitute a peak in the run of the curve for many rating classes. Although there appear to be no definite explanations for this behavior, it is necessary to point this effect out, in particu-

lar as it becomes more evident in the course of the analysis of single trading days. Regarding the subinvestment rating classes, especially for rating class B, a hump-shaped behavior can be observed.
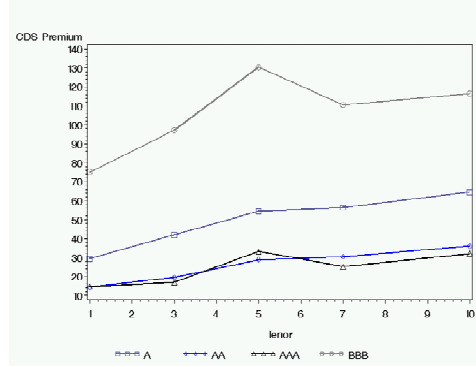

Fig.19. Investment-grade CDS-quotes averaged across sample period

In Table 8 mean, standard-deviation and coefficient of variation are presented for the quotes, covering the whole time horizon. This illustrates the extraordinary variability of the underlying pool of data. The coefficient of variation is generally even higher than for the bond sample. One aspect explaining the high variability deals with the speed of reaction on the different financial markets. Hull, Predescu and White [8] examine, whether the CDS market anticipates the change of credit ratings. Especially for rating downgrades they conclude, that the CDS-market percepts this negative event well in advance, observable by a significant increase of the CDS-premium up to 90 days prior to the rating event. Longstaff, Mithal and Neis [14] apply a vector-autoregression model to analyze the lead-lag relations between the CDS-, bond-and stockmarket. Although limited by a large number of exceptions they generally observe, that changes in CDS-premia lead changes in corporate bond yields, indicating that the CDS-market incorporates credit-relevant information more quickly. Considering these findings it is imaginable, that the quotes in a specific rating class can cover a wider range, because participants at the CDS-markets estimate the credit quality of some issuers within this class to be significantly better or lower, although this has not yet been reflected in a change of the credit rating. This is only presented as one possible explanation, as it is not possible to test this hypothesis with the available data.
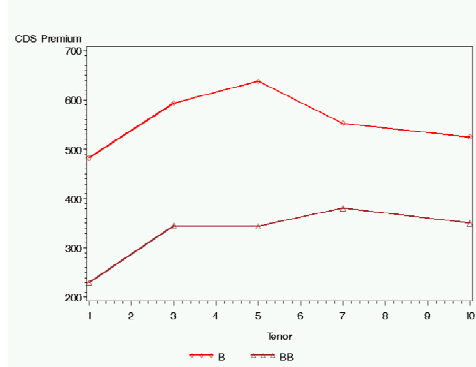
Fig. 20. Subinvestment-grade CDS-quotes averaged across sample period

4.2.3. Results as of February 11th, 2004

Results from the examination of subsets from the pool of CDS-quotes for single trading days are presented in the following. For the same reference date as in the analysis of the bond spreads, February 11th, 2004, the mid-quotes of all available CDS-contracts are examined. By averaging those quotes for the maturities of 1, 3, 5, 7 and 10 years, Figures 21 and 22 are obtained.

A positive relationship between CDS-quotes and maturity is clearly observable for the investment-grade classes. Again the peak for the 5-year maturity can be identified in particular for AAA and BBB rating classes. Although unexplainable it has to be noted, that the quotes for the AAA rating class are uniformly higher than for AA. Regarding the subinvestment-grade rating classes no systematic effect for this date can be identified. For BB the 1-year quote represents an outlier compared to the examination covering the whole sample period. Interpretation of the depiction for rating class B is questionable, due to the fact that the quotes for maturities of 3, 7 and 10 years are only based on two data points each. The findings are supported by the correlation coefficient and the results of a linear regression model, as presented in Tables 9 and 10. Although a positive correlation and slope coefficient for the investment-grade CDS-quotes is obtained while carrying out the regression on the raw data, the positive spread-maturity relationship is in particular supported by analyzing

the average CDS-quotes, where R^2 reaches values between 72% and 96%.

Table 8

Statistical indicators for CDS-quotes across time horizon

|	Time horizon (years)				
	1	3	5	7	10
	AAA				
\mu	14.69	17.09	33.1	25.2	32.11
\sigma	Sep.87	14.01	24.91	15.27	17.02
\sigma	0.67	0.82	0.75	0.61	0.53
n	1463	4199	11866	3685	3274
	AA				
μ	14.62	19.55	28.98	30.49	36.13
σ	48.49	16.61	23.68	18.13	21.53
σ/ μ	March 32	0.85	0.82	0.59	0.6
n	1721	23143	37491	20749	22149
	A				
μ	29.51	42.01	54.44	56.46	64.51
σ	23.92	31.18	47.75	34.1	35.99
σ/ μ	0.81	0.74	0.88	0.6	0.56
n	14389	57081	138746	46091	46858
	BBB				
μ	76.17	97.13	130.45	110.62	116.59
σ	74.74	84.38	131.36	77.05	71.2
σ/ μ	0.99	0.87	1.01	0.7	0.61
n	19037	47619	164328	39660	41245
	BB				
μ	230.05	345.71	344.2	380.79	350.05
σ	193.33	364.73	248.8	306.4	370.42
σ/ μ	0.84	1.06	0.72	0.8	0.77
n	1584	7542	41114	4608	5229
	B				
μ	482.88	594.14	638.05	552.93	542.9
σ	417.03	471.86	695.41	377.75	328.28
σ/ μ	0.86	0.79	1.09	0.68	0.63
n	24	979	8208	687	688
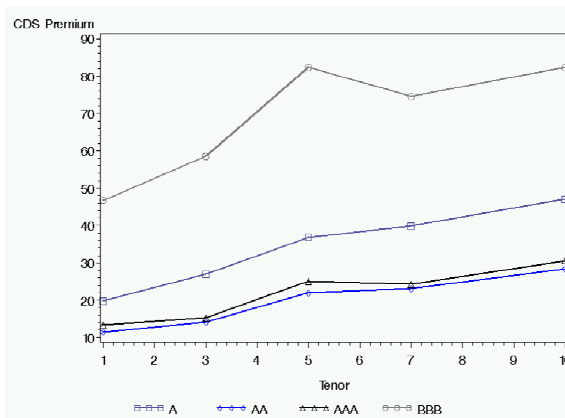
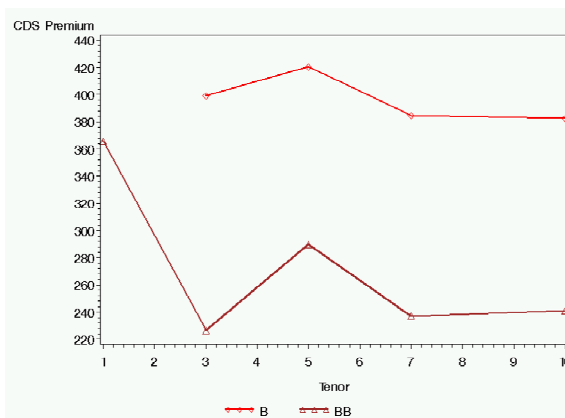Fig. 21. Average investment-grade CDS-quotes as of February 11th, 2004

Fig. 22. Average subinvestment-grade CDS-quotes as of February 11th, 2004

Table 9

Correlation and regression for CDS-quotes as of February 11th, 2004

	n	ρ	b	t-stat.	p-value	R^2
AAA	86	0.391	1.882	3.89	0.0000	0.153
AA	212	0.410	1.819	6.51	<0.0001	0.168
A	915	0.444	2.878	14.96	<0.0001	0.197
BBB	1314	0.166	3.253	6.1	<0.0001	0.028
BB	258	-0.125	-12.101	-2.02	0.0440	0.016
B	41	-0.033	-6.166	-0.2	0.8390	0.001

Comparable to the proceeding while analyzing bondspreads, spreads from forward rates are calculated for the maturities corresponding with the CDS-quotes. As all CDS-quotes in the sample are written on senior unsecured underlyings, the value-weighted average recovery rate of μ =0.44 for senior unsecured issues in 2003 as reported by Moody's [16] is used in calculation. The calculated spreads are given in Table 11 and a graphical representation can be found in Figures 23 and 24. Again the calculated spreads are uniformly below the observed CDS-quotes, in particular in the investment-grade rating classes. The results of a regression for the market spreads

with the calculated spreads as explanatory variable are given in Table 12. Like in the bond sample the fit is in particular good for the investment-grade rating classes and the positive intercept and slope coefficient reflect the above mentioned observation of market spreads being higher than calculated spreads. The negative correlation and slope coefficient for rating class BB contradict the expectation and the quality of the fit of the regression declines while moving to rating class B.

Table 10

Correlation and regression for average CDS-quotes as of February 11th, 2004

	n	ρ	b	t-stat.	p-value	R^2
AAA	5	0.982	3.032	8.97	0.003	0.964
AA	5	0.976	1.923	7.71	0.005	0.953
A	5	0.951	1.958	5.35	0.013	0.904
BBB	5	0.853	3.842	2.84	0.066	0.728
BB	5	-0.630	-10.409	-1.40	0.255	0.397
B	4	-0.634	-3.272	-1.16	0.366	0.402

Like for the bond sample the analysis of CDS-quotes has been conducted for the second reference date, August 11th, 2003. The results are a confirmation of all the conclusions drawn above and are available upon request.

Table 11

Calculated spreads [bp], based on forward-pd's, for February 11th, 2004

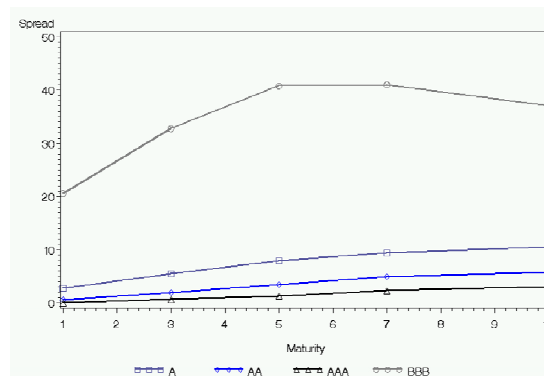|	Time horizon [years]				
Rating	1	3	5	7	10
AAA	0	0.7	1.3	2.3	3.1
AA	0.6	2	3.5	5	5.7
A	2.8	5.5	8	9.4	10.5
BBB	20.6	32.8	40.8	41	37
BB	80.9	148.2	157	150.8	126.1
B	373.3	432.3	373.1	309.6	227.4
CCC	2105	1047.1	736.6	504.3	324.3

Fig. 23. Calculated spreads [bp], based on forward-pd's, for February 11th, 2004
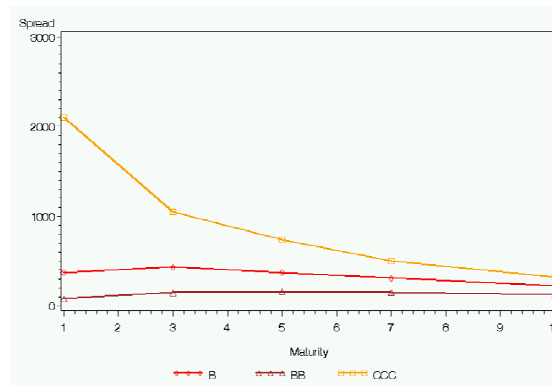
Fig. 24. Calculated spreads for February 11th, 2004

<div align="right">Table 12</div>

Regression of CDS market spreads by calculated spreads for February 11th, 2004

	n	ρ	a	t-stat.	p-value	b	t-stat.	p-value	R^2
AAA	5	0.927	13.653	5.82	0.01	5.416	4.27	0.024	0.859
AA	5	0.972	9.184	5.43	0.012	3.154	7.21	0.006	0.946
A	5	0.991	9.351	4.61	0.019	3.423	13.09	0.001	0.983
BBB	5	0.905	10.881	0.68	0.548	1.684	3.69	0.35	0.819
BB	5	-0.772	461.863	5.01	0.015	-1.432	5.01	0.015	0.596
B	4	0.642	353.57	9.48	0.011	0.128	1.18	0.358	0.412

4.2.4. Comparison of the Results for Bond and CDS-market

As pointed out in 1, the spread of the underlying asset is a first estimation for the CDS-quote. Although the bond sample does not necessarily consist of the underlying assets of the CDS-sample, a comparison on an aggregated level should be conducted. At least for the investment-grade rating classes some interesting results can be obtained from the comparison of CDS-quotes and bond spreads for the same trading day. The positive relationship between CDS-quote and maturity is much more obvious than in the bond sample. As mentioned before, the pure default risk is reflected in a CDS more precisely than it is captured in the bond spread. The fact that the positive slope for the CDS-quotes is more apparent supports the argumentation, which suggests the possible deterioration in credit quality of the issuer as a reason for increasing credit spreads.

The second remarkable result of the comparison deals with the basis. The basis has been introduced as the difference of CDS-quote and bond spread. Various arguments have been provided to explain a basis different from zero. In the present data sample the CDS-quotes are almost uniformly lower than the bond spreads, resulting in a negative basis. For longer maturities the basis decreases, as the maturity effect causes CDS-quotes to increase, whereas this effect is less strong for the bond spreads.

Due to the variability in the bond spreads, the inhomogeneous results for the CDS-quotes and the general lack of data, reliable conclusions can not be drawn for the subinvestment-grade rating classes.

5. Conclusion

Based on the "crisis-at-maturity-hypothesis" and subsequent argumentations, a split behavior of bond spreads with respect to maturity is presumed. This is supported by the theoretical predictions of credit risk models, following both the structural and the reduced-form approach.

Empirical research regarding these maturity effects of bond spreads has been very limited so far. Furthermore the results of the few available studies vary and the answer to the question if the predicted maturity effects are observable in the market, is still controversial. After having summarized the former empirical work and the consideration of possible additional factors contributing to the credit spread, the results of an analysis covering about 2000 -denominated bonds are presented. Although dominated by the extraordinary variability of spread data even within the same rating class, a positive relationship between spread and maturity was detected for the investment-grade rating classes, whereas the results for the subinvestment-grade issues are only of limited explanatory power due to a lack in data quantity. However, during the whole analysis no evidence for a negative relationship was found.

Comparable results were obtained from the examination of a sample of credit default swaps. In this derivative instrument the default risk of the reference issue is extracted most precisely and therefore the presumed maturity effects on the bond market should be observable in the credit default swap market as well. They should even appear more clearly, as many of the potential factors affecting bond spreads do not affect the credit default swaps. While trying to analyze CDS-quotes another problem appears. As these derivative instruments are OTC-contracts, reliable and exhaustive price information is not easily available. An internal database of so-called price indicators (bid and ask quotes provided by different market participants) was used for examination. Generally the positive relationship between spread and maturity was essentially apparent. Furthermore it was possible to compare bond-spreads and CDS-quotes regarding the overall level and thus obtain evidence regarding the so-called basis, the difference between bond spreads and CDS-premium. For the CDS-quotes of subinvestment–grade issues, the same limitations as for the bond spreads hold.

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