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The dynamics of rating based credit benchmark curves

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No. 231

**The Dynamics of Rating Based
Credit Benchmark Curves**

by Thomas Heidorn and Sara Schlamann

April 2022



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Abstract

The paper models and analyses the dynamics of credit spread curves based on ratings over the period from 2004 to 2021. Using more than 1.5 million data points of individual bonds, instead of using index data, monthly asset swap spread (ASW) curves are constructed for all rating levels. The paper focuses on the EUR credit market which has grown significantly in recent years. Also, the data is more contemporary compared to the literature. For a period of almost 20 years EUR corporate bonds (investment grade and high yield) are discussed.

We find that investment grade ASW curves are typically upward sloping, however during time of crisis they turn hump shaped or inverse. Non-investment grade curves tend to be inverse. While most rating classes show substantial rating changes during crises, very low rated bonds seem to depend mainly on idiosyncratic risk. We find that the bond purchase programs by central banks considerably lowered credit spreads. Also, the credit spread for lower ratings are typically higher for the whole curve compared to a better rating. By comparing rating-based credit spread curves with individual curves we find that they are suitable as a benchmark.

Key words: Credit Spread Curves, Benchmark Curves, Asset Swap Spread, Credit Rating and Credit Spread, Credit Spread Development, Rating Benchmark Curves, Credit Spread

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1. Introduction

The corporate bond market stood at USD 16.9 trillion as of 31st July 2021 and has grown by a factor of 8 since 1998¹. Especially in the current low-interest environment it is likely that the market will continue to grow in the foreseeable future.

Most issuers have several bonds with different maturities outstanding. The corresponding credit spreads can be plotted in a term structure. However, these term structures cannot be read directly from the market data but must be modelled. The resulting credit spread curves provide a good basis for investment decisions and can serve as benchmark curves (Hewicker and Cremers, 2011). A decisive determinant for the credit spread is the default probability of companies expressed in terms of a rating (Kruse, 2014). This raises the question to what extent rating based spread curves can be used as benchmark curves.

The academic literature already contains several studies in which rating based corporate bond spread curves have been modelled and analyzed. Most are based on index data instead of individual bonds, and their focus is on the US-dollar corporate bond market. Often, only short time periods have been analyzed, some of which lie far in the past (e.g., Annaert and Ceuster 1999, van Landschoot 2003, 2008 or Boulkeroua and Stark 2010).

This paper models and evaluates rating-based spread curves over the period from January 2000 to July 2021 based on individual constituents of investment grade and high yield indices. The focus is mainly on the European market, using the US-dollar corporate bond market for comparison.

The first part of this working paper elaborates on the current state of research and deduces our approach. Chapter 3 presents the most important input factors and the data set as well as the curve construction. Chapter 4 analyses the behavior of the rating-based spread curves. The asset swap (ASW) curves for euro denominated corporate bonds are examined over the entire period for each rating class, also specific time periods are examined in more detail. Furthermore, the ASW-curves of different rating classes are compared, and the ASW-curves of euro and US dollar denominated as bonds are contrasted. Chapter 5 summarizes the results, critically reviews the modelling procedure, and gives an outlook on possible future research fields in this area.

¹ ICE Bank of America/Merrill Lynch Index data provided by Bloomberg (Sum of Market Value of Global Broad Market Corporate Index (G0BC) and Global High Yield Index (HW00) as of 31st July 2021).

2. Literature Review

Many studies in the past have focused on the pricing of corporate bonds and on the development of theoretical models for credit risk. One of the first approaches was the structural-form approach. Merton (1974) modelled firm value as a Brownian motion. Here a default arises, if the value of the firm's assets is lower than the nominal value of its debt. Thus, the firm's default risk is directly linked to the firm's value (business risk), the value of the debt issued (leverage ratio) and the maturity. However, this approach has some disadvantages (e.g., Longstaff and Schwartz, 1995)., special input data was needed, which is not always available (e.g., firm's value). In addition, the model only allowed a default at a certain point in time, namely at the maturity date of debt. The biggest problem, however, was that the models always predicted the default shortly before it occurred.

Some authors have tried to address this problem by assuming that the value of the company does not always follow a continuous path, but also experiences a jump that leads to an immediate default (e.g., Jarrow and Turnbull 1995, Jarrow et al. 1997, Annaert and Ceuster, 1999). They introduced reduced-form models. The publication of Fons' (1994) paper on the term structure of credit spreads can be seen as one of the first empirical analysis of this approach. In contrast to the structural-form models, which focuses on the value of the issuing company, reduced-form models focus directly on the default or the recovery process. They can also be applied to credit rating changes, which have a significant impact on the pricing of bonds in the secondary market. The disadvantage of these models is that the default and recovery processes are assumed to be exogenous, which makes it difficult to link it to the fundamental characteristics of the issuer. Furthermore, the same default process is assumed for each bond of the same rating class. Actually, different bonds of the same rating class have different credit spreads (Annaert and Ceuster, 1999). Many researchers use the reduced models despite the possible disadvantages (e.g., Duffie and Singleton 1997, 1999, Jarrow and Turnbull 1995, and Jarrow et al. 1997). As this working paper models credit curves based on credit spreads, it follows the reduced form approach.

Both approaches show a relationship between the maturity of the bond and the credit spread, which is not necessarily upward sloping (see Figure 1) and changes over time. The effects that occur can be classified into shift, twist and butterfly similar to the yield curve. A shift describes a parallel downward or upward move. A twist describes a rotation around a certain point. The butterfly influences the curvature and describes a "hump" (Scheck, 2001).

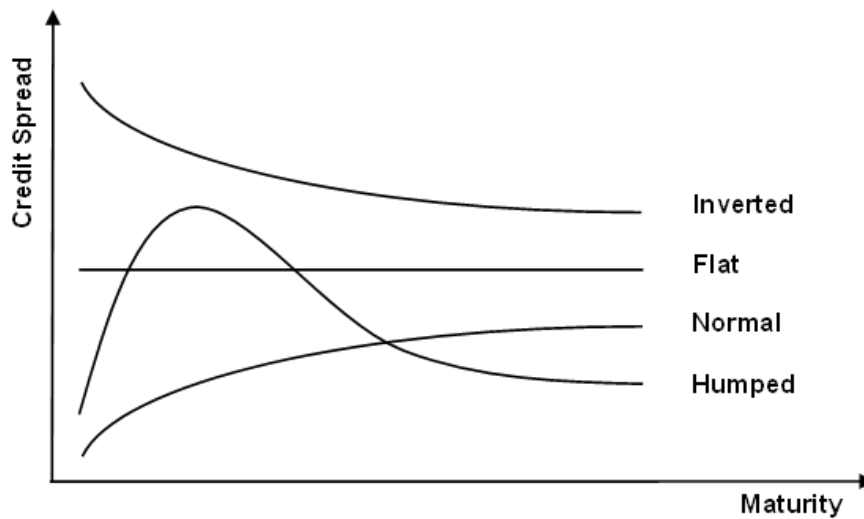


Figure 1: Various Term Structures (Source: Hewicker and Cremers, 2011)

Duffie and Singleton (1999) showed that corporate bond spreads can rise as well as fall with increasing maturity. Spread curves of highly rated companies are usually upward-sloping and those of low rated companies downward-sloping or hump-shaped. Jarrow et al. (1997) find that most investment grade bonds have an upward-sloping curve, while BB and B rated bonds face hump-shaped credit curves and CCC rated firms have curves that are strictly downward-sloping. The intuition behind this is that for companies with a good credit quality the risk of a default is very low in the short term, but the probability of a downgrade is higher as time progresses. In contrast, companies with low credit ratings and poor creditworthiness have a high short-term risk. However, if the firm survives, the investor could lock in a high credit spread, and therefore, prefers a long maturity. In this case spreads can be lower at the long end than at the short end of the curve. Firms that are less risky and better rated with the potential for credit quality deterioration being relevant in the short term, but the potential for improvement in the long term often tend to have a hump-shaped curve. This phenomenon has also been empirically proven by Sarig and Warga (1989) and Fons (1994). However, for B and C rated bonds, Sarig and Warga (1989) show a strict negative-sloped structure. The evidence for BB rated bonds was slightly weaker. For A and AA rated bonds they identify an upward sloping curve. Fons (1994) finds a negative or flat credit curve for speculative-grade firms and no clear trend for AAA rated bonds (Annaert and Ceuster, 1999; Li et al., 2013).

Bedendo et al. (2007) found that idiosyncratic risks have a stronger impact on the long end of the curve for investment grade companies and on the short end of the curve for high yield companies. Hence, they found upward sloping curves for investment grade companies and downward sloping curves for high yield companies, with less robust results for high yield companies due to the small sample size and high heterogeneity in the sample. Helwege and Turner (1997) point out that the downward-sloping credit spread curve could be a consequence of using average credit spreads of bonds in each rating class, even though firms have

different credit quality within the rating class. The data of the empirical studies were therefore subject to a bias. In addition, companies with a high credit rating tend to issue bonds with longer maturities, so credit spreads for long-dated bonds are underestimated as the spread across ratings decreases with increasing maturity. For an individual company, however, the spread could increase with increasing maturity. According to their results, this is mainly the case for companies with high-yield ratings. Therefore, the empirical studies arrived at downward-sloping curves for companies with low ratings. They therefore analyzed the bonds of BB and B rated companies at issuer level. The bonds thus had the same seniority but not the same maturity, which is why the different spreads could only be explained by the maturity. In most cases, they determine upward-sloping credit curves (Annaert and Ceuster, 1999; Li et al., 2013).

In contrast to Helwege and Turner (1997), He et al. (2000) came to the conclusion that the spread curves are downward-sloping for low rated companies (CCC and CC rating), upward-sloping for good-rated companies (AAA and AAA+ rating), and humped-shaped for medium rated companies (AA to B rating). They also found that the curves of low rated companies showed a higher peak spread and the time to peak was shorter than for high rated companies. Other authors can also underline the initial results and those of He et al. (2000).

Nevertheless, many studies in the literature focus only on the investment grade sector (see for example, Annaert and Ceuster, 1999 or van Landschoot, 2003, 2008). Helwege and Turner (1997) is one of the few studies on the high yield sector. They concentrate on the analysis of BB and B bonds but face the problem of selection bias when bonds with the same credit rating though different creditworthiness are grouped together. In other words, the credit quality of the bonds may not be the same even if they have the same rating. To isolate the effect, Helwege and Turner (1997) as well as He et al. (2000) decided to focus on an individual firm and only pooled bonds per rating category that were issued by one company. However, this led to a second problem of a very small sample size. Both studies, Helwege and Turner (1997) as well as He et al. (2000), represent the shape of the credit curves visually by plotting the bonds on a graph. This creates arbitrariness and a dependence on the authors' assessment. To reduce this dependency of judgement, this paper uses the parametric approach of Nelson and Siegel (1987) and Svensson (1994) to model the spread curves, as do van Landschoot (2003, 2004, 2008) and Li et al. (2013). In addition, the paper considers both investment grade and high yield bonds, following the approach of Li et al. (2013).

The most common method used in the literature so far is the use of bond indices for the corresponding rating category to analyze the relationship and change in credit spreads and the changes in credit curves (e.g., Longstaff and Schwartz 1995, Duffee 1998, van Landschoot 2003, 2008, Boulkeroua and Stark, 2010). Bond indices often do not exist specifically for one maturity but cover maturity bands. ICE Bank of America / Merrill Lynch offers indices with maturity bands of 1-3, 3-5, 5-7 and 7-10 years, as used for example in van Landschoot (2008). To avoid this problem, this working paper directly uses the constituents of two major global corporate bond indices (further details are explained in chapter 3). Moreover, in order to keep the data set as large as possible, the credit curves are not modelled per company and rating category as in Helwege and Turner (1997) and He et al. (2000), but rather all companies from the data set are considered per rating class according to corresponding criteria described in chapter 3.3.

Past research has focused mainly on the US as government and corporate bond market, as they are the largest in the world in terms of bonds outstanding and the most liquid in terms of transactions (Boulkeroua and Stark, 2010). Empirical studies in this area of the European bond market have been very limited. Annaert and Ceuster (1999) analyzed credit spreads of euro bonds for different rating categories and time-to-maturity buckets (van Landschoot, 2003). Trück et al. (2004) also focused their analysis on euro-denominated bonds. Over the last decade the euro corporate and government bond market has grown strongly. The main driver of this growth has been the increase in bond issuance by corporations and financial institutions (van Landschoot, 2008). This paper will focus on modelling credit spread curves of euro-denominated corporate bonds. For comparison, credit spread curves of US-dollar-denominated bonds will also be computed. The modelling approach and the criteria for the selection of the bonds are described in the following chapter 3.

3. Model and Data Description

Before explaining the data basis of the analysis, the curve modelling approach is presented.

3.1 Curve Modelling (Nelson/Siegel/Svensson)

Charles R. Nelson and Andrew F. Siegel developed a parametric model for modelling interest rate curves in 1989 that is also consistent with most bond pricing models. The approach is characterized by its simplicity of application and the possibility of representing all possible shapes of the interest rate curve (Nelson and Siegel, 1987).

The Nelson/Siegel approach estimates spot rates for all points in time via the associated short-term forward rates. The spot rate can be written as an average of the forward rates starting between t_0 and t_n .

$$r_n = \frac{\int_{m=0}^n f_m dm}{T(t_0, t_n)} \quad (1)$$

Nelson/Siegel define the following regression approach for the short-term forward rate:

$$f_m(b) = \beta_0 + \beta_1 e^{-\frac{m}{\tau}} + \beta_2 \frac{m}{\tau} e^{-\frac{m}{\tau}} \quad (2)$$

It should be noted that m is the time and $\mathbf{b}^T = (\beta_0, \beta_1, \beta_2, \tau)$ is the parameter vector (β_0 and τ must be positive). Thus, the regression approach consists of three components. The first parameter, β_0 , is a constant. The second component, $\beta_1 e^{-\frac{m}{\tau}}$, is an exponential term that decreases monotonically with an increasing time to settlement (or increases if β_1 is negative). The third component, $\beta_2 \frac{m}{\tau} e^{-\frac{m}{\tau}}$, generates a hump (or a u-shape if β_2 is negative). When the time to settlement m tends towards infinity, the function value f_m approaches the value β_0 . If the time to settlement m tends towards zero, the function value approaches the value $\beta_0 + \beta_1$ (Hewicker and Cremers, 2011; Svensson, 1994).

The function for calculating the spot rates can be derived from equation (1) and (2).

$$r_n(b) = \beta_0 + \beta_1 \frac{1 - e^{-\frac{n}{\tau}}}{\frac{n}{\tau}} + \beta_2 \left(\frac{1 - e^{-\frac{n}{\tau}}}{\frac{n}{\tau}} e^{-\frac{n}{\tau}} \right) \quad (3)$$

When looking at the factor loadings over time (i.e., the factors for the parameters β_0 , β_1 and β_2), it can be seen that β_1 is responsible for the short-term shape of the spot curve, as the factor loading starts at one and then drops off quickly. In contrast, β_2 represents the medium-term shape. The factor loading starts at zero, then rises and falls again in the medium term. This allows a hump or u-shape evoke in the interest rate structure. The third parameter, β_0 , determines the level of the interest rate structure at the longer end, since the factor loading is constant at one and is thus the only significant influence for long maturities.

Using this equation to calculate the spot rates, parameters $\mathbf{b}^T = (\beta_0, \beta_1, \beta_2, \tau)$ can now be estimated for the different maturities. However, the function is not linear due to the parameter τ . Thus, an estimation using the ordinary least squares (OLS) method is not directly possible. Nelson/Siegel vary the parameter τ and estimate β_0 , β_1 and β_2 , using the ordinary least squares (OLS) method (Hewicker and Cremers, 2011; Nelson and Siegel, 1987; Svensson, 1994).

Svensson (1994) found, the Nelson/Siegel model has its difficulties depicting the term structure, when more than one hump or u-shape occurs. He developed a modified form to improve the estimation performance. The forward rate function with the parameters β_3 and τ_2 added by Svensson (1994) therefore is:

$$f_m(b) = \beta_0 + \beta_1 e^{-\frac{m}{\tau_1}} + \beta_2 \frac{m}{\tau_1} e^{-\frac{m}{\tau_1}} + \beta_3 \frac{m}{\tau_2} e^{-\frac{m}{\tau_2}} \quad (4)$$

Corresponding to the calculation of the forward rates, the calculation of the spot rates is adjusted as well.

$$r_n(b) = \beta_0 + \beta_1 \frac{1 - e^{-\frac{n}{\tau_1}}}{\frac{n}{\tau_1}} + \beta_2 \left(\frac{1 - e^{-\frac{n}{\tau_1}}}{\frac{n}{\tau_1}} - e^{-\frac{n}{\tau_1}} \right) + \beta_3 \left(\frac{1 - e^{-\frac{n}{\tau_2}}}{\frac{n}{\tau_2}} - e^{-\frac{n}{\tau_2}} \right) \quad (5)$$

Due to this small modification, the estimation quality of the model can be improved considerably, without increasing the complexity excessively. Svensson chooses the maximum likelihood method (MLE). The Svensson expansion can also apply OLS if two parameters are fixed (τ_1 and τ_2 , with the constraint $\tau_2 > 0$) (Hewicker and Cremers, 2011; Svensson, 1994; Urs, 2018).

Due to the widespread use of this model, its ease of application and the simultaneous possibility of representing all conceivable interest rate curve shapes, the approach according to Nelson/Siegel/Svensson is used for modelling the rating-based spread curves in this paper. This approach is similar to van Landschoot (2003, 2008) and Li et al. (2013).

3.2 Data

The analysis is based on ICE/Bank of America Merrill Lynch indices. These are industry standard benchmarks and are monthly rebalanced. The first index covers the investment grade universe (ICE/Bank of America Merrill Lynch Global Broad Market Corporate = G0BC). It was launched on 31st December 1996. The high yield universe is represented by HW00 ("Global High Yield") Index. The index started one year later, on 31st December 1997. Both indices include bonds with fixed coupon schedule (including zero), a minimum face value of USD 250 (or EUR) million, at least one rating from Standard & Poor's, Moody's or Fitch, a time to maturity above 18 months at time of issuance and a remaining maturity of more than one year (ICE Data Services, 2020c, 2020b). The valuations and prices rely on industry standard models like TRACE and Merrill Lynch Traders.

3.3 Data Selection

To create a uniform data set filters were chosen similarly to van Landschoot (2008) to use only corporate bonds from developed countries. Therefore, bonds issued by industrial companies and utilities as well as bonds issued by financial institutions are examined. To ensure good comparability only senior bonds are considered. Euro versus US-dollar bonds are handled within currency buckets.

All key figures are measured at the end of each month: 1) the time to maturity (indicated in years) 2) the ASW (see chapter 3.4) in basis points (bps) and 3) the composite rating (see chapter 3.5). Although the Global Corporate Index (G0BC) was launched on 31st December 1996 and has the first month-end data as of 31st January 1997, euro-denominated bonds are only included in the index from January 1999. Similarly, the Global High Yield Index (HW00) only includes euro-denominated bonds since January 1999. Therefore, the first data point for euro-denominated bonds is 31st January 1999.

During the first years of the analysis (starting 1999) the universe of euro-denominated bonds was very small (Figure 2) compared to US-dollar. The euro denominated BBB segment was initially not represented at all. By June 1999 there were only two BBB rated bonds. Since then, the database has grown strongly in particular the BBB segment. In contrast, the share of bonds with good ratings (AAA and AA) has declined significantly. The composition of the euro denominated portion of the index has thus changed considerably over the last two decades. The US-dollar portion has also grown strongly. Here, it can be observed that all rating classes have grown to roughly the same extent. Only the very good rating classes (AAA, AA1 and AA2) have a very small share.

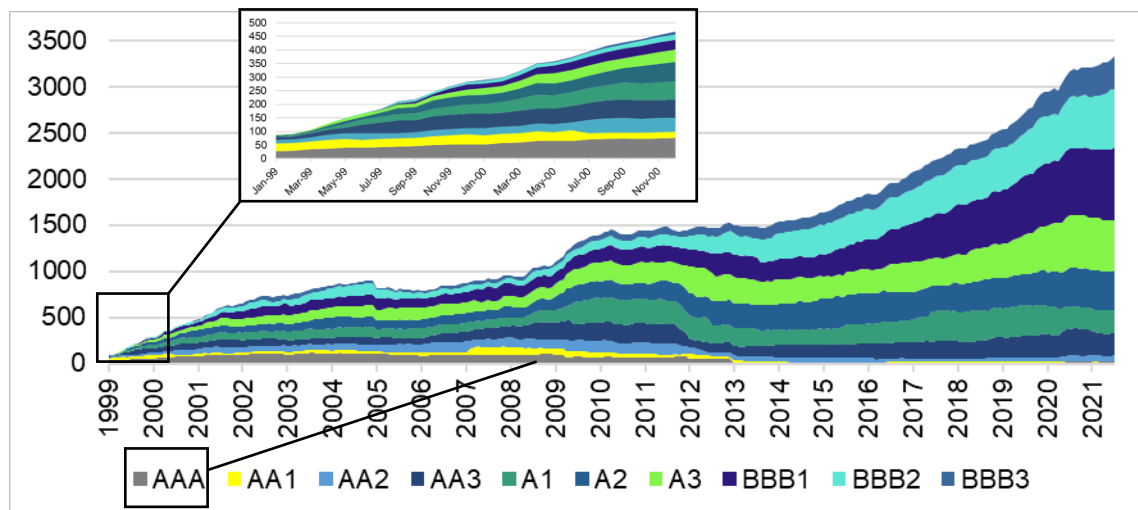


Figure 2: Number of EUR Corporate IG Bonds (January 1999 to July 2021)

To have sufficient bonds available, 2004 was chosen as the starting point. For the same reason the benchmark curves are representing a rating class level and not a sublevel (e.g., one rating curve for BBB with no subgroup e.g., BBB+). Also, the rating classes AAA and AA were combined as in 2015 and 2016; sometimes only five or six AAA rated bonds were included in the index. To create a meaningful database, curves were only calculated if at least eight bonds were available in all maturity ranges. CCC bonds are excluded as the selection bias is especially strong in this class (Helwege and Turner 1997).

These criteria result in a database of 1.95 million data points for bonds over the whole period (January 2000 until July 2021). Of these, 1.52 million data points are denominated in US-dollars and around 0.43 million in euro. Overall, 140,000 are euro denominated financial bonds and 300,000 are non-financial bonds. The average remaining maturity of the investment grade universe is 9.28 years and 6.86 years for high yield universe.

3.4 Asset Swap Spread

In the original approach according to Nelson/Siegel and Svensson, spot and forward rates are used to model the interest rate curves (see chapter 3.1). In practice, due to disadvantages like coupon effects (Steiner et al., 2017), credit spreads are quoted in comparison to the swap curve. An asset swap is an exchange of the fixed coupon of a bond for a floating with the asset swap spread (ASW) as a premium (ICE Data Services, 2018b, Heidorn and Schäffler, 2017). Since this paper focuses on the credit component, ASWs according to ICE's official benchmark pricing methodology are used. The pricing methodology is based on the mid-price for interest rate swaps (the fixed leg) and is calculated off tradeable quotes from electronic trading platforms or quotes by Merrill Lynch (ICE Data Services, 2020a).

3.5 Rating Methodology

The benchmark curves are based on a composite rating adopted according to the methodology of the benchmark provider ICE. The composite rating is a simple average of the bond ratings by Moody's, S&P and Fitch. It is calculated by assigning a numerical equivalent to the ratings in each agency's scale as follows: AAA = 1, AA+ = 2, AA = 3, etc. The average is rounded to the nearest whole number and then converted to a corresponding composite rating. If only two (one) agencies rate a bond, the composite is based on these two (one) ratings (ICE Data Services, 2018a, 2018b).

Composite ratings are updated once a month as part of the index rebalancing. Changes to the composite ratings will take effect on the last calendar day of the month. The bonds selected in chapter 3.3 are clustered according to the ICE Composite Rating. Using the corresponding ASWs, the credit benchmark curves are modelled over a maturity of 1 to 20 years from 2004 to 2021.

4. Rating-Based Asset Swap (ASW) Curves

In this chapter ASW-curves for Euro corporate bonds as a function of rating level and time are described in detail. Also, the function as a benchmark curve is tested.

4.1 Modelling the ASW-Curves

Svensson parameters ($\mathbf{b}^T = (\beta_0, \beta_1, \beta_2, \beta_3, \tau_1, \tau_1)$) are estimated once at the end of each month, using a R-package by Union Investment² for modeling curves with Nelson/Siegel/Svensson (R Core Team, 2016). The Package has been chosen for this as it uses the Ridge approach, which provides more stable and better results (e.g., Annaert et al. 2012).

4.2 Results for Euro Denominated Bonds for Each Rating Class

This section presents the results of the ASW-curves for each single rating class of euro-denominated bonds (including financials and non-financials) over the period of April/May 2004 to July 2021. The 3D charts show the ASW-curves in basis points by remaining maturity (in years) over the entire time horizon. Always two diagrams are shown from different perspectives.

4.2.1. AAA and AA Rated Euro Bonds

There were four major crises in the period under review: First was the financial crisis starting in 2007 with the insolvency of the investment bank Lehman Brothers in September 2008, followed by Eurozone crisis. The next turmoil was the sovereign debt crisis with a focus on Greece and Brexit in 2006. Finally, the Corona pandemic started 2020. All crises resulted in significant widening of corporate bond spreads and are clearly visible in Figure 3. The exact extent of the financial crisis can be better analyzed by distinguishing between industrials and financials (see chapter 4.4).

Even though these bonds have ratings of AAA and AA sometimes they traded at ASW levels above 200bps. Some bonds in the sample are government-related or have a government guarantee. This could possibly be one reason why the euro sovereign crisis also resulted in significant spread widening. Interestingly, the Corona pandemic led to less spread widening compared to the sovereign crisis at the end of 2011, although the larger part of the bonds were industrial companies being severely affected by the Corona pandemic. However, the environment before the Corona pandemic was characterized by much tighter spreads than before, despite other events in the period since 2016, such as the Brexit.

² The package is not freely available but was programmed by Union Investment.

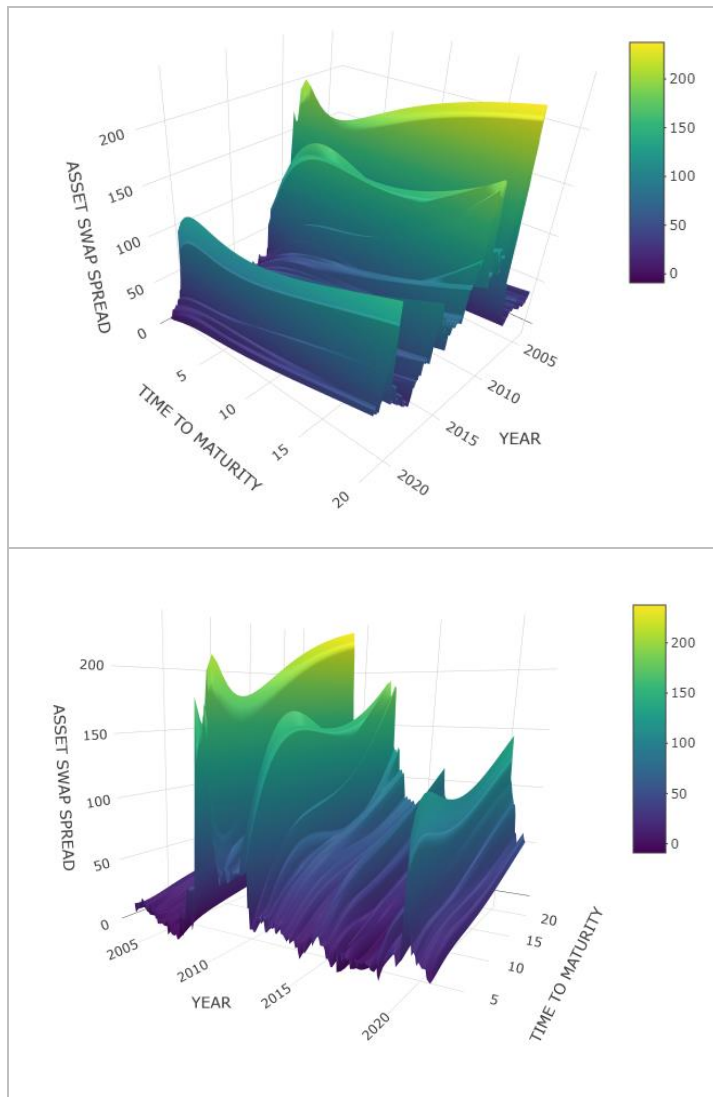


Figure 3: Euro ASW-Curves for AAA & AA Rated Bonds (May 2004 to July 2021)

One reason was the announcement of the corporate bond purchase program (CSPP) by the ECB in June 2016. It can be observed in Figure 3 that the spread curves tightened significantly following the swings caused by the eurozone crisis (Bonfim and Capela, 2020). According to Abidi and Miquel-Flores (2018), the program has a significant lowering impact on the spreads of investment grade companies.

It can be noted that the AAA and AA ASW-curves have, for the most part, a normal shape. This is in line with the literature (see chapter 2). Since the two rating classes AAA and AA were combined in this working paper, the findings of He et al. (2000) for a rising curve for AAA ratings as well as a humped-shaped curve for AA ratings can be confirmed. However, the humped-shaped curves can predominantly be found in the crisis periods, as humped-shaped curves reflect a period of uncertainty and volatility (Spremann and Gantenbein, 2007). At the height of the respective crises there was a hump in the shorter maturities. In the financial crisis spreads were extremely wide, but the curve still showed a normal shape after a small hump at the short end. In the euro sovereign crisis in fall/winter 2011 there was a much bigger hump. In the Corona pandemic there was also a hump at the short end, but the curve

flattened. Already in the middle of 2020, spreads over the entire maturity tightened again significantly. The hump decreased, and the curve shifted downward in parallel. However, when there was further uncertainty in the market at the end of 2020 and another strong Corona wave threatened to emerge, the AAA /AA curve briefly inverted. Finally, the curve has a slight upward slope but has returned to a normal shape.

4.2.2. A Rated Euro Bonds

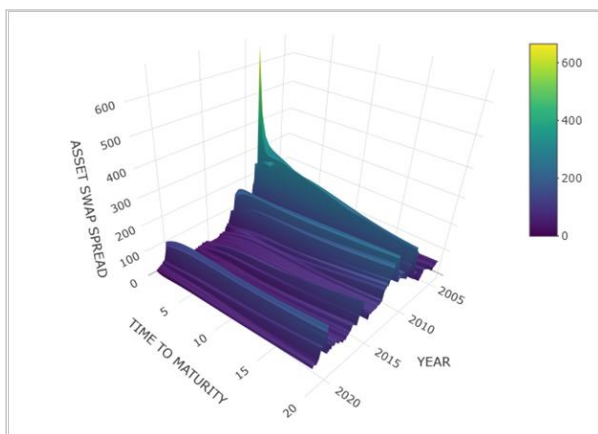


Figure 4: Euro ASW-Curves for A Rated Bonds (May 2004 to July 2021)

Looking at A rated bonds, it is noticeable that a data point in 2008 (October 2008) clearly influences the curve (see Figure 14). Since the underlying data set includes both industrial and financial bonds, and Lehman Brothers had an A+ rating from S&P and Fitch and an A2 rating from Moody's until shortly before its insolvency³, it stands to reason that this is a major cause of the outlier (see chapter 4.4. for more detail). Figure 5 shows the curve without the outlier.

As expected, the curves of the A rated bonds also reacted with strong spread widening during crises. However, it becomes evident that the spread curves were almost flat at a very high level in both, the euro sovereign crisis and the Corona pandemic. There is only a slight hump at the short end, which was much more pronounced for AAA and AA bonds. In the financial crisis, however, the spread curve was completely inverted, showing a clear contrast to the AAA and AA rating spread curves from before the crisis. Only a butterfly movement of the curve had led to a humped-shaped curve. Sarig and Warga (1989), Fons (1994) and Jarrow et al. (1997) argued as firms with poor credit quality (BB and B ratings) have a high short-term risk leading to a humped-shaped spread curve, as the scope for a worsening is small. This phenomenon could also have applied to A-companies. With insolvency of Lehman Brothers, great uncertainty spread across the market and many market participants lost confidence in ratings and banks. This was especially the case for financial bonds (see chapter 4.4). Following the announcement of the CSPP a significant tightening of spreads and flattening of the curves can also be observed for A rated bonds similar to AAA and AA rated bonds (Abidi and Miquel-Flores, 2018; Bonfim and Capela, 2020).

³ Rating data provided by Bloomberg, S&P and Fitch Rating A+, Moody's A1 until 15th September 2008.

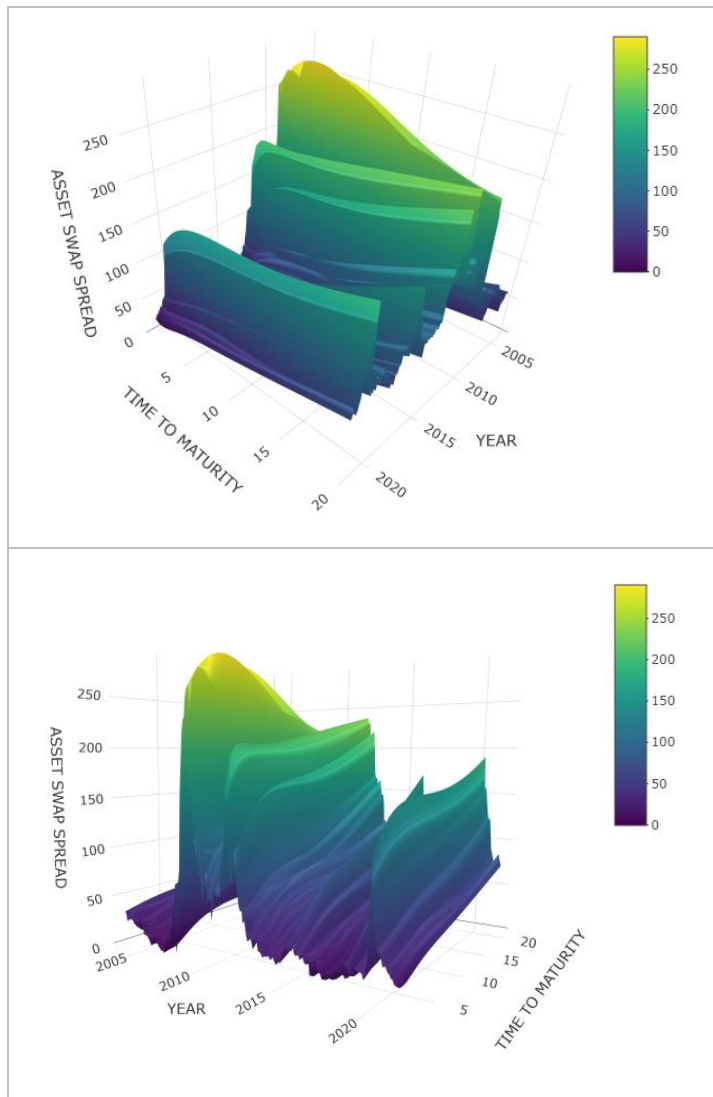


Figure 5: Euro ASW-Curves for A Rated Bonds (May 2004 to July 2021 without October 2008 to avoid distortion due to outliers)

However, it can be noted that the curves outside the crisis periods generally exhibit a normal upward shape and were steeper than those of AAA and AA rated group. Thus in principle, the findings of Sarig and Warga (1989), Jarrow et al. (1997), Duffie and Singleton (1999), Amato and Remolona (2003) and Trück et al. (2004) can be confirmed. It can also be shown that the spread level of A rated bonds is generally higher than that of the AAA or AA rated bonds. A humped-shape curve as found by He et al. (2000) is only evident in the sovereign debt and Corona crisis, even though the hump is not very pronounced.

4.2.3. BBB Rated Euro Bonds

Figure 6 shows ASW-curves for BBB rated bonds. In some months in 2011 strong swings can be seen at the short end of the curve.

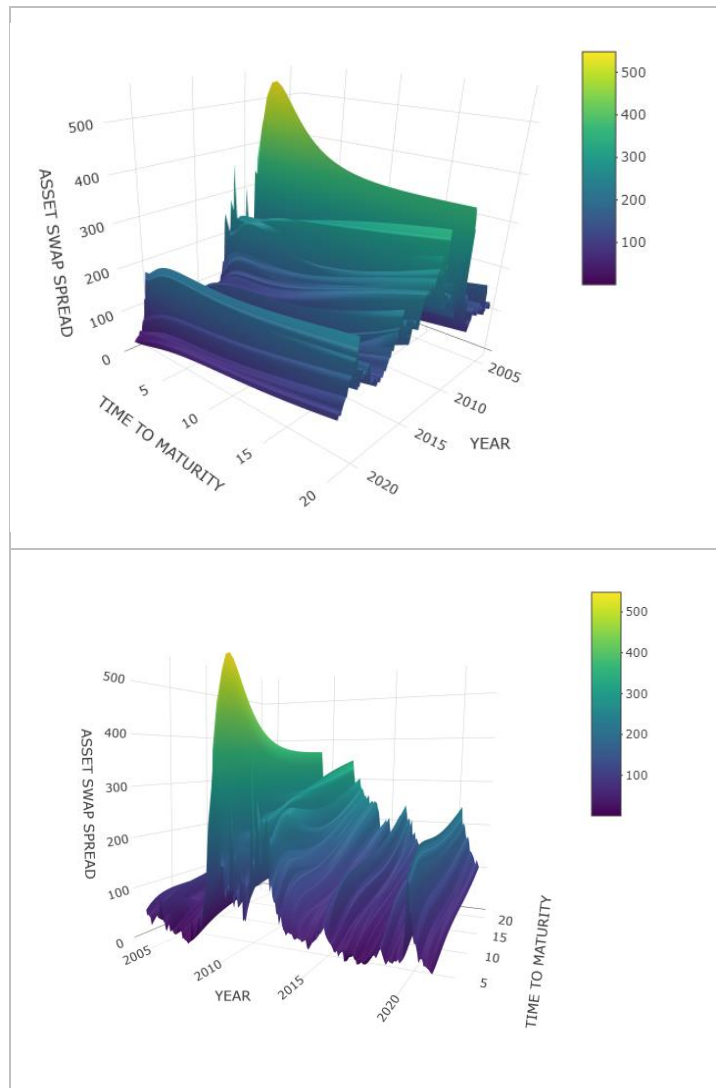


Figure 6: Euro ASW-Curves for BBB Rated Bonds (May 2004 to July 2021)

In this case one major drawback of Svensson extension is evident. This approach is heavily influenced by outliers, especially when only a few bonds are available. As Scheck (2001) pointed out, this can lead to overfitting. Otherwise, the ASW-curves of BBB rated bonds show similar shapes to those of AAA and AA or A rated bonds. They were also characterized by strong spread widening during the crises. The overall curves of the BBB bonds trade at a significantly higher spread level than the curves of the AAA / AA and the A rated bonds. This is true for both the short end of the curve and the long end of the curve and is consistent with the findings of Amato and Remolona (2003). However, the spread widening was much less pronounced in the Corona pandemic than in the other crises.

The curves of the BBB rated bonds are also mostly of normal and upward sloping. Again, this confirms the literature (see chapter 2). He et al. (2000) found a humped-shaped curve for BBB rated bonds. Again, this can only be confirmed for most of the crisis periods. In particular, the reaction of the ASW-curve in the financial crisis should be highlighted. The spread reaction was more pronounced than in the years thereafter because spreads traded at a quite low level for BBB rated bonds before the financial crisis and reached a level of over 500bps in the

short-term during the crisis. Here the same explanation, namely that at the height of the financial crisis, it was more likely that corporate ratings would deteriorate on the short term and then improve. Nevertheless, it is interesting to note that BBB rated bonds have been narrowing very steadily since the peak of the euro sovereign debt crisis in November 2011 and the curves have gradually become flatter (Bonfim and Capela, 2020). This movement was strongly reinforced by the central banks' purchase of corporate bonds (CSPP), as bonds with a BBB rating still fall within this program (Deutsche Bundesbank, 2016) (see also chapter 4.4).

The continuous spread tightening was only interrupted twice by the crisis at the beginning of 2016, when oil prices fell significantly, and the major oil companies came under pressure and by the Corona pandemic. Before the Corona pandemic, the spread curves reached their lowest point since 2004. In the meantime, the spreads are again at a similarly low level even after the Corona pandemic. However, since the highest spread level in April 2020, only parallel shifts in the curve have been observed. In contrast to AAA and AA rated bonds, where the curve inverted briefly, the curve for BBB rated bonds was always upward sloping.

4.2.4. BB Rated Euro Bonds

The ASW-curves of BB rated bonds are also influenced by strong data outliers, especially in the months around the financial crisis (see Figure 7). Since around 50 BB rated bonds were included in the index at this time, it is likely that the spread movements of individual bonds distort the curve. Especially in times of crisis, individual stories can cause significant spread reactions. To make the curves interpretable and to be able to evaluate them, the months from November 2008 to March 2009 were excluded.

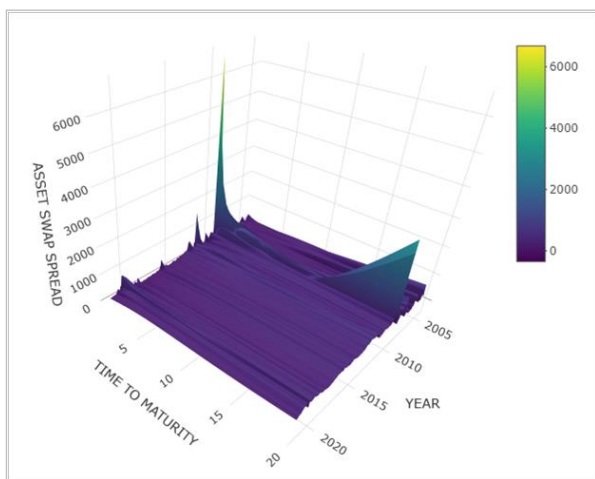


Figure 7: Euro ASW-Curves for BB Rated Bonds (May 2004 to July 2021)

The curve of BB rated bonds turns out to be significantly different from what has been the case so far for investment grade bonds (see Figure 8). At first glance, spread widening is much less evident in times of crisis. Overall, the spread level is significantly higher than for investment grade bonds including BBB. In October 2008 the curve reached around 1300bps at the short end. In the Corona pandemic, spreads at the short end around 730bps were observed. Between the crisis periods the spreads tightened much less than investment grade. One reason for this phenomenon is certainly that BB bonds are not part of the CSPP (Abidi and Miquel-Flores, 2018; Deutsche Bundesbank, 2016).

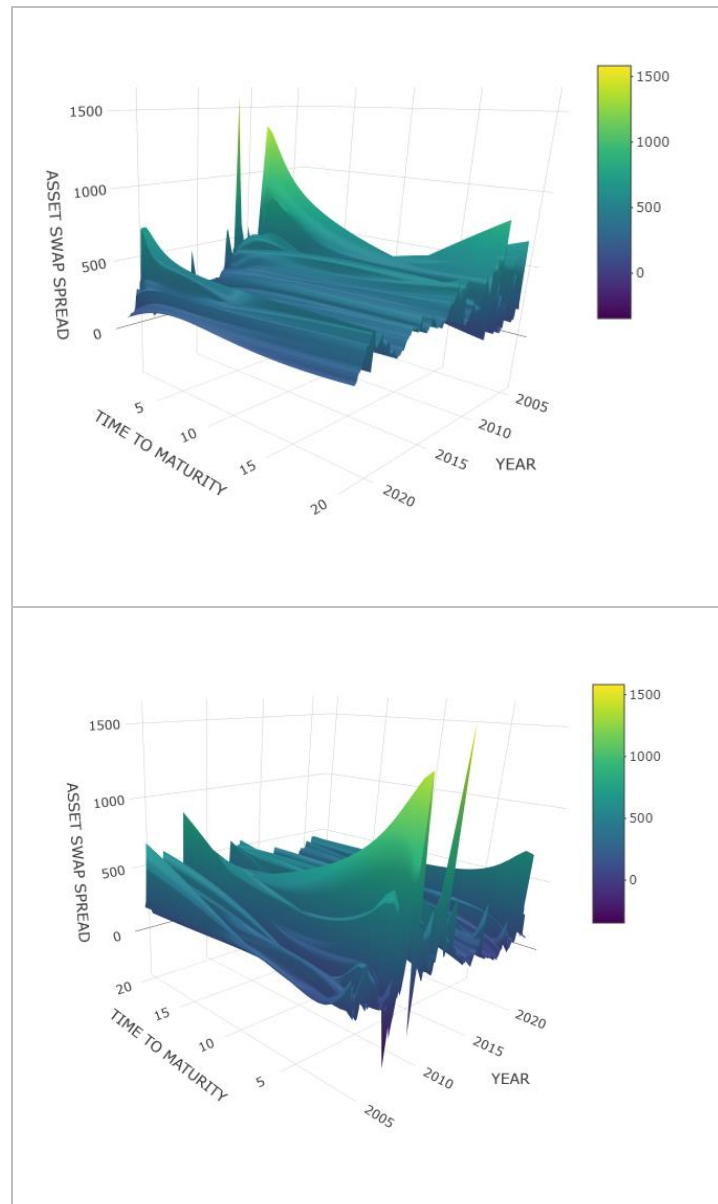


Figure 8: Euro ASW-Curves for BB Rated Bonds (May 2004 to July 2021 without November 2008 to March 2009 to avoid distortion due to outliers)

During the financial crisis and the Corona pandemic, there is a clear butterfly move that leads to inverse curves. This might be due to the general uncertainty and the poor economic outlook at that time (Spremann and Gantenbein, 2007). At the beginning of this period (bottom of Figure 8), most of the curves have a hump shape. Those results in the early 2000s correspond to Jarrow et al. (1997), who also found humped-shaped curves for BB and B. Again, companies with poor credit quality (BB and B ratings) exhibit a downward sloping curve due to the high short-term risk. The scope for a worsening is small in the short-term, but high in the long-term. After the financial crisis, the curve is normal with a slight upward slope. Helwege and Turner (1997), however, who only examined the curves of individual companies, concluded that curves of BB and B companies are upward sloping. Huang and Zhang (2008) also found that the term structures of credit spreads are generally upward sloping regardless of

credit quality or coupon. It should be noted, however, that in these studies the authors analyzed a data set with data from earlier years. The results of Fons (1994) as well as Amato and Remolona (2003), which showed declining curves for bonds with high yield rating, is only supported by the data for October 2008 and March/April 2020. Besides, Li et al. (2013) found that the curves have a downward sloping shape when the companies are close to default. This again fits our results that the curves are downward sloping only during crises. At these times, the default risk is often highest in the lower rating classes (Helwege and Turner, 1997).

4.2.5. B Rated Euro Bonds

Typically, in lower rating classes the number of bonds is small (see Figure 2, chapter 3.3.). In case of B rated bonds, strong outliers in mid-2009 influence the overall curve (see Figure 9). Again, May 2009, which was based on the data of only 52 bonds, was removed from the data set (see Figure 10). Still, some of the spread curves are characterized by sharp swings.

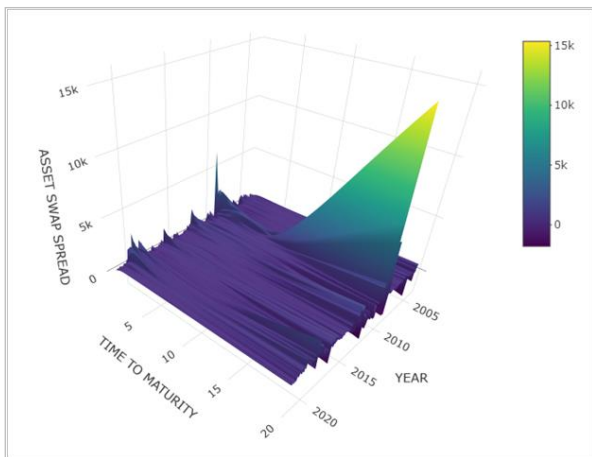


Figure 9: Euro ASW-Curves for B Rated Bonds (May 2004 to July 2021)

These curves are characterized by sharp swings. This mostly affects either the short or the long end of the curves and is caused by the well-known overfitting problem. On a spread basis, these curves therefore become increasingly difficult to interpret, especially when negative ASWs occur, which must be due to data errors or illiquid (old) bond prices. Especially in the lower rating classes there is often a great divergence in credit quality, so that it becomes increasingly difficult to analyze them in one bucket (see chapter 3.3). This is a major reason for the rather inconsistent picture in Figure 10.

We cannot confirm the findings by Helwege and Turner (1997) that credit curves for BB and B rated bonds are upward sloping. Jarrow et al. (1997), on the other hand, found humped-shaped curves for this group. This is true for most of our monthly spread curves. Companies with poor credit ratings have little potential for rating improvement in the short term and the probability of default is quite high. The longer the maturity, the more recovery time these companies have, and thus, the potential for rating upgrades is high. In this analysis, the humps at the short end of the curves are more pronounced during the crisis periods. Especially during periods of stress in the market, companies with poor credit quality are quickly close to default. This leads to curves with a pronounced hump at the short end, and often showing a normal, very steep, upward shape at the longer end.

Otherwise, the crisis periods are hardly visible in Figure 10, in contrast to well-rated companies. The results of Li et al. (2013) showed downward sloping curves for companies that are closed to default. Sarig and Warga (1989), as well as Amato and Remolona (2003) and Fons (1994) also found downward sloping curves for high yield and B rated companies, respectively. This can also be seen in Figure 10 on the bottom, especially at the beginning of the period.

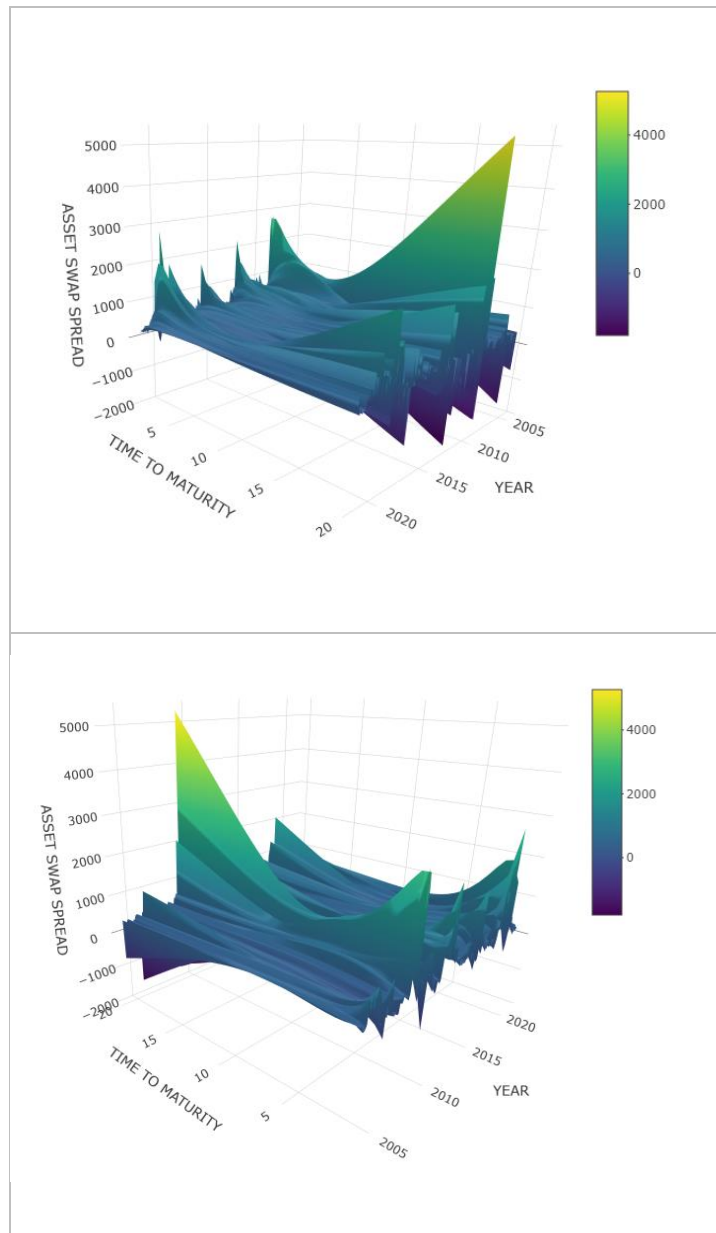


Figure 10: Euro ASW-Curves for B Rated Bonds (Mai 2004 to July 2021 without May 2009 to avoid distortion due to outliers)

It should be noted that the spread level is significantly higher overall than that for investment grade rated bonds. The spread level remains almost unchanged over the entire two decades. Unlike investment grade bonds, B bonds could also not benefit from the CSPP (Abidi and Miquel-Flores, 2018). It seems that the spread movements in the lower rating range are less dependent on the overall sentiment of the market, but rather on idiosyncratic risks. This is also confirmed by Schlecker (2009), who finds that the spread of investment grade rated companies is only 20-30% influenced by idiosyncratic events, whereas for high yield rated companies this percentage is 50-80%.

4.3 Comparison of ASW-Curves for Specific Dates

This chapter compares ASW-curves at three specific dates. The ASW is given in basis points.

4.3.1. ASW-Curves by Rating Class as of 31st December 2006

The first exemplary date is 31st December 2006 (see Figure 11). The financial crisis began in summer 2007, so the environment was one of low volatility and tight spreads.

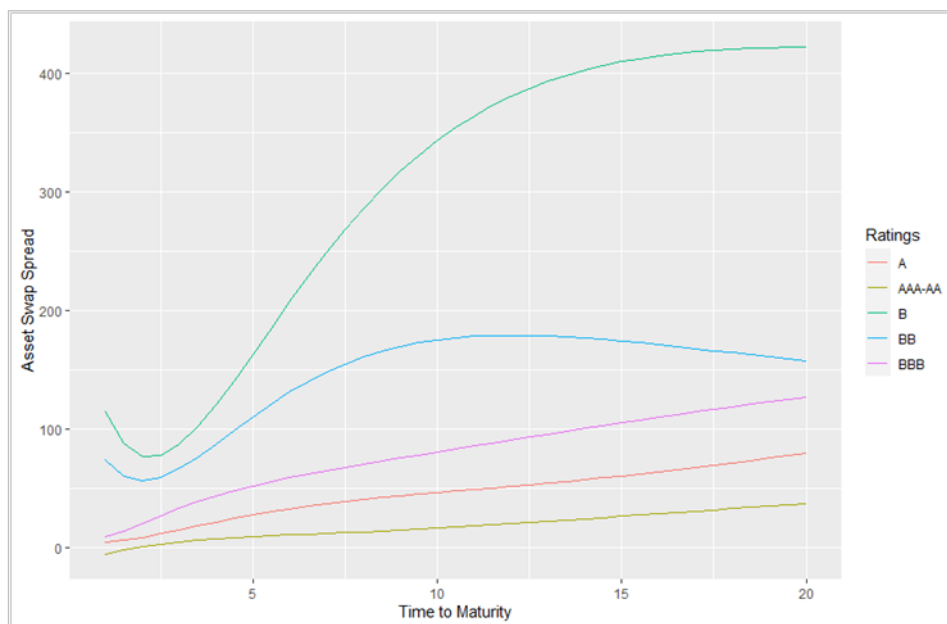


Figure 11: Rating Based ASW-Curve for Euro Corporate Bonds as of 31st December 2006

The three-ASW-curves of investment grade rated bonds are upward sloping. This picture is in line with the literature (see chapter 2). The spread difference between AAA/AA rated companies and A rated companies is similar to the spread difference between A rated companies and BBB rated companies. However, the curve of BBB rated companies is slightly steeper. Thus, as would be expected in a calm market environment, the curve of AAA/AA is the flattest and the spread increases the most for BBB rated companies as the maturity increases.

The two high yield curves (BB and B) are also mostly upward sloping but concave in the medium and long maturities. In case of the lower rating classes, this may be related to a strong increase in default probability in the short term. At the short end, the curves show a small bend. This could be due to the problem of overfitting which appears often when applying the Nelson/Siegel/Svenson model (Scheck, 2001). Most empirical studies find downward sloping curves for high yield rated firms except for Helwege and Turner (1997). They recognized that especially in the lower rating classes credit quality can fluctuate strongly. We find that upward sloping curves for BB and B rated companies are rather an exception.

4.3.2. ASW-Curves by Rating Class as of 30th November 2008

The second date to be considered is 30th November 2008. With the beginning of the subprime crisis in 2007 and the insolvency of Lehman Brothers in October 2008, spreads widened sharply. The peak of the financial crisis has been reached and the spread level is now significantly higher (see Figure 12).

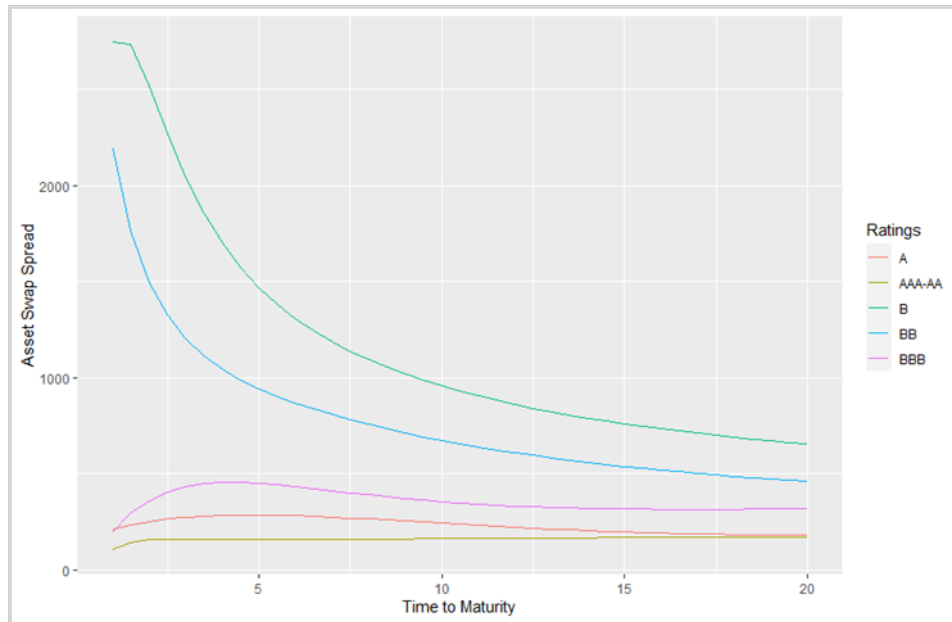


Figure 12: Rating Based ASW-Curve for Euro Corporate Bonds as of 30th November 2008

The ASW-curves have changed significantly. Only the AAA/AA curve is slightly upward sloping at the short end and levels afterwards. As expected, the credit spread remains almost stable in a market environment characterized by stress. The curve of A rated companies has inverted slightly. The curve of BBB rated companies is still trading wider than the curve of A rated companies and has developed a hump at the short end. Both curves of the high yield companies (BB and B) are strongly inverted, downward sloping and convex. These curves can be seen as evidence of a volatile environment characterized by uncertainty and fears of the future (Spremann and Gantenbein, 2007; van Landschoot, 2004). Most empirical studies concluded that spread curves of investment grade companies slope upward. Only Fons (1994) found no trend for AAA rated companies. Amato and Remolona (2003), for example, showed downward sloped curves for high yield rated companies. Duffie and Singleton (1997) found the same for "bad" rated companies, which can be considered as high yield. However, it must be noted that this is a market situation strongly influenced by exogenous factors, which does not reflect a common picture.

4.3.3. ASW-Curves by Rating Class as of 30th June 2020

Finally, we consider the 30th June 2020. After strong spread widening due to the Corona pandemic and first lockdowns in Europe which started in March 2020, financial markets have

recovered, although they have not yet reached pre-crisis and are still trading at wider levels (see Figure 13)

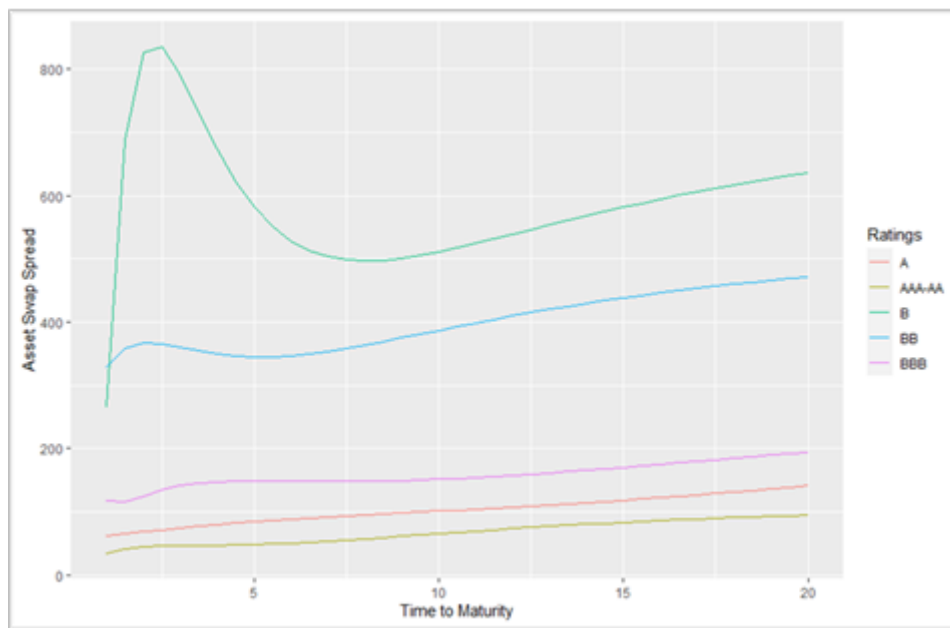


Figure 13: Rating Based ASW-Curve for Euro Corporate Bonds as of 30th June 2020

The curves of investment grade rated companies (AAA/AA, A and BBB) follow an upward sloping term structure. They rise continuously over time. This is in line with the literature (see chapter 2). The BBB curve shows a small hump at the short end. Amato and Remolona (2003) also found humped-shaped curves for BBB companies. The significant spread difference between investment grade and high yield rated companies, especially between BBB and BB is striking. As Abidi and Miquel-Flores (2018) has proven, this is due to the CSPP (ECB purchase program). Both curves (BB and B) have a humped shape, with the hump in the B curve being much more pronounced. This is consistent with the results of Sarig and Warga (1989) and Helwege and Turner (1997). Especially in the case of B rated companies, the risk of default is greater in the short term. Consequently, investors demand a higher risk premium. They also identified upward sloping curves for BB and B rated companies. This finding can also be confirmed. In addition, the period is characterized by a difficult market sentiment, which puts pressure on companies with high leverage and poor credit quality (Helwege and Turner, 1997).

4.4 Comparison of ASW-Curves for Specific Periods

The following section focuses on specific periods within the period under review. Three periods with strong movements of credit spreads have been identified (see chapter 4.2). Here we distinguish between financial and non-financial, and bonds denominated in euros and in US-dollars.

4.4.1. ASW-Curves During the Financial Crisis

A decisive event within the financial crisis was the insolvency of the investment bank Lehman Brothers in September 2008. Immediately prior to the insolvency, the bank had an A+ rating from S&P and Fitch and an A2 rating from Moody's⁴. The effects on the ASW-curves and the corresponding changes will be examined as an example for the A rated companies. Before looking at the US-dollar market and the spread changes there, the picture of euro-denominated bonds will be analyzed first. Figure 14 shows ASW-curves of A rated companies with industrial companies above and financial institutions below.

From mid-2006, inflationary pressures in the U.S. economy necessitated a tightening of monetary policy. Rising interest rates subsequently led to a sharp increase in loan defaults in the U.S. subprime market. A very high oversupply of unsold homes and increasing foreclosures caused real estate prices to fall. The recoverability of real estate-backed loan receivables came under pressure. From mid-2007, uncertainty about the actual extent of subprime mortgage defaults triggered global turmoil in the capital markets. The distortions particularly affected securities issued by financial institutions (Wissenschaftliche Dienste des Deutschen Bundestages, 2009). This can also be observed by comparing the shape of the ASW-curves of financial institutions with the shape of the ASW-curves of industrial companies in Figure 14. While the spreads of financial institutions at the long end of the curve are already trading at around 400 bps at the end of 2007, and the curves have already become very steep, the spreads of industrial companies initially widened to a much lesser extent. They still trade at around 100 bps at the long end of the spread curve in the same period. With the onset of the crisis, only slight parallel upward shifts in the curve can be recognized.

Banks, especially those with a high leverage had to reduce their balance sheets and were forced to loss-making distress sales. Uncertainty about the extent to which credit institutions were affected by losses, led to a decline of confidence in the interbank market. Due to major liquidity bottlenecks caused by the non-functioning interbank market, short-term refinancing became increasingly expensive and difficult. Uncertainty in the financial market reached its peak when the investment bank Lehman Brothers had to declare insolvency on 15th September 2008, and it became apparent that it would not be rescued by the government. With various stability mechanisms the governments prevented a complete collapse of the financial system (Wissenschaftliche Dienste des Deutschen Bundestages, 2009).

Both curves of financial institutions and industrial companies are upward sloping to this point in time. The curves for A rated financial companies invert from March 2008 onwards. With the insolvency of Lehman, the spreads explode. The curve gets a hump at the short end and becomes extremely steep at the long end. By contrast, the curves of A rated industrial companies do not jump significantly until the height of the financial market crisis. However, the general uncertainty is spreading to the entire economy and thus also to industrial companies, so their curve is also inverting.

⁴ Rating data provided by Bloomberg, S&P and Fitch Rating A+, Moody's A1 until 15th September 2008.

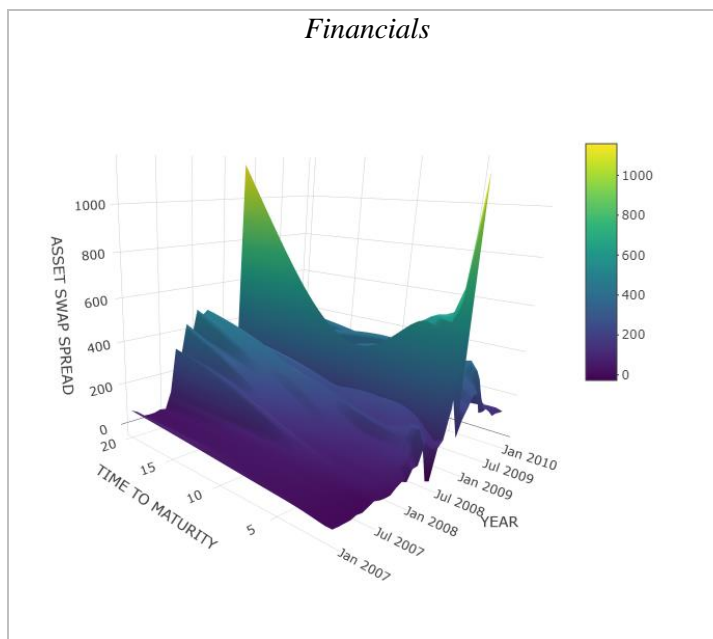
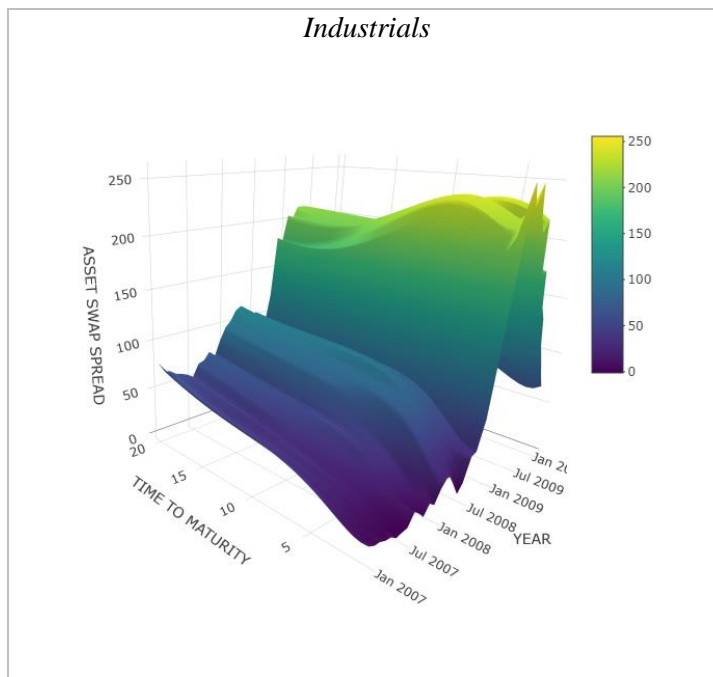


Figure 14: Euro ASW-Curves for A Rated Bonds (December 2006 to November 2009)

Looking at the US-dollar denominated A rated bonds in Figure 15, a very similar picture emerges. The curves of the industrial companies have a normal, upward-sloping shape. The spread level is very low. In spring 2007, it was still around 50 bps, then around 100 bps during the crisis. Until the peak of the crisis in October 2008, when the spreads widened rapidly, the curves shifted dramatically upwards and inverted. The curves of A rated US-dollar denominated financial bonds behave similarly to the euro denominated bonds. Here too, the spread level for financials of around 200 basis points is significantly higher than for industrials in mid-2007. The spread curves invert from March 2008 onwards, but the rise in spread

levels in September 2008 at the short end of the spread curve is once again exorbitantly higher. Following the government interventions, spread levels for both, US-dollar denominated and euro denominated bonds, declined slightly again from May 2009 onwards and the curves resumed to a normal upward sloping shape from June 2009.

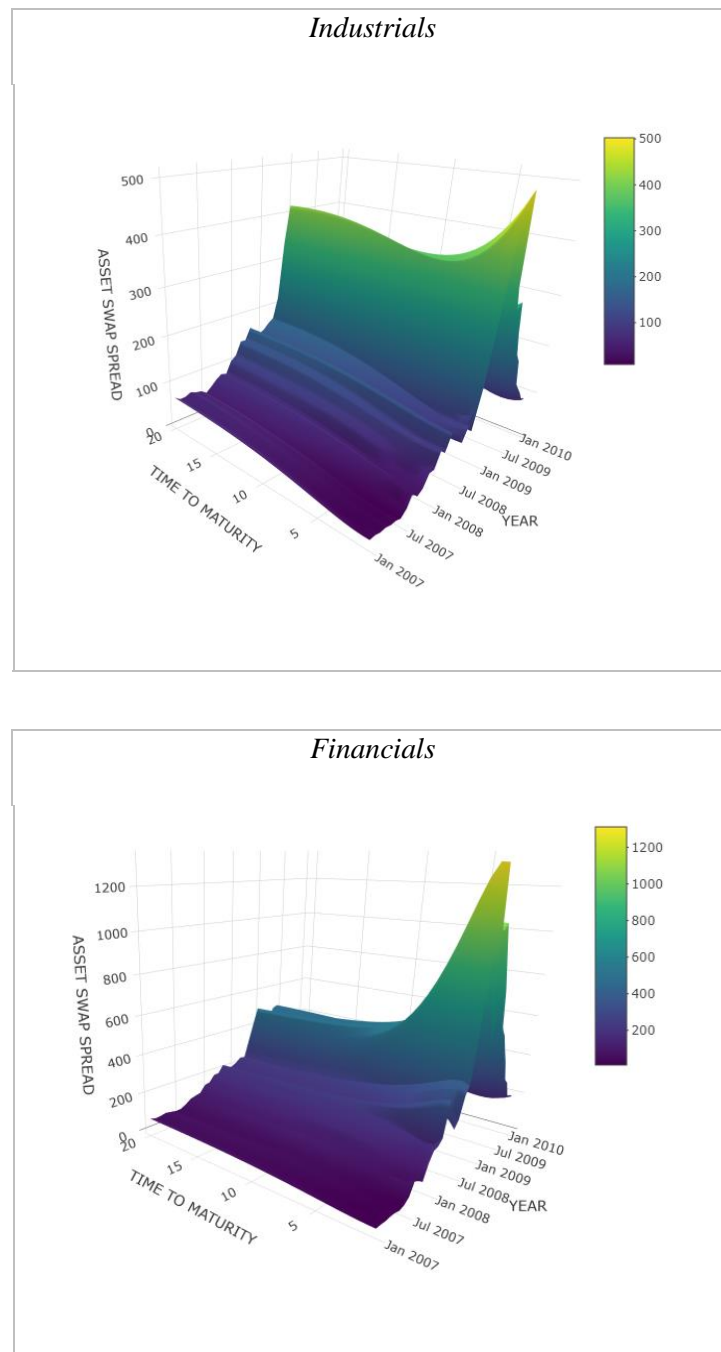


Figure 15: US-Dollar ASW-Curves for A Rated Bonds (December 2006 to November 2009 without September 2008 for Financials to avoid distortion due to outliers)

Many empirical studies have tried to identify the determinants of credit spreads after the financial market crisis. It is apparent that not only the credit quality of companies but also mar-

ket liquidity became increasingly relevant and is still a main driver of credit spreads (Heidorn et al., 2010; van Landschoot, 2004) (see also chapter 5.2).

4.4.2. ASW-Curves During the CSPP Program

On 26th July 2012, at the height of the euro crisis, the ECB President Mario Draghi proclaimed that he would do "whatever it takes" to save the euro, including the purchase of government bonds by the ECB. This statement was considered a turning point in calming financial markets and was called the "Draghi effect". On 22nd January 2015, the ECB's central council announced the expanded asset-purchase programme (EAPP). The aim of this monetary policy of "quantitative easing" was to move the inflation rate back towards 2%. In March 2016, it was announced that the already launched EAPP would be supplemented by the CSPP (Corporate Sector Purchase Programme). The CSPP started on 8th June 2016 and was implemented by the national central banks in Europe. The purchase of bonds continued until 19th December 2018. The ECB made net purchases under the CSPP of an average of EUR 5.74 billion per month from June 2016 onwards, resulting in holdings of EUR 178.05 billion in December 2017. After December 2018, only the holdings were initially reinvested. The CSPP provided for the purchase of bonds issued by industrial companies (non-financials) domiciled in the euro area. Bonds issued by financial institutions or by companies whose parent company belongs to a banking group are not considered. The minimum rating of the bonds to be purchased must be BBB- or Baa3 from the rating agencies S&P, Moody's, Fitch or DBRS. A maximum of 70% of an ISIN may be acquired (Deutsche Bundesbank, 2016; Europäische Zentralbank, 2016). The announcement of the purchase programme led to significantly increased issuance volumes in euro denominated bonds that are eligible for purchase (Abidi and Miquel-Flores, 2018). As it can be seen in Figure 2 (chapter 3.3), the data base increases from around 1,500 bonds in 2016 to over 3,000 in 2021. Especially the issues in the BBB range have grown strongly. The focus should therefore be on the spread curve change of BBB rated bonds.

When comparing the spread curves for euro-denominated BBB rated bonds of financial institutions and industrial companies from January 2016 to January 2019 (Figure 16), it is noticeable that the spread curves of financial institutions have a higher volatility compared to the industrial companies. The spreads of financial institutions most likely reacted to the uncertainty in the market due to macroeconomic events such as the Brexit decision and the referendum in Italy.

The spreads of industrial companies, which were initially hump-shaped probably due to the sharp decrease in oil prices in January 2016, showed a first parallel shift downwards after the announcement of the CSPP in March 2016 and a second one with the first purchases under the CSPP in June 2016 (Abidi and Miquel-Flores, 2018). A tightening of spreads across the entire maturity structure can be observed. In addition, they have returned to a normal shape and were sloping upwards, despite the significant increase in issuing activity as well as macroeconomic events. The overall spread level of financial companies is also significantly higher than that of industrial companies. It is also interesting to note that towards the end of the period (end of 2016), the spreads are continuously widening again. The market had apparently already anticipated the fact that the CSPP would expire in December 2018.

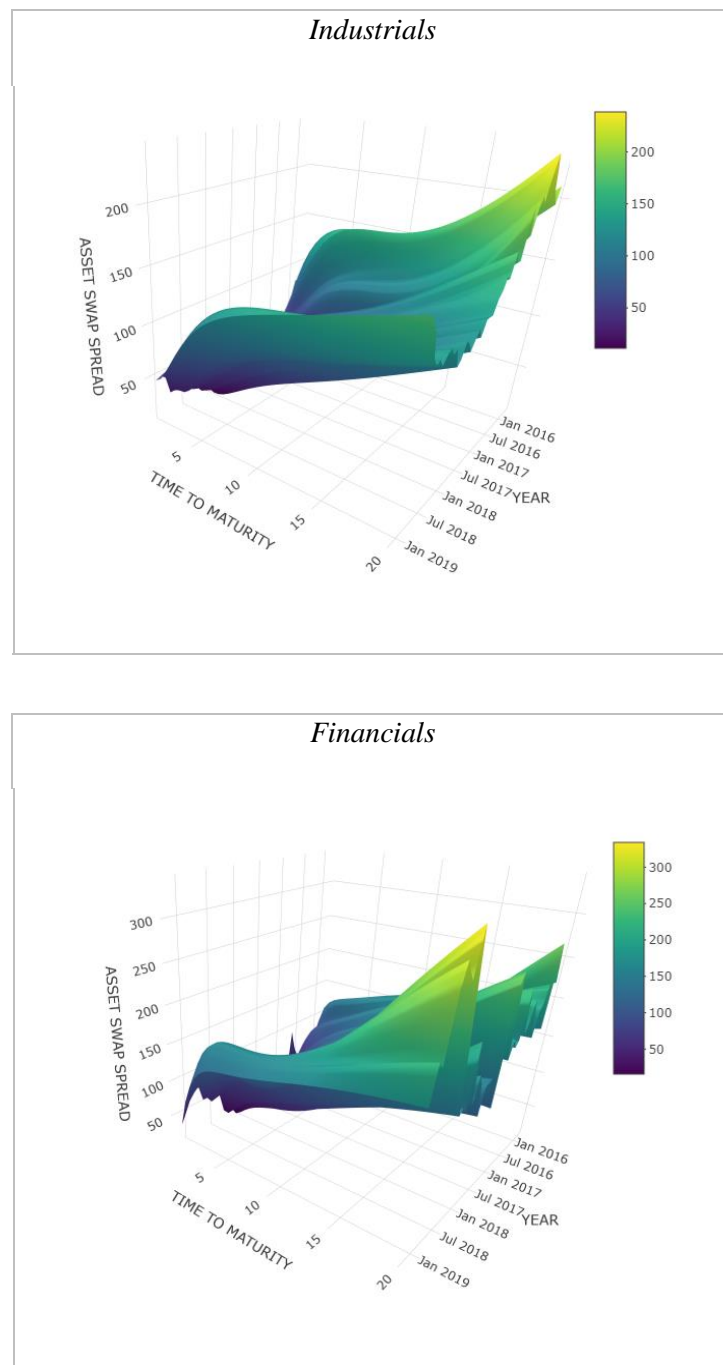


Figure 16: Euro ASW-Curves for BBB Rated Bonds (January 2016 to January 2019)

Looking at the spread curves of the US-dollar companies (see Figure 17), there is hardly any difference between the industrial companies and the financial companies. Both plots show a very similar shape. The sharp drop in oil prices in January 2016 was noticeable in both spread curves. Industrials are trading at slightly wider levels but will also most likely be more affected by the environment due to the drop in oil prices. At the end of 2016, there was an upward parallel shift for both industrial companies and financial institutions. This is possibly due to the risk of a trade war between the USA and China.

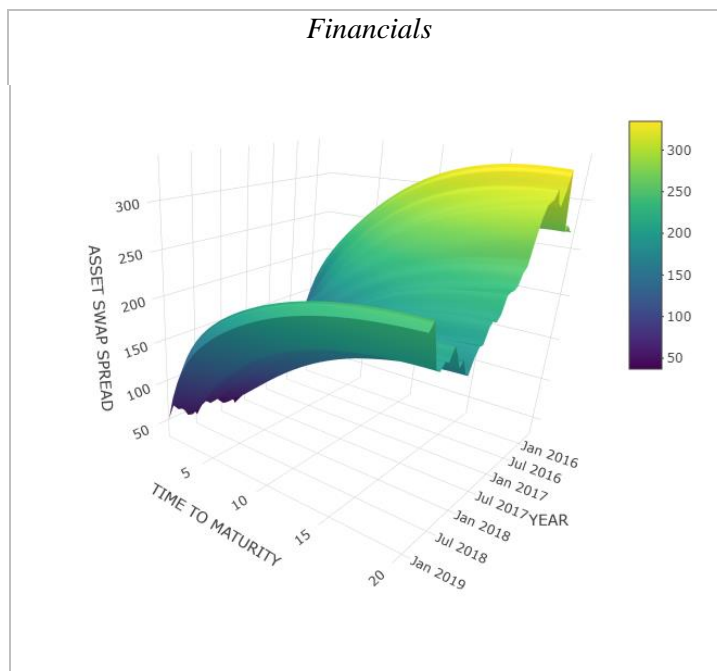
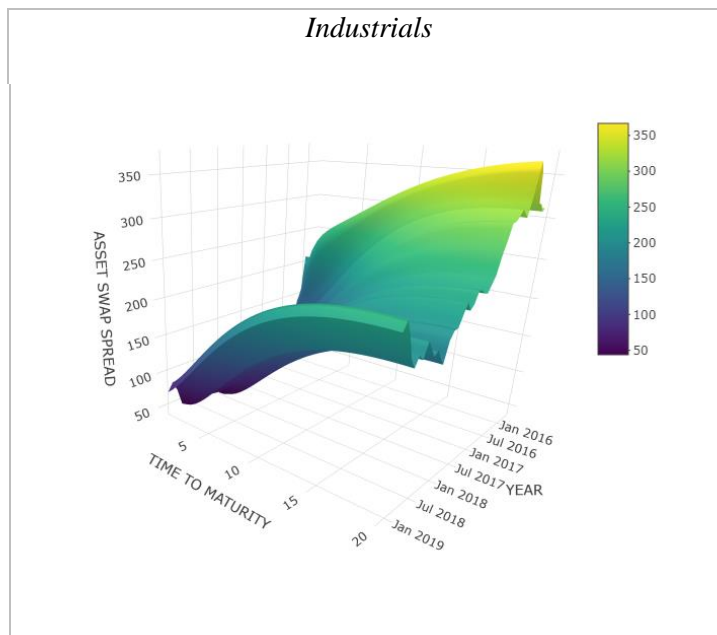


Figure 17: US-Dollar ASW-Curves for BBB Rated Bonds (January 2016 to January 2019)

Thus, empirical evidence from these data suggests that the CSPP had a significant lowering impact on credit spreads of eligible bonds, which is consistent with previous research such as Abidi and Miquel-Flores (2018) and Bonfim and Capela (2020).

4.4.3. ASW-Curves During the Corona Pandemic

On 31st December 2019, the World Health Organization (WHO) informed about cases of pneumonia with unknown cause. The Chinese authorities identify a novel coronavirus. On 30th January 2020, the WHO declares the outbreak to be a public health emergency of international concern with the highest alert level. Due to the rapid increase in the number of cases, the WHO officially declared the outbreak as a pandemic on 11th March. Europe became a center of the pandemic during this time with over 40% of all cases reported worldwide. For this reason, the first lockdowns were imposed in Europe in March 2020 bringing the economy to a virtual standstill (WHO, 2021).

After the ECB's first CSPP expired in December 2018 and the maturing bonds were only to be reinvested, net purchases have been made again since 1st November 2019. In April 2020, an additional CSPP was launched to combat the consequences of the pandemic (Deutsche Bundesbank, 2016). Therefore, spreads of industrial companies should remain well supported. The change in spread curves during this pandemic will also be examined using the BBB rated companies, which have already accounted for approx. 50% of the index since 2017 (see Figure 2). Figure 18 shows the spread curves from January 2020 to March 2021 for euro denominated BBB rated bonds.

As observed during the CSPP the spread curves of financial institutions have a higher volatility compared to industrial companies. This is most likely due to the fact that financial bonds are not eligible for purchase. At the beginning of 2020, the spread curves of financial institutions as well as those of industrial companies are sloping upwards. With the spread of the pandemic and the first lockdowns in March 2020, financial bond spreads double across the curve (at the long end towards 20 years from around 100 bps to over 200 bps) and the curve inverts. The industrial curve only forms a slight hump at the short end of the curve, but the spreads widen abruptly over the entire curve. In the further course, the curve of industrials at the long end flattens again in April 2020 after governments and the central bank have sent clear signals to take measures to calm the market. The spreads tighten gradually, and the spread curve thus shifts parallel downwards. At the beginning of 2021, supported by the CSPP, the spreads of industrial companies have returned to their pre-crisis levels. However, the term structure of the financial companies, conversely, changes in April 2020. The inverted curve has now an upward convex shape again with a hump at the short maturity end. In this shape, the spread curve moves gradually downwards based on parallel shifts. In January 2021 the curve becomes significantly flatter again at the long end but is still trading at around 150 bps at the long end of the curve and thus around 50 bps wider than pre-pandemic levels.

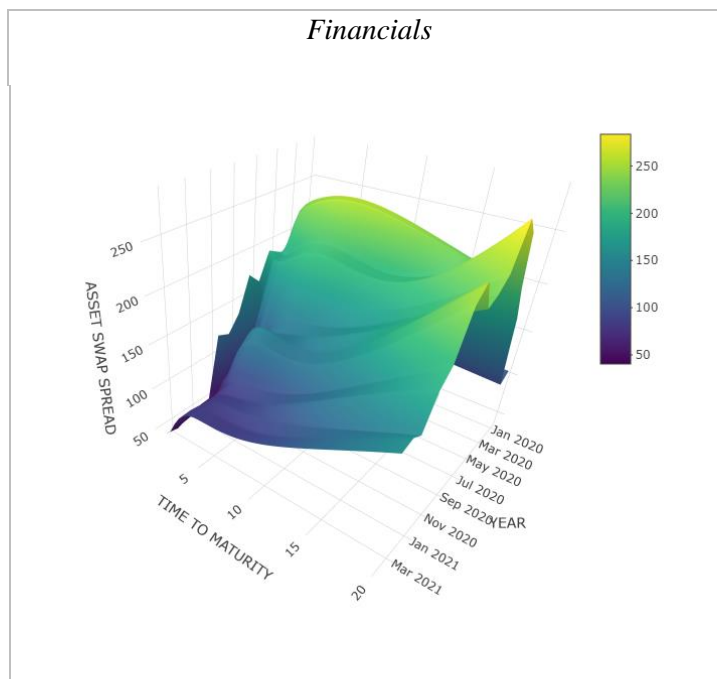
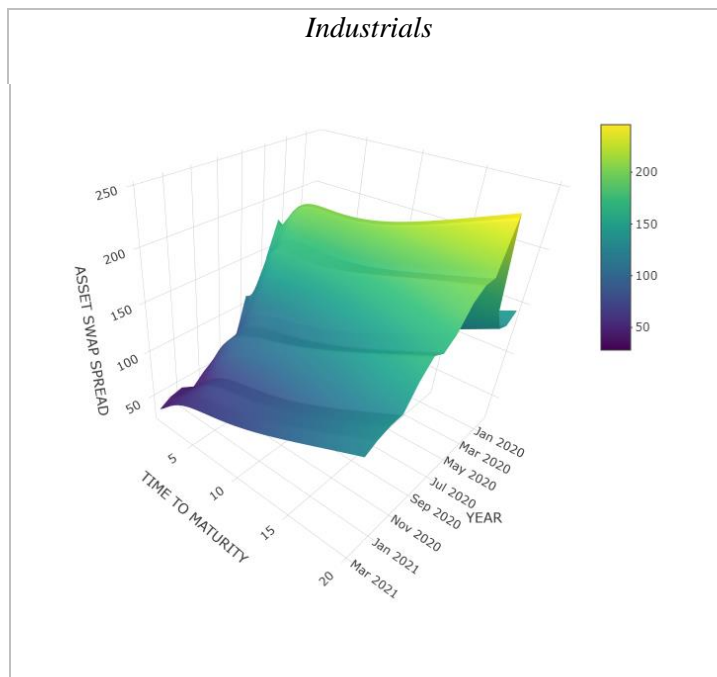


Figure 18: Euro ASW-Curves for BBB Rated Bonds (January 2020 to March 2021)

For the US-dollar curves (see Figure 19) both spread curves of industrial companies and financial institutions have a butterfly effect at the short end in March 2020. The curve of industrial companies is upward sloping, while the curve of financial institutions is completely flat. This term structure does not change in the further course of the pandemic. The spread curves of the industrial companies show a normal upward sloping shape again from April 2020 and then also move downwards in parallel shifts over the entire term structure. The spread curves of the financials are only steep at the short end. The middle and long ends of the curves are

flat. Here too, the spreads tighten across the entire term structure from April 2020 onwards following the announcements of support measures by governments and central banks.

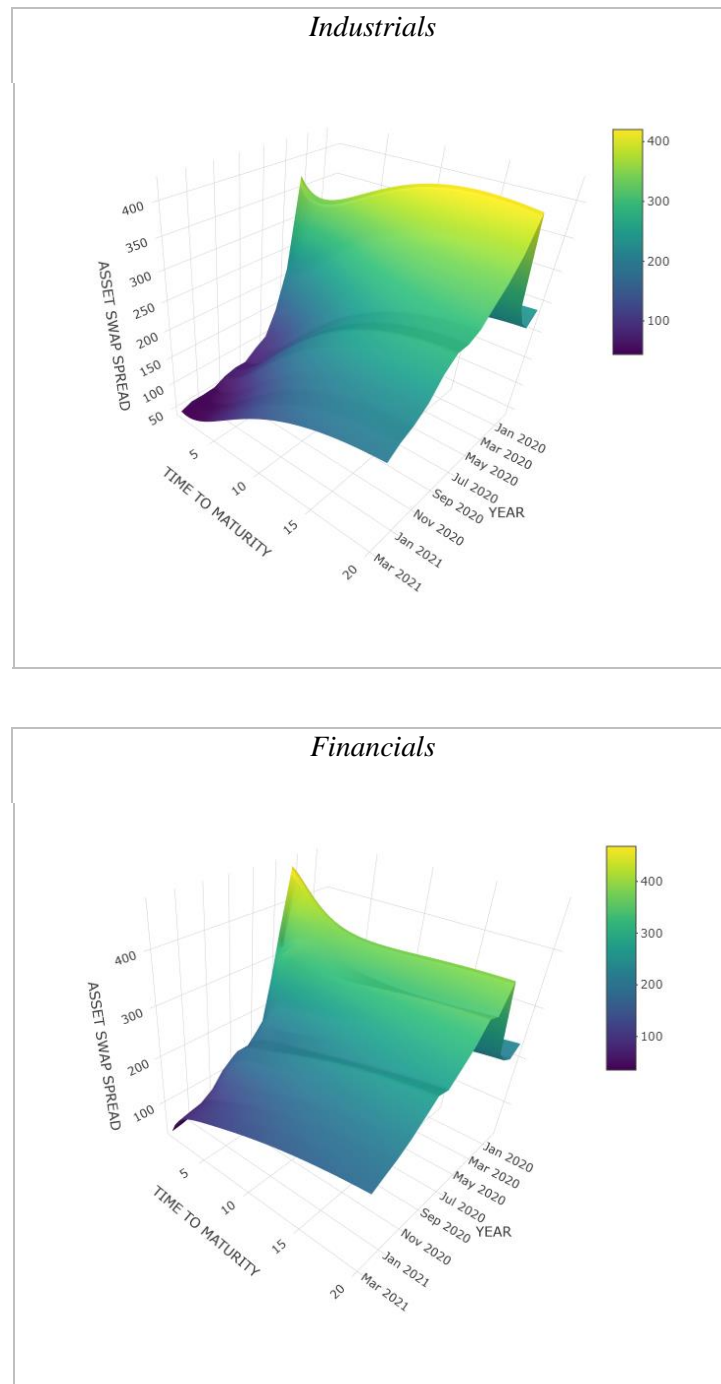


Figure 19: US-Dollar ASW-Curves for BBB Rated Bonds (January 2020 to March 2021)

On 28th March 2020, the Fed announced the secondary market corporate credit facility (SMCCF), which also provided for the purchase of corporate bonds from industrial companies and insurance companies with an investment grade rating and a maximum maturity of 5 years (Federal Reserve Bank of New York, 2020). The purchase programme started on 12th

May 2020. Initially, the curve still has a small hump at the short end of the maturity, but from May 2020 it also upward sloping. The curves of industrial companies are much steeper than those of financial companies as a result. In particular, the short end to 5 years has been trading very tightly since then (Gilchrist et al. 2020). In March 2021, the spreads of both industrial companies and financial institutions are back at the pre-crisis level and at around 200 bps at the long end of the term.

In summary, it can be said that the support measures of the central banks, in particular the purchase programmes of the Fed and the ECB, have led to a calming of the financial markets. Thus, the spreads on both the US-dollar and the euro investment grade rated industrial bonds have tightened significantly. This effect has also been demonstrated in other academic studies, such as Nozawa and Qiu (2021).

4.5 Single Issuer vs. Rating Class

In the following section, the function of ASW-curves as benchmark curves is evaluated based on three examples by comparing the spread of individual issuers with their corresponding industry (financial or non-financial) and rating class.

4.5.1. HSBC vs. Euro Financial Rating Class

Figure 20 compares the ASW-curve of euro denominated bonds of HSBC with the ASW-curve of euro denominated A rated financial bonds as of 31st July 2021.

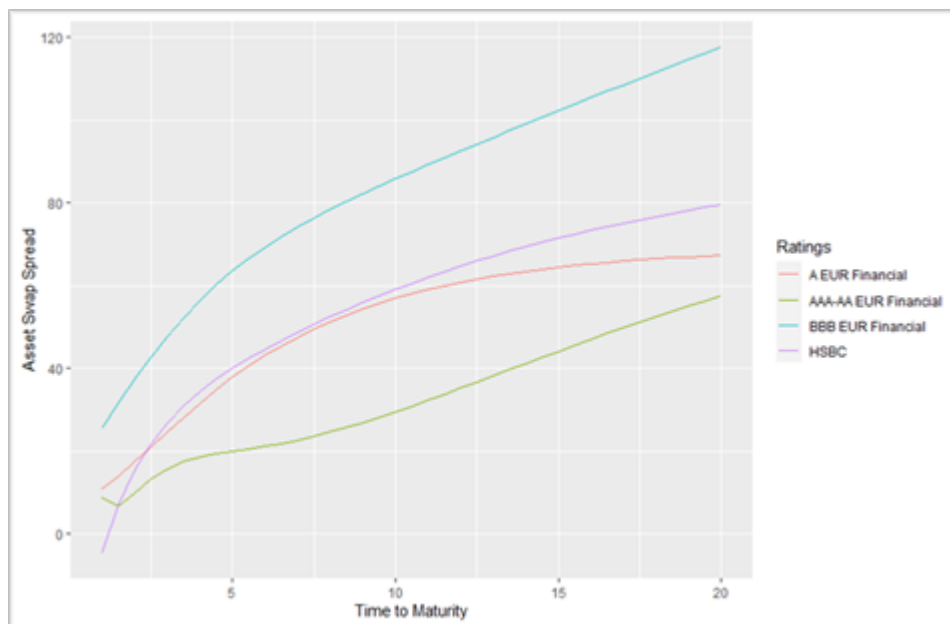


Figure 20: HSBC Euro ASW-Curve vs. Euro Financial Rating Class ASW-Curves

Note that HSBC's outstanding bonds included in the benchmark have two different structures (senior and senior non-preferred). Due to the different rank in the capital structure, the bonds have different ratings. HSBC's senior bonds have an A1 composite rating, while the senior non-preferred bonds have an A2 composite rating. As both structures are included in our sample, together they form HSBC's ASW-curve. The HSBC curve in the short and medium maturity is close to A rated financials. Only at the long end HSBC bonds have a higher spread, even though its rating is at the upper end of the rating class (average rating of the composite ratings A1 and A2). The widening at the long end could be due to idiosyncratic risks or lower liquidity.

4.5.2. Ford vs. Euro Industrial Rating Class

The second example shows Ford's ASW-curve compared to the BB rated euro denominated corporate bonds (see Figure 21)⁵. Ford has a composite rating of BB1 and belongs to the highest credit quality in the rating category.

The ASW-curve of the euro denominated Ford has lower spread compared to the entire peer rating curve for corporate bonds. Since Ford has a large number of bonds (45) denominated in euro and US-dollar outstanding, it can be assumed that the bonds are among the more liquid ones in the high-yield segment. As Ford bonds are on the upper band of the rating class and most likely more liquid, it is reasonable that the curve is below the benchmark.

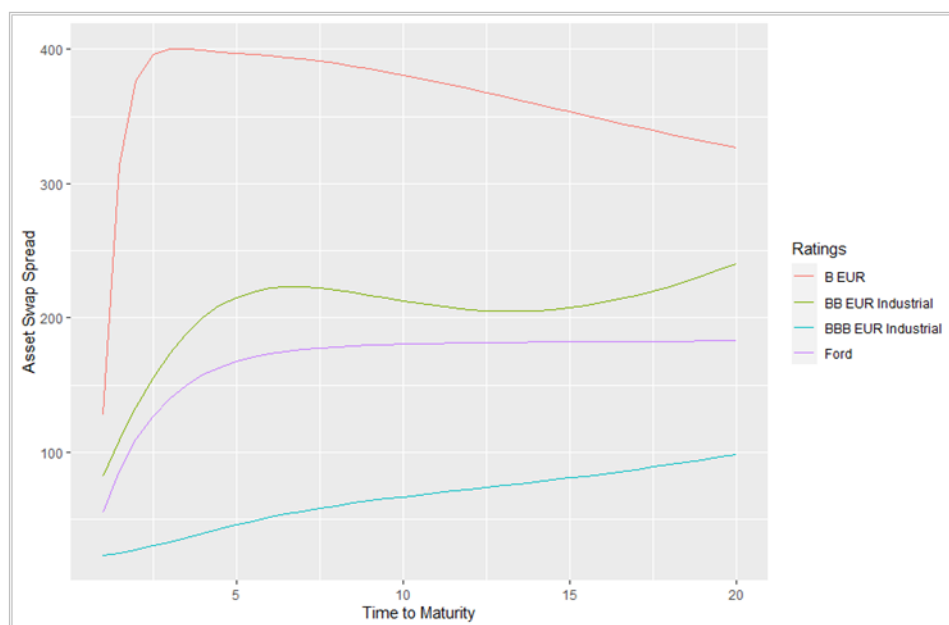


Figure 21: Ford Euro ASW-Curve vs. Euro Financial Rating Class ASW-Curves

⁵ The curve for B rated industrial bonds did not yield meaningful results due to the small sample size, so the curve for B rated financial and non-financial bonds was plotted for comparison.

4.5.3. AT&T vs. USD Industrial Rating Class

Finally, a comparison is drawn with the US-dollar market. Figure 22 shows the ASW-curve of AT&T vs. the ASW-curve of BBB rated US-dollar denominated corporate bonds. AT&T is one of the largest mobile phone companies in the United States and has a composite rating of BBB2 in the benchmark. AT&T's rating is therefore exactly in the middle of the BBB rating class. Figure 22 illustrates that AT&T's ASW-curve exactly matches the ASW-curve of the BBB rated industrial companies in the middle and the long end of the curve. Only at the short end of the spread curve AT&T offer less risk premium.

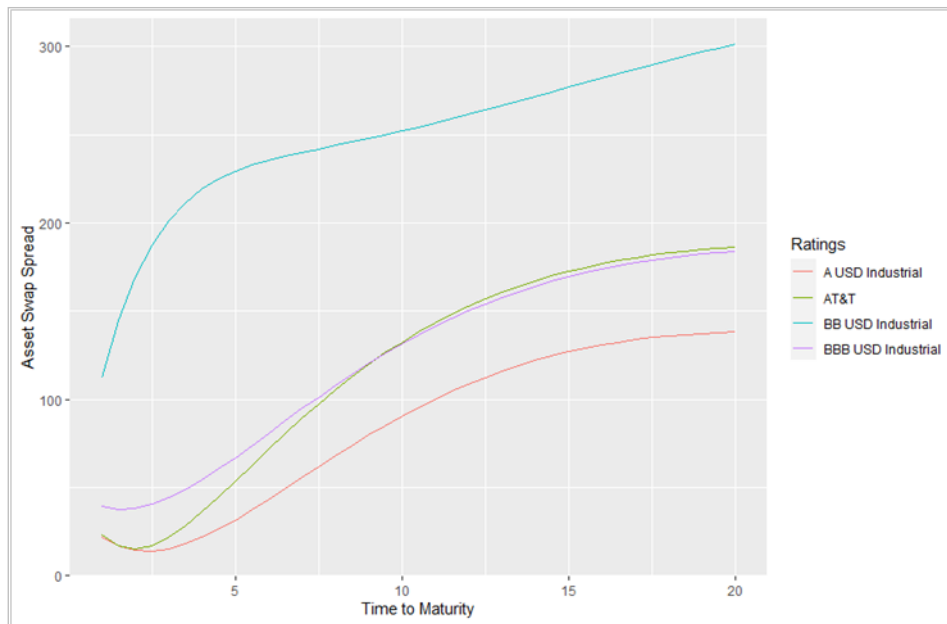


Figure 22: AT&T USD ASW-Curve vs. USD Industrial Rating Class ASW-Curves

Overall, it can be said that all three companies trade close to their benchmark curves of their rating class. The ASW-curves thus provide a good indication of the spread levels at which the corresponding companies should trade.

5. Conclusion

This chapter summarizes the results, identifies limitations, and discusses the findings of the analysis.

5.1 Summary

We found that investment grade ASW-curves since 2004 are upward sloping in a non-crisis environment. This is consistent with most of the previous academic literature (e.g., Jarrow et al. 1997, Duffie and Singleton, 1999, Trück et al. 2004).

During the four main crisis periods since 2004 the investment grade curve changed considerably. A humped-shaped curve was found for the AAA to A curves during most of the crisis periods. This is consistent with the findings of He et al. (2000). In the case of an A rating a closer look at the financial crisis reveals that only A-rated financial institutions inverted, while the spread curve of A rated industrial companies developed a hump. The ASW-curves of US-dollar denominated A rated companies, both industrial and financial, reacted very similar during the financial crisis. The spread curves of the financial companies showed an inverse spread curve for a short time in March 2008, so that no major differences between the euro and the US-dollar could be identified.

The BBB curves mostly had a normal, upward-sloping shape. He et al. (2000) and Amato and Remolona (2003) found humped-shaped curves for BBB rated companies, which again was only shown in times of crisis. In particular, spreads widened significantly during the financial crisis but also during the eurozone crisis. From 2016 onwards, a continuous spread tightening across the entire curve could be observed, which caused the curves to become flatter. This was due to the ECB's corporate bond purchase programme (CSPP) (Abidi and Miquel-Flores, 2018; Bonfim and Capela, 2020). This continuous spread tightening could be seen in the spread curves of AAA/AA and A rated companies. However, the spreads of financial companies that are not eligible for purchase showed a higher volatility. With the Corona crisis in March 2020 spreads widened again significantly. Yet, the reaction of spreads to the crises before the purchase programme was stronger, especially for industrial companies. Since then, spreads have continued to narrow and are already trading at pre-crisis levels (Nozawa and Qiu, 2021). For the spread curves of US-dollar denominated companies, there is hardly any difference between industrial and financial companies. However, a steepening of the spread curve of industrial companies could only be observed through the SMCCF corporate bond purchase programme initiated by the Fed in March 2020, in which the spreads at the short end to 5 years narrowed significantly (Gilchrist et al., 2020).

Looking at euro denominated high yield spread curves, all shapes of yield curves were observed. At the beginning of the observation period the spread curves were mostly humped-shaped (BB rating) or downward sloping (B rating). This is in line with the results of Sarig and Warga (1989), Fons (1994), Duffie and Singleton (1999), He et al. (2000), Amato and Remolona (2003) and Li et al. (2013). However, both BB and B rated companies reacted less strongly to the crisis periods than the investment grade sector. No spread tightening over the

term was observed in either rating class. For the most part, the spreads are trading at the same level, supporting the theory that for companies with poor credit quality idiosyncratic risks are more decisive for spread movements than the macroeconomic environment. However, due to the smaller number of bonds and significant swings these results are less robust.

A direct comparison of the rating classes showed that a better rating means a lower spread across the entire term structure. The results are in line with the findings of He et al. (2000) and Amato and Remolona (2003).

Comparing rating-based curves with individual company curves showed good fit for all selected examples. Therefore, we find evidence that rating-based curves might serve as a useful benchmark curve for single-name spread curves.

5.2 Limitations

The pricing of bonds in practice is not just determined by the credit quality but also the liquidity of the bond. Therefore, a spread consists of both components and the rating only covers one aspect. If the rating deteriorates, the bonds are generally also less liquid. On the other hand, credit quality is rather idiosyncratic, and a liquidity squeeze is more of a general effect. However, the correlation of these two factors seems to be substantial, so our approach is not able to distinguish these components.

Another important component is migration risk. Investors must be compensated for the volatility resulting from a deterioration in credit quality and a possible downgrade (Everling and Schmidt-Bürgel, 2005; Kiesel et al., 2003). In addition, other determinants of the credit spread have been identified in the literature. These include the currency of the bond, the interest rate level, and tax components (Elton et al., 2001; Kronos and Cremers, 2012; Schlecker, 2009). The spread can, therefore, not be understood as a pure risk measure for the creditworthiness of a company or a certain rating class but covers the entire risk that a corporate bond entails (Amato and Remolona, 2003).

5.3 Discussion

Modelling credit benchmark curves using Nelson/Siegel/Svensson approach provide evidence that a lower rating leads to higher credit spreads across the entire curve. The spread curves of the worst rating class (B rating) examined in this paper, showed by far the highest, the best rating class (AAA/AA rating) the lowest spread level at all points observed. As expected, all other rating-based spread curves are located in between. Investment grade spread curves have in non-crisis periods an upward slope, while those of high yield ratings are often either humped-shaped or sloping downwards. Our findings are in line with most empirical studies (e.g., Jarrow et al. 1997, Duffie and Singleton 1999, Trück et al. 2004, and Bedendo et al. 2007).

In times of crisis, when credit spreads widened drastically, the lower rating classes traded at a much higher spread level compared to the higher rating classes. At the same time, downward sloping or humped-shape curves occur in high rating classes. Overall, all movements and

shapes of term structures known in theory could be found. However, the volatility was clearly more intense in the lower rating classes.

We can confirm that a rating by the major agencies is a good spread indicator for corporate bonds. This supports using rating driven spread curves as benchmark. These are also helpful to determine fair credit spreads for new issuers.

Further research should refine rating-based benchmark curves to an industry sector level. Since sector-related market movements can often be observed, such curves could possibly provide an even better benchmark for individual issuers. However, the availability of bonds in certain rating classes could be problematic. The period considered in this working paper of over 20 years (January 2000 to July 2021) was unusually long in contrast to previous academic studies. A more in-depth study of the extent to which the determinants of the credit spread changed over this long period of time could provide new insights for the credit market.

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