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# German Mittelstand bonds: yield spreads and liquidity

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**Abstract** We estimate a cross-sectional model of the yield spreads of German Mittelstand bonds as a function of liquidity measures as well as a number of variables that control for both the characteristics of the issuing firm and the bond characteristics. Our results show a significant positive effect of illiquidity on the yield spread, which persists after controlling for the risk of the bond. Economically, the size of the liquidity premium of Mittelstand bonds is approximately twice the size of speculative grade US corporate bonds. Our findings are robust to different measures of liquidity and potential endogeneity biases.

**Keywords** German Mittelstand bonds · Liquidity · Yield spread · SME · Minibonds

**JEL Classification** G12 · G32

## 1 Introduction

The German Mittelstand is often hailed as the powerhouse of the German economy. It is characterized by being mostly medium-sized, family-owned, and family-run companies, which traditionally lend through relationship banking to cover their financing needs. However, with the phase-in of the Basel II regulations, financing via relationship banking has become more restrictive for many Mittelstand firms, as the new regulations enforce a mandatory rating for all issued loans (Schindele and Szczesny 2015). Launched in 2010, the possibility to issue Mittelstand bonds with

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volumes of less than 100 million Euro on the capital market is a remedy for the Mittelstand to close this financing gap. Yet, the observed yield spreads of Mittelstand bonds are high. Longstaff et al. (2005) argue that default risk is the key determinant for the yield spread of corporate bonds over government benchmarks. Notwithstanding, they also find that default risk cannot explain the entire variation of the spread. Indeed, market frictions such as liquidity costs also play an important role (Fisher 1959; Chen et al. 2007). The size of the liquidity premium, however, depends on the the credit rating of the issuing firm, i.e. less solvent firms show higher liquidity premia. Since the solvency of Mittelstand firms is often unclear, we empirically examine the size of the liquidity premium that is priced in the spread of Mittelstand bonds. We find that illiquidity is indeed significantly associated with the yield spread after controlling for default risk. Economically, the size of the liquidity premium of Mittelstand bonds is approximately twice the size of speculative grade US corporate bonds. Our results are robust to different measures of liquidity and a potential endogeneity bias.

Mittelstand bonds are a young financing vehicle enabling small and mid cap firms to directly tap capital markets. Since its launch in 2010 the market for Mittelstand bonds has developed rapidly. Five German stock exchanges[1] created segments for Mittelstand bonds and more than 120 bonds with a total volume exceeding 6 billion Euros have been issued in the period to July 2015. However, studies such as Kammler and Röder (2013) report a total loss of capital of 3.71 % on the Stuttgart Stock Exchange for Mittelstand bonds by the end of 2012. After the default of several Mittelstand bonds, two stock exchanges (Stuttgart and Dusseldorf) decided to close their segments for Mittelstand bonds. By contrast, the remaining stock exchanges successfully established their Mittelstand segments. For instance, the Frankfurt Stock Exchange reports four new bond emissions in the first half of 2015.

For the analysis of the relationship of bond-specific liquidity and the yield spread, we use two different liquidity estimates, namely the bid–ask spread and the LOT liquidity estimate based on Lesmond et al. (1999). While the bid–ask spread is a canonical measure of liquidity (see e.g. Brandt and Kavajecz 2004; Fleming 2003), data to calculate that spread is not available for all bonds. Therefore, we use the LOT liquidity estimate as an alternative measure of liquidity. The LOT liquidity estimate reflects the round-trip liquidity costs based on the frequency of zero returns. To analyze the yield spread determinants, we apply fixed effects panel regressions with clustered standard errors and regress the yield spread on the liquidity estimates and bond-specific, firm-specific, and macroeconomic variables. To control for potential endogeneity of the liquidity measures and the credit rating, we apply a simultaneous equation model performing a three-stage least squares estimation technique.

Analyzing a comprehensive sample of 92 Mittelstand bonds, we find that investors demand a higher liquidity premium for more illiquid Mittelstand bonds. Both liquidity measures are significantly positively related to the yield spread in our

[1] Namely Stuttgart (bondm), Frankfurt (Entry Standard), Dusseldorf (Der Mittelstandsmarkt), Munich (m:access) and Hannover/Hamburg (Mittelstandsboerse).

regressions. A 1 % increase in the bid–ask spread leads to an incremental increase in the yield spread in the range of 3.19–6.41 %. The predicted increase of the yield spread is slightly smaller for a similar increase in the LOT liquidity estimate. Since the within $R^2$ ranges between 58 and 82 %, our models provide high explanatory power for the variation of the yield spread of Mittelstand bonds. Therefore, we confirm that default risk accounts for only part of the variation of the yield spread. Bond liquidity is another key determinant of the spread, which is especially pronounced for Mittelstand bonds.

Our paper has important implications for financial managers of Mittelstand firms. While the observed high yield spreads are commonly perceived as a proxy for default risk, which is exogenous for the firms, we highlight that a significant part of the yield spread indeed originates from illiquidity. Illiquidity, in turn, results as a consequence of trading costs, search problems, private information, and inventory risk of market makers (Bagehot 1971; Amihud and Mendelson 1980) and is therefore, at least partly, endogenous for firms. Thus, by reducing the sources of illiquidity, Mittelstand firms can decrease the yield spreads of their issued bonds and thus reduce their effective cost of capital.

The remainder of this paper is organized as follows. Section 2 outlines the theory of this paper and Sect. 3 explains the institutional setting of the Mittelstand bond market, our data, and our methodological framework. We present and discuss our results in Sect. 4. Section 5 concludes.

## 2 Background

Due to their opportunity costs, investors expect to be compensated for lending money. On the one hand, they expect to earn the risk-free interest rate as compensation for the time value of money. Moreover, for risk-bearing investments, investors expect to earn an additional return—the risk premium—as compensation for the risk of their investment. The *yield spread* of a corporate bond is the difference between the bond's yield to maturity and the yield to maturity of a benchmark government bond that has exactly the same maturity and currency. Since such a benchmark government bond rarely exists, the benchmark yield is typically interpolated using a benchmark government bond with a lower maturity and a benchmark government bond with a higher maturity. As government bonds are considered to be risk-free, the yield spread measures the risk premium for the investment in a corporate bond.

While default risk, i.e. the risk that the principal of the bond is not repaid in full at maturity, certainly is a crucial determinant of the yield spreads, default risk cannot explain the full variation of corporate bond yield spreads. For instance, Fisher (1959) analyzes the determinants of corporate bond yield spreads for the years 1927, 1932, 1937, 1949, and 1953. He finds that yield spreads are positively influenced by default risk and negatively influenced by marketability—a synonym for liquidity. More recently, Chen et al. (2007) confirm the existence of a liquidity premium using a comprehensive sample of US corporate bonds over the period from 1995 to

2003 and find that the liquidity premium is higher for speculative grade bonds compared to investment grade bonds.

Generally, the term *liquidity* describes the ease of trading a security (Amihud et al. 2005). In frictionless markets, every security can be traded at no cost all of the time. Therefore, in standard asset pricing theories which are based on the assumption of frictionless markets (e.g. Cochrane 2001; Duffie 1996), liquidity does not affect asset prices. However, real markets are far from being frictionless. In particular, there are four market imperfections that induce illiquidity to the markets:[2] exogenous trading costs, search problems, adverse selection due to private information, and inventory risk for market makers. Trading costs and search problems directly adversely influence liquidity by reducing the number of noise traders on the markets. Private information induces the existence of informed and uninformed traders. Since market makers generally lose from trades with informed traders, they need to charge a certain bid–ask spread to gain from trades with uninformed (noise) traders (Bagehot 1971). Finally, since not all traders are present at all times, market makers need to build up an inventory in order to provide immediate trading to any trader. Such an inventory inhibits a price risk which the market makers have to hold and wish to be compensated for by higher bid–ask spreads (Amihud and Mendelson 1980; Ho and Stoll 1981).

Given this theoretical framework, we hypothesize that liquidity influences the yield spreads of Mittelstand bonds, too. Due to the relatively small size of Mittelstand firms, we expect a relatively large liquidity premium as private information is adversely related to firm size (Diamond and Verrecchia 1991; Vega 2006). To gain evidence on this hypothesis, we continue our paper with an empirical study of a comprehensive sample of Mittelstand bonds that disentangles the influences of default risk and liquidity on the yield spreads.

## 3 Data and methodology

In this chapter, we commence with a brief overview on the development of the Mittelstand bond market and describe our sample of Mittelstand bonds. Afterward, we introduce the two liquidity measures employed in our study in detail.

### 3.1 German Mittelstand bonds

The application of the Basel II rules on all banks in the European Union in January 2007 introduced a mandatory rating for each firm applying for a loan. As a result, the interest rates offered to low-rated firms have increased significantly because of higher equity requirements for such loans (Müller et al. 2011; Schindele and Szczesny 2015). Mittelstand firms are affected in particular by these adverse conditions due to their relatively low equity ratios compared to large firms (Feiler and Kirstein 2014). The Basel III accords continue to pursue the aim of the Basel II capital requirements to increase the resilience of banks during crises. The

[2] We refer to Amihud et al. (2005) for a detailed overview of the sources of illiquidity.

relationship bank system, which was an essential backbone for German Mittelstand firms, is facing serious difficulties in offering reasonable loan conditions for poorly or non-rated Mittelstand firms. Therefore, the Mittelstand needs an alternative source of financing. Since Mittelstand firms are often family-run, they are reluctant to tap equity markets in order to not dilute their ownership and control rights.

Common stock exchanges, so far, allowed only bond emissions with a volume of at least 100 million Euros, which exceeds the required amount of capital for small or mid cap firms in general. As long as the relationship bank system runs properly, small and mid cap firms can avoid costly public bond issues. However, in the light of the new requirements stemming from the developments according to bank regulations, small and mid cap firms have to reconsider this method of financing. Instead of solely relying on relationship bank loans, they need to tap other sources of debt financing to be able to invest and successfully compete in an international market environment.

Recognizing this funding gap, the Stuttgart Stock Exchange was the first German stock exchange to create bondm, a segment that enables small and mid cap firms to access the public capital market in 2010. Four other German stock exchanges—namely Frankfurt (Entry Standard), Dusseldorf (Der Mittelstandsmarkt), Munich (m:access), and Hannover/Hamburg (Mittelstandsboerse)—followed suit. Yet, the requirements for bond emissions vary considerably between the exchanges. While in Stuttgart, Dusseldorf, and Munich a minimum volume of 25 million Euros or 10 million Euros respectively is obligatory, Hannover/Hamburg and Frankfurt accept any size of emission. Furthermore, a strict rating obligation only exists in Dusseldorf and Munich. The Frankfurt and Stuttgart exchanges accept emissions without ratings for listed companies while the Hannover/Hamburg exchange generally waives the rating obligation. Despite this heterogeneous institutional setting, Mittelstand bonds usually have certain common characteristics. Most bond have an issue volume of 15–150 million Euros, a maturity of 5 years, and a fixed coupon.

In our paper we define Mittelstand bonds as corporate bonds that are or were traded in the respective segments on any one of the five stock exchanges. We hand-collect the International Securities Identification Numbers (ISINs) of the Mittelstand bonds from the homepages of the five stock exchanges to form our data set. In sum, we derive a data set of 120 bonds in the period from November 24, 2010, to July 15, 2015, with a total issue volume of more than 6 billion Euros. Since the introduction of Mittelstand bonds, several issuers have declared insolvency. Analyzing the bondm segment up to December 2012, Kammler and Röder (2013) find a total loss of capital of 3.71 % and a negative internal rate of return of −3.04 % for investments into Mittelstand bonds. Schöning (2014) also uses bondm data to calculate the risk-adjusted interest rate for Mittelstand bonds. He finds that the coupons of many bonds are well below the risk-adjusted value. In the light of this development, the stock exchanges of Stuttgart and Dusseldorf decided to shut down their segments for Mittelstand bonds. By contrast, Frankfurt's Entry Standard continues to be successful. In the first half of 2015 four new bonds with a total volume of 220 million Euros were issued.

### 3.2 Yield spreads and corporate information

We use the ISINs of our sample of 120 Mittelstand bonds to match bond and firm-characteristic data from four different sources. Daily data on the clean price and the yield spread are obtained from Thomson Reuters Datastream. For our regression analysis we use the yearly average of the daily yield spreads. Bond-specific and macroeconomic factors are crucial for explaining the yield spread and the bond liquidity (Elton et al. 2001; Chakravarty and Sarkar 1999; Campbell and Taksler 2003). Therefore, we also download the time to maturity, the age of the bond, the 1-year yield on German Bunds, and the term slope (difference in yields of 10-year and 2-year German Bunds) from Datastream. Additionally, we estimate the bond volatility by calculating the yearly standard deviation of the clean prices.

Default risk is another important bond characteristic (Longstaff et al. 2005). However, Mittelstand bonds are usually not rated by any of the three leading rating agencies but by smaller German agencies instead. Hence, we collect the credit ratings from rating reports when they are accessible on http://anleihen-finder.de, a website that provides data for most Mittelstand bonds. When available, we use the bond rating, otherwise the credit rating of the issuing firm. From the credit ratings, we construct the variable *Rating Scale* which codes a numeric value to each rating class ranging from 1 for A (the best rating in our sample) to 15 for D (default). Furthermore, we double check the ratings of bonds with a clean price below 80 % at any point during our sample period. We find that the issuers of 24 bonds in our sample have bankrupted throughout the observation period. We use the day they declared insolvency to manually change the respective ratings to D.

However, as there is no general rating obligation on all five stock exchanges, not all firms and bonds are rated. Since credit ratings are mostly derived from financial ratios, accounting data can provide similar insights into the default risk and the solvency of a firm. In particular, we consider interest coverage, operating income to sales, long-term debt to assets, and debt to capital as firm-specific control variables (Campbell and Taksler 2003). We define interest coverage as EBIT plus interest divided by interest. Accounting data to calculate these performance measures is obtained from Bureau van Dijk's Dafne, a database with financial information for more than one million German companies. In the case that Dafne data was not available (i.e. for non-German companies) we use Bureau van Dijk's Amadeus (via WRDS) as a second database for financial information. To avoid a potential forward-looking bias, we lag these ratios by 1 year for our further analysis.

Furthermore, we exclude all bonds that defaulted during our sample period for our regression analysis to avoid a potential bias due to the non-linear increase in the yield spread of firms that are close to default. We also exclude one bond with obviously incorrect clean prices in Datastream. We finally disregard bonds for which no yield spread is available on Datastream and callable bonds after the announcement of the exercise of the call since the clean price usually equals the call price after the announcement. In sum, our final sample comprises 92 German Mittelstand bonds. We list all bonds of our final sample and the main bond characteristics in Table 8 in Appendix 1.

### 3.3 Bid–ask spread

As it describes the round-trip transaction costs for an immediate transaction, the bid–ask spread is a canonical and commonly used measure of liquidity. We obtain data on daily composite bid and ask prices from Datastream. These composite prices are calculated as the average of all available contributors' quotes. The (relative) bid–ask spread is the difference between the ask and bid prices divided by the average of both prices. Yet, data to calculate this spread is not always available. In particular in the beginning of our observation period, data on bid and ask quotes is rare, since the coverage of ask prices in Datastream starts for most bonds only in October 2013. For each bond, we estimate the average yearly bid–ask spread by calculating the mean of all daily spreads, if at least one bid–ask spread is available in the respective bond-year.

### 3.4 LOT liquidity estimate

Our second measure of liquidity is based on the limited dependent variable model of Tobin (1958) and Rosett (1959). Lesmond et al. (1999) use this model to estimate transaction costs based on the frequency of zero returns of equity. We refer to this measure as the LOT liquidity estimate and calculate it in the version of Chen et al. (2007) for corporate bonds. In contrast to bid–ask spreads that are only available for a limited number of firms due to poor data availability, the LOT liquidity estimate requires only the time series of daily returns to endogenously estimate liquidity in terms of transaction costs on a firm level. In a nutshell, the LOT liquidity estimate models illiquidity through the incidence of zero returns. In the presence of transaction costs, not all information will be immediately priced. Only if the value of the information exceeds the costs of trading, will a marginal investor trade on it. On the other hand, if the value of the information is below the costs of trading, a marginal investor will refrain from trading, causing a zero return. The LOT liquidity estimate is defined as the difference between the buy-side and sell-side transaction costs for a marginal investor. It is estimated by modeling the return generating process of a bond and comparing the thereby computed 'true' returns with observed bond returns. In particular, it estimates the buy-side and sell-side transaction costs by observing the thresholds of the 'true' returns that lead to a trade, i.e. a non-zero observed return.

Liquidity costs cause assets to have lower prices in order to compensate investors for illiquidity (Amihud and Mendelson 1986). In the case of bonds, the difference between the observed value on the market and the intrinsic 'true' value is the liquidity premium (Amihud and Mendelson 1986, 1987). Figure 1 illustrates the liquidity effects on bond returns. The bold line represents the case of perfect information. In this instance, a marginal trader will only buy (sell) a bond $j$ at time $t$ if she receives information about the bond that has a higher value than the buy-side costs $\alpha_{2,j}$ (sell-side costs $\alpha_{1,j}$). Therefore, the observed return $R_{j,t}$ is zero when the value of the new information, i.e. the 'true' return $R^*_{j,t}$, is between $\alpha_{1,j}$ and $\alpha_{2,j}$. Only if the 'true' return $R^*_{j,t}$ exceeds the buy-side costs $\alpha_{2,j}$ (sell-side costs $\alpha_{1,j}$), does a

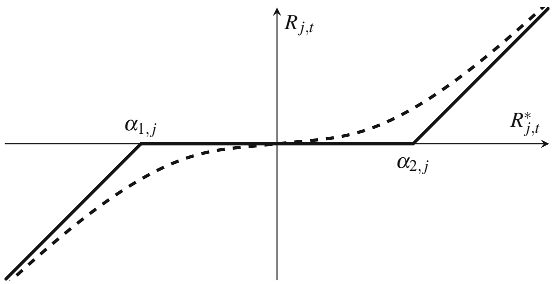


**Fig. 1** LOT liquidity estimate model. This graph details the relationship between the 'true' return $R^*_{j,t}$ (on the $x$-axis) and the measured return $R_{j,t}$ (on the $y$-axis). The *bold solid line* depicts the case of perfect information, the *dashed line* depicts the measured *expected* return that the investors would price given uncertainty about the true return

marginal trader start trading and we observe a return $R_{j,t}$, which is the 'true' return $R^*_{j,t}$ reduced by the buy-side costs $\alpha_{2,j}$ (sell-side costs $\alpha_{1,j}$). Therefore, in the case of perfect information, we have the following relationship of $R_{j,t}$ and $R^*_{j,t}$:

$$\begin{aligned} R_{j,t} &= R^*_{j,t} - \alpha_{1,j} \quad \text{if } R^*_{j,t} < \alpha_{1,j} \quad \text{and} \quad \alpha_{1,j} < 0 \\ R_{j,t} &= 0 \quad \text{if } \alpha_{1,j} \leq R^*_{j,t} \leq \alpha_{2,j} \\ R_{j,t} &= R^*_{j,t} - \alpha_{2,j} \quad \text{if } R^*_{j,t} > \alpha_{2,j} \quad \text{and} \quad \alpha_{2,j} > 0. \end{aligned} \tag{1}$$

To compute the liquidity cost threshold for each bond, we need a model for the 'true' return $R^*_{j,t}$. Following the methodology of Chen et al. (2007), we use a two-factor model to estimate the 'true' return of corporate bonds. The first factor is the long-term interest rate and the second factor the equity market return. This model accounts for the fact that corporate bonds are essentially a hybrid between a risk-free bond and equity. In order to obtain stable estimation coefficients, the risk coefficients are scaled by the duration $D$ of the respective bond (see Jarrow 1978). In particular, our two-factor model for the 'true' returns is

$$R^*_{j,t} = \beta_{j,1} D_{j,t} \cdot \Delta R_{f,t} + \beta_{j,2} D_{j,t} \cdot \Delta \text{DAX}_t + \epsilon_{j,t}, \tag{2}$$

where $\Delta R_{f,t}$ is the daily change in the 10-year German Bunds rate and $\Delta \text{DAX}_t$ is the daily return on the DAX 30 composite stock index.

Since the error term $\epsilon_{j,t}$ in model (2) introduces uncertainty about the 'true' return, the expected return that investors price given the uncertainty about the 'true' return slightly differs from Eq. (1). Rosett (1959) models the locus of this curve. The dashed line in Fig. 1 illustrates the relationship of the measured return and the measured expected return in the case of uncertainty.

With $\sigma_j$ being the (unknown) standard deviation of the error term $\epsilon_{j,t}$, we estimate the liquidity cost thresholds $\alpha_{1,j}$ and $\alpha_{2,j}$ of each bond $j$ in year $t$ by maximizing the logarithm of the likelihood function $L(\alpha_{1,j}, \alpha_{2,j}, \beta_{j,1}, \beta_{j,2}, \sigma_j \mid R_{j,t}, \Delta \text{DAX}_t)$

$$
\begin{aligned}
\max_{\alpha_{1,j},\alpha_{2,j},\beta_{j,1},\beta_{j,2},\sigma_j} \ln L = & \sum_{t\in\mathscr{R}_1} \ln \frac{1}{\sqrt{2\pi\sigma_j^2}} \\
& - \sum_{t\in\mathscr{R}_1} \frac{1}{2\sigma_j^2}\left(R_{j,t} + \alpha_{1,j} - \beta_{j,1} D_{j,t}\cdot\Delta R_{f,t} - \beta_{2,t} D_{j,t}\cdot\Delta \mathrm{DAX_t}\right)^2 \\
& + \sum_{t\in\mathscr{R}_2} \ln \frac{1}{\sqrt{2\pi\sigma_j^2}} \\
& - \sum_{t\in\mathscr{R}_2} \frac{1}{2\sigma_j^2}\left(R_{j,t} + \alpha_{2,j} - \beta_{j,1} D_{j,t}\cdot\Delta R_{f,t} - \beta_{2,t} D_{j,t}\cdot\Delta \mathrm{DAX_t}\right)^2 \\
& + \sum_{t\in\mathscr{R}_0} \ln(\Phi_{2,j} - \Phi_{1,j}),
\end{aligned}
$$

where $\mathscr{R}_1$ denotes the set of days with negative measured returns $R_{j,t}$, $\mathscr{R}_2$ denotes the set of days with positive measured returns $R_{j,t}$, and $\mathscr{R}_0$ denotes the set of days with zero returns. The term $\Phi_{i,j}$ represents the cumulative distribution function of the standard normal distribution for each bond-year evaluated at $(\alpha_{i,j} - \beta_{j,1} D_{j,t}\cdot\Delta R_{f,t} - \beta_{j,2} D_{j,t}\cdot\Delta\mathrm{DAX_t})/\sigma_\mathrm{j}$. For purposes of liquidity estimation, the critical parameters of the limited dependent variable model are in the intercept terms, $\alpha_{1,j}$ and $\alpha_{2,j}$. We define the LOT liquidity estimate for bond $j$

$$\mathrm{LOT}_j = \alpha_{2,j} - \alpha_{1,j}$$

by the difference of the buy-side and the sell-side cost estimates per year.

Daily clean prices, duration, DAX index, and Bunds returns are obtained from Datastream. Table 1 reports upon the number of bonds, the average sell-side and buy-side cost estimates, the average LOT liquidity measure, and the average $t$-statistics testing for zero LOT per year. The LOT liquidity estimates are significantly different from zero in all years. The Spearman correlation of the LOT liquidity measure and the bid–ask spreads is 65.7 % over all bond-year observations.

Notice that the LOT liquidity measure accounts for additional information from the return generating process besides zero returns, such as commission costs, opportunity costs, and price impact costs. Potential limitations of the LOT model

**Table 1** This table reports upon the number of bonds, average costs of sell trades ($\alpha_{1j}$), buy trades ($\alpha_{2j}$), LOT liquidity estimate ($\alpha_{2j} - \alpha_{1j}$), and the $t$-statistics testing for zero LOT separated by year

| Year | # Obs | $\hat{\alpha}_1$ (%) | $\hat{\alpha}_2$ (%) | LOT (%) | $t$(LOT) |
|---|---|---|---|---|---|
| 2010 | 3 | −0.093335 | 0.178805 | 0.272140 | 1.977116 |
| 2011 | 25 | −0.338217 | 0.528104 | 0.866321 | 2.441339 |
| 2012 | 51 | −0.113481 | 0.221435 | 0.334916 | 3.315454 |
| 2013 | 78 | −0.273492 | 0.400965 | 0.674457 | 5.948445 |
| 2014 | 88 | −0.712876 | 0.749138 | 1.462014 | 5.244218 |
| 2015 | 88 | −0.859537 | 0.796175 | 1.655712 | 5.384455 |

occur in the case of no or too many zero returns (more than 85 %) within one year. In our sample the average yearly percentage of zero returns of the cross-section of all bonds is 18.7 %. Furthermore, our data contains at least one zero return observation in each bond-year.

## 4 Results

Before performing our main regression analysis on the yield spread determinants of Mittelstand bonds, we commence this chapter presenting summary statistics of our sample and several tests regarding the consistency of our two liquidity measures. Table 9 in Appendix 2 presents a summary of all variables, their detailed meanings, and their respective data sources.

### 4.1 Summary statistics

Table 2 reports upon summary statistics for the time-invariant bond characteristics and accounting data of the issuing firms of the Mittelstand bonds in our sample. The average issue volume equals 46 million Euros and is small compared to common corporate bonds. Furthermore, the bonds pay relatively high interest with an average coupon of 7.23 %. However, the size of the coupons varies noticeably and ranges from 2.00 % (*DF Deutsche Forfait AG*) to 11.5 % (*Air Berlin AG*). In terms of maturity the bonds do not show much variation. A mean maturity of 5.21 years and a standard deviation of 0.08 years suggest that the bonds are relatively homogenous in this property. Additionally, issuing firms' accounting data at the emission date of the bonds is presented. With −20.6 million Euros in 2011, *Air Berlin AG* has the lowest EBIT in our sample. By contrast, *Porr AG* is highly profitable with an EBIT of more than 88 million Euros. Taking sales and total assets into account, the figures indicate that the firms in our sample differ considerably in size and in profitability. The same pattern can be observed with respect to leverage. While some firms have a very low debt to assets ratio (*Peach Property*: 0.01), other companies are deeply indebted (*FC Schalke 04*: 1.33). Yet, in the case of *FC Schalke 04* the extremely high leverage mostly results from discretionary accounting policies such as the non-capitalization of the fair value of the squad.

Further summary statistics on time-variant measures grouped by year are presented in Table 3. The average yield spread and both liquidity measures—the bid–ask spread and the LOT liquidity estimate—tend to increase over the sample period. The average bid–ask spread is particularly high in 2011 (9.24 %). However, data to calculate the spread is scarce at the beginning of the sample period and thus there is only one firm with valid bid–ask spread data available in 2010 and 2011. Along with the yield spread and the liquidity measures the rating scale increases over time. This is a first indication that higher liquidity costs are reflected in higher yield spreads.

**Table 2** This table reports upon descriptive statistics of the Mittelstand bonds in the year of the emission of the bonds

| | # Obs | Mean | SD | Skewness | Kurtosis | min | q25 | Median | q75 | max |
|---|---|---|---|---|---|---|---|---|---|---|
| Volume (in millions) | 92 | 46.21 | 46.96 | 2.528 | 9.072 | 3.46 | 20.00 | 30.00 | 50.00 | 225.00 |
| Coupon (%) | 92 | 7.27 | 1.05 | −1.685 | 10.087 | 2.00 | 6.75 | 7.25 | 8.00 | 11.50 |
| Maturity (years) | 92 | 5.21 | 0.08 | 2.791 | 13.987 | 3.00 | 5.00 | 5.00 | 5.00 | 10.00 |
| EBIT (in millions) | 67 | 1.26 | 41.19 | −3.293 | 18.200 | −206.33 | −1.00 | 2.89 | 10.29 | 88.03 |
| Total assets (in millions) | 72 | 307.99 | 538.02 | 2.594 | 8.531 | 0.37 | 43.13 | 106.13 | 259.35 | 2296.47 |
| Sales (in millions) | 61 | 259.98 | 689.29 | 5.158 | 30.950 | 1.53 | 31.51 | 79.04 | 174.97 | 4663.80 |
| Debt to assets | 64 | 0.47 | 0.22 | 0.735 | 5.934 | 0.01 | 0.36 | 0.47 | 0.57 | 1.33 |

We report the number of observations (# Obs), the mean value of all bonds, the standard deviation (SD), skewness, kurtosis, minimum value (min), first quartile (q25), median value, third quartile (q75), and maximum value (max)

**Table 3** This table reports upon summary statistics of the Mittelstand bonds separated by year

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|
| Yield spread (bp) | | | | | | |
| Mean | 474.519 | 621.519 | 674.059 | 687.959 | 996.540 | 1236.411 |
| # Obs | 3 | 24 | 50 | 76 | 86 | 86 |
| Bid–ask spread (%) | | | | | | |
| Mean | 0.300 | 9.236 | 3.134 | 1.312 | 1.968 | 2.367 |
| # Obs | 1 | 1 | 5 | 67 | 85 | 85 |
| LOT (%) | | | | | | |
| Mean | 0.272 | 0.895 | 0.340 | 0.674 | 1.462 | 1.656 |
| # Obs | 3 | 24 | 50 | 78 | 88 | 88 |
| Rating Scale | | | | | | |
| Mean | | 5.154 | 5.493 | 6.092 | 6.572 | 6.723 |
| # Obs | 0 | 13 | 39 | 61 | 70 | 71 |

Yield spread refers to the difference of a bond yield and an equivalent government benchmark. Bid–ask spread is a proportional spread as described in Sect. 3.3. LOT equals the liquidity estimate as described in Sect. 3.4. Rating scale assigns a numeric value to each rating class starting with 1 for A up to 15 for D. Yield spreads are denoted in basis points, # *Obs* denotes the number of observations

## 4.2 Bid–ask spread tests

The correlation of 65.7 % between the bid–ask spread and the LOT liquidity estimate indicates a relatively strong dependence between our two measures of liquidity. To confirm the consistency of these liquidity estimates we perform further tests. We regress the bid–ask spread on the LOT liquidity estimate and control variables.

Analyzing stock data from 1997 and 1998, Stoll (2000) finds expanding bid–ask spreads with increasing volatility of stock returns. Furthermore, Brandt and Kavajecz (2004) emphasize the importance of bond volatility in explaining liquidity costs in the US Treasury market. Thus, we include bond volatility as a control variable. Chakravarty and Sarkar (1999) use further bond characteristics to identify determinants of the bid–ask spreads of corporate, municipal, and government bonds. They argue that the age of the bond and credit risk are positively related to the spread. Sarig and Warga (1989) argue that bonds become less liquid with time and therefore use the age of the bond as a measure of liquidity. Their results support the hypothesis of a positive relationship between the age of the bond and the yield spread. Hence, we also include the age of the bond as bond-specific control and use the variable *Rating Scale* to capture the effect of credit risk.

We analyze the bid–ask spread by a fixed effects panel regression as follows:

$$\begin{aligned} Bid-Ask\,Spread_{i,t} = \; & \eta_0 + \eta_1 LOT_{i,t} + \eta_2 Bond\,Volatility_{i,t} \\ & + \eta_3 Age_{i,t} + \eta_4 Rating\,Scale_{i,t} + \epsilon_t, \end{aligned}$$

where the subscript $i,t$ denotes bond $i$ in year $t$. We first regress the bid–ask spread on the LOT liquidity estimate only and second on the LOT liquidity estimate

**Table 4** This table reports upon liquidity measure tests

| | Bid–ask spread | | Yield spread | |
|---|---|---|---|---|
| | (L) | (L) | (B) | (L) |
| Bid–ask spread | | | 269.24** | |
| | | | (2.45) | |
| LOT | 0.56*** | 0.51** | | 197.53*** |
| | (3.23) | (2.06) | | (3.07) |
| Bond volatility | | 0.09*** | | |
| | | (3.38) | | |
| Age of the bond | | 0.22** | | |
| | | (2.03) | | |
| Rating Scale | | 0.14 | | |
| | | (0.93) | | |
| Constant | 1.38*** | 0.93 | 444.90** | 686.13*** |
| | (7.49) | (0.97) | (2.04) | (9.60) |
| # Obs | 244 | 192 | 239 | 325 |
| *F*-statistic | 10.42 | 6.65 | 5.98 | 9.45 |
| Within $R^2$ | 0.55 | 0.68 | 0.55 | 0.43 |

The dependent variable is the bid–ask spread in the first and the second model and the yield spread in the third and the fourth model. We apply fixed effects panel regressions and cluster the standard errors at bond level. (B) indicates that we use the bid–ask spread and (L) the LOT liquidity estimate as explanatory liquidity measure. The absolute value of *t*-statistics are shown in parenthesis

** and *** Significance at a 5 and 1 % level, respectively

including the control variables. The results are reported in the first two columns of Table 4.

The first model suggests a highly significant positive relationship between both liquidity measures. According to the within $R^2$ the LOT liquidity estimate explains 55 % of the variation of the bid–ask spread. This result is robust to adding control variables in the next model. In line with the above literature, higher bond volatility and higher age of the bond is associated with higher bid–ask spreads. However, the rating is insignificant in our sample.

### 4.3 Yield spread determinants of Mittelstand bonds

Having confirmed the consistency of our liquidity measures, we now move on with our main analysis—the examination of whether illiquidity in fact explains part of the yield spread variation in our sample.

To gain more preliminary insight into the relationship of the yield spread and our liquidity measures, we directly regress the yield spread on the bid–ask spread and the LOT liquidity estimate, respectively. The results are reported in the last two columns of Table 4. The coefficients of both liquidity estimates are positive and significant at a 1 % level. The regressions including the bid–ask spread and the LOT liquidity estimate show a within $R^2$ of 55 and 43 %, respectively, and thus, a high explanatory power regarding the variation of the yield spreads. This suggests that higher liquidity costs are indeed associated with higher yield spreads.

However, these preliminary findings neglect that there are other determinants for the yield spread that might affect the outcome of the regressions. In order to add rigor to our results, we include an array of bond-specific, firm-specific, and macroeconomic control variables that are other well-documented determinants of yield spreads.

Default risk is the most prominent determinant of the yield spread. Longstaff et al. (2005) analyze a comprehensive data set on credit default swaps and corresponding bond price data and point out that default risk accounts for the majority of the yield spread. Depending on the credit rating, between 51 and 83 % of the yield spread can be explained by default risk. Hence, we add the variable *Rating Scale* to capture this effect in our regression. Yet, approximately 23 % of our bonds are not rated. Therefore, we include accounting ratios to measure the effect of the default risk for these bonds, too. Campbell and Taksler (2003) argue that while high values of the interest coverage and the income to sales ratio suggest healthy companies, the opposite is true for the two other accounting ratios. Long-term debt to assets and debt to capital describe the leverage of a company. Since highly leveraged firms are more likely to default, we expect the former two accounting variables to be negatively and the latter two to be positively related to the yield spread. Complete accounting ratios are available for only 57 % of our observations, however. Nevertheless, we can increase our sample, as there are 44 bond-years without rating but with accounting data.

Campbell and Taksler (2003) document a positive relationship between the time to maturity and the yield spread for investment grade bonds. Chen et al. (2007) confirm this effect for investment grade bonds. Yet they find the opposite effect for speculative grade bonds. To control for this potential influence we include time to maturity as a control variable in our regression analysis.

Furthermore, the general economic growth plays an important role. Longstaff and Schwartz (1995) argue that increases in the spot rates cause a steeper risk-neutral drift term in the firm value process. Therefore, the probability of default of the firm decreases (see e.g. Merton 1974) and thus the yield spreads decrease, too. Hence, we add the rate on 1-year German Bunds, our proxy for the risk-free interest rate, as a control variable and expect it to be negatively associated with the yield spread. Collin-Dufresne et al. (2001) argue that the term structure of the yield curve has an effect on the yield spread as well. A decreasing term slope indicates an expected weaker economy and therefore lower recovery rates. In turn, we expect this to lead to higher yield spreads. Thus, we include the term slope as an additional control variable.

We specify our general regression model as follows:

$$\begin{aligned} \mathit{Yield\,Spread}_{i,t} = \eta_0 &+ \eta_1 \mathit{Liquidity}_{i,t} + \eta_2 \mathit{Maturity}_{i,t} + \eta_3 \mathit{Government\,Bond}_{i,t} \\ &+ \eta_4 \mathit{Term\,Slope}_{i,t} + \eta_5 \mathit{Rating\,Scale}_{i,t} + \eta_6 \mathit{Income/Sales}_{i,t-1} \\ &+ \eta_7 \mathit{Debt/Assets}_{i,t-1} + \eta_8 \mathit{Interest\,Coverage}_{i,t-1} \\ &+ \eta_9 \mathit{Debt/Capital}_{i,t-1} + \epsilon_t, \end{aligned}$$

where the subscript *i*,*t* denotes bond *i* in year *t* and *Liquidity* refers to either the bid–ask spread or the LOT liquidity estimate, respectively.

We apply three different regression models for each liquidity estimate. Model 1 includes credit rating but not accounting data. Model 2 includes both credit rating and accounting data. Model 3 includes accounting data but not credit rating. Considering the availability of rating and accounting data in our overall sample, Model 1 maintains the largest sample whereas Model 2 has the smallest sample. We run each model for our two liquidity measure specifications, bid–ask spread and LOT liquidity estimate. Using the LOT liquidity estimate maintains larger sample sizes compared to the bid–ask spread due to better data availability. The results of the regressions are presented in Table 5.

The liquidity estimates are highly significant in each model irrespective of whether credit rating, accounting variables, or all control variables are used. We find that the results are consistent for both liquidity estimates. In each model the coefficients of the bid–ask spread and the LOT liquidity estimate are positive and significant at a 1 % level. A higher value of the liquidity measures indicates higher liquidity costs. Hence, our results do indeed support our main hypothesis that lower bond liquidity is associated with a higher yield spread for Mittelstand bonds.

The economic significance varies slightly between the liquidity estimates. The first model suggests that a 1 % increase of the bid–ask spread is related to an incremental 3.19 % increase in the yield spread. When using the LOT liquidity estimate instead the associated incremental increase of the yield spread only equals 2.04 %. While the coefficient of the bid–ask spread increases in the second model after adding the accounting data the coefficient of the LOT liquidity estimate remains at a similar level compared to the first model. Yet, the coefficients on both liquidity estimates show the highest values in Model 3, in which accounting data instead of the rating information is included. Here, we can report that a 1 % increase in the bid–ask spread (LOT liquidity measure) is related to an incremental 6.41 % (2.65 %) increase in the yield spreads. Comparing our results to the results of Chen et al. (2007), we observe that the effect of the liquidity measures for Mittelstand bonds is approximately twice as strong as for speculative grade US corporate bonds and four to eight times as pronounced as for investment grade US corporate bonds.

Credit rating, one of our proxies for the default risk, is also highly significant. In both Models 1 and 2, and also for both liquidity specifications, a higher rating scale, and thus a higher default risk, is associated with a higher yield spread. In each model and each specification the coefficient of rating scale is positive indicating that a rating downgrade by one step is related to an increase of the yield spread by 3.00–4.90 %. All other control variables are insignificant in Models 1 and 2. Yet, in the LOT liquidity specification of Model 3, term slope and interest coverage are significant. Consistent with Collin-Dufresne et al. (2001) the sign of term slope is negative. Interest coverage is also negatively related with the yield spread. As a high interest coverage suggests high financial performance and solvency, this result is intuitive. To further detail the effect of the accounting variables we modify Model 3 and include the accounting variables one by one. The results are presented in Table 6. Using bid–ask spread as the liquidity measure specification, debt to capital is the only significant accounting control variable. On the other hand, regressing the yield spread on the LOT liquidity estimate plus the control variables shows that while the accounting variables related to the firm performance (interest coverage

**Table 5** This table reports upon panel regression results with yield spread as dependent variable and fixed effects

| | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
| | (B) | (L) | (B) | (L) | (B) | (L) |
| Bid–ask spread | 319.48*** | | 579.83*** | | 641.42*** | |
| | (3.17) | | (4.90) | | (5.60) | |
| LOT | | 203.68*** | | 201.41*** | | 264.95*** |
| | | (3.28) | | (2.76) | | (3.00) |
| Time to maturity | −70.95 | 78.09 | 394.18 | 136.33 | −244.91 | 35.51 |
| | (0.13) | (0.96) | (0.63) | (1.02) | (0.56) | (0.36) |
| Government bond | −48.56 | −223.00 | −535.33 | −316.60 | −1862.36 | −223.52 |
| | (0.03) | (1.37) | (0.21) | (1.26) | (0.92) | (1.30) |
| Term slope | 107.53 | −303.83 | −782.24 | −818.78 | 574.39 | −952.95* |
| | (0.06) | (1.56) | (0.38) | (1.60) | (0.39) | (1.93) |
| Rating Scale | 303.61* | 301.12*** | 483.37*** | 318.12*** | | |
| | (1.96) | (2.99) | (3.23) | (2.80) | | |
| Income to sales | | | −89.57 | −63.91 | −237.32 | −147.85 |
| | | | (0.70) | (0.94) | (1.25) | (1.54) |
| Debt to assets | | | −687.59 | 38.80 | −855.18 | −11.66 |
| | | | (0.92) | (0.05) | (1.04) | (0.02) |
| Interest coverage | | 32.77 | −5.63 | | 38.48 | −5.82*** |
| | | | (0.90) | (0.83) | (0.95) | (3.07) |
| Debt to capital | | | 145.47 | −81.56 | 2728.49 | 703.78 |
| | | | (0.10) | (0.12) | (1.38) | (0.90) |
| Constant | −1517.63 | −1126.31 | −3339.77** | −630.79 | −1721.13 | 1251.83** |
| | (1.20) | (1.50) | (2.08) | (0.84) | (0.92) | (2.45) |

**Table 5** continued

| | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
| | (B) | (L) | (B) | (L) | (B) | (L) |
| # Obs | 187 | 248 | 106 | 148 | 132 | 188 |
| *F*-statistic | 7.02 | 4.56 | 7.53 | 3.18 | 8.91 | 3.83 |
| Within $R^2$ | 0.71 | 0.59 | 0.82 | 0.60 | 0.75 | 0.58 |

Standard errors are clustered at bond level. (B) indicates that we use the bid–ask spread and (L) the LOT liquidity estimate as explanatory liquidity measure. The absolute values of the *t*-statistics are shown in parenthesis

*, **, *** Significance at a 10, 5, and 1 % level, respectively

**Table 6** This table reports upon panel regression results with yield spread as dependent variable and fixed effects

| | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| | (B) | (L) | (B) | (L) | (B) | (L) | (B) | (L) |
| Bid–ask spread | 623.40*** | | 370.14** | | 374.45*** | | 405.95*** | |
| | (6.10) | | (2.50) | | (2.77) | | (2.82) | |
| LOT | | 261.36*** | | 264.09*** | | 274.37*** | | 277.69*** |
| | | (3.00) | | (2.98) | | (3.14) | | (3.04) |
| Time to maturity | −469.26 | −10.55 | −539.25*** | 50.40 | −1157.65* | 25.31 | −481.55*** | 84.82 |
| | (0.89) | (0.14) | (2.93) | (0.54) | (1.82) | (0.33) | (2.87) | (0.94) |
| Government bond | −2377.79 | −25.47 | −933.08 | −119.20 | −5021.13* | −262.14 | −826.68 | −99.99 |
| | (0.97) | (0.17) | (0.89) | (0.83) | (1.90) | (1.50) | (0.82) | (0.72) |
| Term slope | 1195.04 | −925.46* | 641.72 | −979.41** | 3167.37 | −909.53* | 560.14 | −1005.60** |
| | (0.68) | (1.98) | (1.13) | (2.11) | (1.54) | (1.95) | (1.04) | (2.23) |
| Income to sales | −99.99 | −189.38** | | | | | | |
| | (1.52) | (2.17) | | | | | | |
| Debt to assets | | | 554.89 | 247.00 | | | | |
| | | | (0.69) | (0.61) | | | | |
| Interest coverage | | | | | −25.60 | −6.43** | | |
| | | | | | (1.52) | (2.49) | | |
| Debt to capital | | | | | | | 1724.20** | 820.53 |
| | | | | | | | (2.49) | (1.49) |
| Constant | 159.20 | 1914.35*** | 1145.90 | 1618.96*** | 586.40 | 1750.09*** | −112.16 | 946.20** |
| | (0.25) | (4.09) | (1.29) | (4.35) | (0.92) | (4.10) | (0.12) | (2.06) |

**Table 6** continued

| | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| | (B) | (L) | (B) | (L) | (B) | (L) | (B) | (L) |
| # Obs | 140 | 197 | 144 | 202 | 139 | 196 | 158 | 221 |
| *F*-statistic | 10.79 | 4.28 | 8.28 | 3.33 | 9.27 | 4.15 | 9.41 | 3.51 |
| Within $R^2$ | 0.73 | 0.56 | 0.63 | 0.55 | 0.65 | 0.57 | 0.63 | 0.52 |

Accounting variables are added one by one. Standard errors are clustered at bond level. (B) indicates that we use the bid–ask spread and (L) the LOT liquidity estimate as explanatory liquidity measure. The absolute values of the *t*-statistics are shown in parenthesis

*, **, *** Significance at a 10, 5, and 1 % level, respectively

and income to sales) are as expected negatively significant, both leverage ratios are insignificant.

Both liquidity measures provide high explanatory power regarding the yield spread of Mittelstand bonds. The values of the within $R^2$ range from 71 to 82 % for the bid–ask spread and from 58 to 60 % for LOT liquidity estimate. We observe higher within $R^2$ for regressions using the bid–ask spread compared to the LOT liquidity estimate. In particular, in Model 2 the bid–ask spread explains in combination with the other control variables 82 % of the variation of the yield spread. Using the same control variables, the LOT liquidity estimate provides a within $R^2$ of 60 % and thus, slightly lower explanatory power.

### 4.4 Simultaneous equation model tests

To control for potential endogeneity biases we apply a simultaneous equation model. A possible source of endogeneity are the liquidity estimates. In particular, liquidity costs could be influenced by credit rating. Credit quality is a main driver of adverse selection costs due to private information in the context of corporate bonds. Assuming that private information problems are more severe for bonds with a higher default risk indicates that bonds with a lower credit rating should incorporate higher private information costs. Private information costs, in turn, are a determinant of the liquidity costs. Thus a lower credit rating might lead to lower bond liquidity. Furthermore, the credit rating itself could be a second source of endogeneity. Rating agencies might not only consider accounting data to assess the quality of a bond but also account for market information observed through the yield spread. Hence, a higher yield spread could result in a lower credit rating.

To recognize that the liquidity and the credit rating might be determined endogenously we specify a system of three equations as follows:

$$\begin{aligned}
\mathit{Yield\,Spread}_{i,t} &= \eta_0 + \eta_1 \mathit{Liquidity}_{i,t} + \eta_2 \mathit{Maturity}_{i,t} + \eta_3 \mathit{Government\,Bond}_{i,t} \\
&\quad + \eta_4 \mathit{Term\,Slope}_{i,t} + \eta_5 \mathit{Rating\,Scale}_{i,t} + \epsilon_t \\
\mathit{Liquidity}_{i,t} &= \eta_0 + \eta_1 \mathit{Bond\,Volatility}_{i,t} + \eta_2 \mathit{Rating\,Scale}_{i,t} \\
&\quad + \eta_3 \mathit{Yield\,Spread}_{i,t} + \epsilon_t \\
\mathit{Rating\,Scale}_{i,t} &= \eta_0 + \eta_1 \mathit{Income/Sales}_{i,t-1} + \eta_2 \mathit{Debt/Assets}_{i,t-1} \\
&\quad + \eta_3 \mathit{Interest\,Coverage}_{i,t-1} + \eta_4 \mathit{Debt/Capital}_{i,t-1} \\
&\quad + \eta_5 \mathit{Yield\,Spread}_{i,t} + \epsilon_t
\end{aligned}$$

where the subscript *i,t* denotes bond *i* in year *t* and *Liquidity* refers to the bid–ask spread or the LOT liquidity estimate. As both the liquidity measures and the credit rating are endogenous in our framework, we use a three-stage least squares estimation technique to examine how these variables simultaneously impact the yield spread. The results are presented in Table 7. We estimate a separate model for each liquidity measure. The first column of each model shows a GLS-type estimation using the yield spread as dependent variable and the instrumented values instead of

**Table 7** This table reports upon simultaneous equation tests using three-stage least squared regressions

| | Model (B) | | | Model (L) | | |
|---|---|---|---|---|---|---|
| Instrumental variable | Yield spread | Bid–ask spread | Rating scale | Yield spread | LOT | Rating Scale |
| Bid–ask spread | 573.68*** | | | | | |
| | (4.92) | | | | | |
| LOT | | | | 729.52*** | | |
| | | | | (4.42) | | |
| Time to maturity | 3.72 | | | −2.67 | | |
| | (0.09) | | | (0.12) | | |
| Government bond | −767.65 | | | −176.39 | | |
| | (0.63) | | | (0.56) | | |
| Term slope | −248.24 | | | 87.00 | | |
| | (0.60) | | | (0.35) | | |
| Rating Scale | 54.92 | −0.10 | | 91.64 | −0.13 | |
| | (0.54) | (0.63) | | (0.81) | (0.88) | |
| Bond volatility | | 0.11*** | | | 0.02 | |
| | | (2.90) | | | 0.58) | |
| Yield spread | | 1.03E−3*** | 1.35E−3*** | | 1.30E−3*** | 1.76E−3*** |
| | | (4.86) | (4.61) | | (4.45) | (6.39) |
| Interest coverage | | | −0.07 | | | 0.03 |
| | | | (0.80) | | | (0.77) |
| Income to sales | | | 0.06 | | | −0.07 |
| | | | (0.21) | | | (0.26) |
| Debt to assets | | | −2.61*** | | | −0.97 |
| | | | (2.77) | | | (1.34) |
| Debt to capital | | | 3.71*** | | | 2.49*** |
| | | | (2.91) | | | (2.64) |
| Constant | −64.13 | 0.92 | 3.47*** | −410.00 | 0.50 | 2.94*** |
| | (0.08) | (1.13) | (3.42) | (0.73) | (0.65) | (4.10) |
| # Obs | 106 | 106 | 106 | 148 | 148 | 148 |
| $R^2$ | 0.65 | 0.67 | 0.35 | 0.05 | 0.19 | 0.18 |
| *p*-Value | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

The instrumental variable indicates the dependent variable of each regression. The first column of each model represents a GLS-type estimation using the instrumented values instead of the endogenous regressors. The last two columns represent the first-stage regression. (B) indicates that we use the bid–ask spread and (L) the LOT liquidity estimate as explanatory liquidity measure. The absolute values of the *t*-statistics are shown in parenthesis

*** Significance at a 1 % level

the endogenous variables. The last two columns represent the first-stage regression of the endogenous variables.

The results highlight that a possible bias due to endogeneity does not affect the previously examined relationship between liquidity and yield spread. In our sample the first-stage regressions cannot confirm an influence of the credit rating on the liquidity measures. However, the yield spread is significantly associated with both liquidity estimates. Regressing the rating scale on the yield spread and other variables also indicates that a higher yield spread is related to a higher rating scale and thus a lower bond quality. Nonetheless, when accounting for these endogeneities using the simultaneous equation model we find that the coefficients of both liquidity measures remain positive and significant at 1 % level in the third-stage regressions. Therefore, after controlling for potential endogeneity bias we can indeed conclude that lower liquidity leads to a higher yield spread for the Mittelstand bonds.

Credit rating has a positive sign in the third stage of both models, yet, the coefficients are insignificant. Moreover, none of the other control variables is significantly associated with the yield spread. The $R^2$ indicates that 65 % of the variation in the yield spread can be explained by Model (B). However, performing the same regression with the LOT liquidity estimate instead of the bid–ask spread only explains 5 % of the variation.

## 5 Conclusion

The decision on the capital structure is critical for firms all over the world. US firms frequently tap capital markets to raise money and cover only one quarter of their funding requirements with traditional bank loans. By contrast, the German Mittelstand relied heavily on loans via relationship banking. Yet, in the light of tighter regulation, a trend towards other funding sources is clearly observable. Issuing bonds is a promising option to structure debt for Mittelstand firms.

Since the launch of the Mittelstand bond market in 2010, yield spreads have increased steadily. In the next few years many of the early issued bonds will mature. Therefore, the near future will show whether Mittelstand firms will be able to reschedule their debt. Rescheduling debt requires issuing a new bond to pay back the existing bond. The new bonds, however, will require a coupon that is adjusted to the contemporaneous level of the yield spread. Pessimists claim that given the current level of yield spreads, many Mittelstand firms will not be able to afford such new bonds. Moreover, with the default of more Mittelstand bonds, the perceived risk of this investment class will increase, increasing the yield spreads further and thus closing the vicious circle.

Our research provides important insights into this debate. We show that the effect of illiquidity on the yield spread is especially pronounced for Mittelstand bonds. This finding could open a back door towards the future of Mittelstand bonds. While, given fixed investment and operating policies, default risk of Mittelstand firms is mostly exogenous,[3] liquidity is endogenous for the firms. As an example, firms could increase the liquidity of their bonds by decreasing the adverse selection costs due to private information, for instance by more timely and comprehensive

[3] Notice that as discussed in Sect. 3.1 Mittelstand firms are very reluctant to increase their equity on public markets in order to not dilute the founding family's ownership and control rights.

reporting. As our research shows, even small increases in the liquidity of Mittelstand bonds can lead to substantial decreases in the yield spreads.

## Appendix 1: List of all Mittelstand bonds

See Table 8.

**Table 8** This table reports upon characteristics of all German Mittelstand bonds in our final sample

| ISIN | Borrower name | Maturity (years) | Coupon (%) | Volume (in thousands) | Issue date |
|---|---|---|---|---|---|
| AT0000A0U9J2 | Scholz AG | 5 | 8.5 | 182,500 | 03/08/12 |
| AT0000A0XJ15 | Porr AG | 4 | 6.25 | 50,000 | 12/04/12 |
| AT0000A185Y1 | UBM Realitätenentwicklung AG | 5 | 4.875 | 200,000 | 07/09/14 |
| DE000A11QGQ1 | KTG Agrar AG | 5 | 7.25 | 50,000 | 10/15/14 |
| DE000A11QHZ0 | HanseYachts AG | 5 | 8 | 20,000 | 06/03/14 |
| DE000A11QJA9 | Vedes AG | 5 | 7.125 | 20,000 | 06/24/14 |
| DE000A12T1W6 | Beate Uhse AG | 5 | 7.75 | 30,000 | 07/09/14 |
| DE000A12UAA8 | KSW Immobilien GmbH & Co. KG | 5 | 6.5 | 25,000 | 10/07/14 |
| DE000A12UD98 | Studierendengesellschaft Witten Herdecke EV | 10 | 3.6 | 7500 | 12/02/14 |
| DE000A13SAD4 | Neue ZWL Zahnradwerk Leipzig GmbH | 6 | 7.5 | 25,000 | 02/17/15 |
| DE000A161F97 | Katjes International GmbH & Co. KG | 5 | 5.5 | 60,000 | 05/15/15 |
| DE000A1CR0X3 | Albis Leasing AG | 5 | 7.625 | 50,000 | 10/04/11 |
| DE000A1ELQU9 | KTG Agrar AG | 5 | 6.75 | 50,000 | 06/01/09 |
| DE000A1EWGX1 | Duerr AG | 5 | 7.25 | 225,000 | 09/28/10 |
| DE000A1EWL99 | Nabaltec AG | 5 | 6.5 | 30,000 | 10/15/10 |
| DE000A1EWNF4 | Hahn Immobilien Beteiligungs AG | 5 | 6.25 | 20,000 | 10/01/12 |
| DE000A1G9AQ4 | Enterprise Holdings LTD | 5 | 7 | 35,000 | 09/26/12 |
| DE000A1H3EY2 | MAG IAS GmbH | 5 | 7.5 | 50,000 | 02/08/11 |
| DE000A1H3F20 | Albert Reiff GmbH & Co. KG | 5 | 7.25 | 30,000 | 05/27/11 |
| DE000A1H3GE9 | Joh. Friedrich Behrens AG | 5 | 8 | 30,000 | 03/15/11 |
| DE000A1H3J67 | German Pellets GmbH | 5 | 7.25 | 75,000 | 04/01/11 |
| DE000A1H3V53 | ENO Energy GmbH | 5 | 7.375 | 25,000 | 06/30/11 |
| DE000A1H3VN9 | KTG Agrar AG | 6 | 7.125 | 200,000 | 06/06/11 |
| DE000A1H3YJ1 | Semper Idem Underberg GmbH | 5 | 7.125 | 70,000 | 04/20/11 |
| DE000A1H3YK9 | Valensina GmbH | 5 | 7.375 | 85,000 | 04/28/11 |
| DE000A1HJLL6 | S&T AG | 5 | 7.25 | 15,000 | 05/22/13 |
| DE000A1HLTD2 | Metalcorp Group BV | 5 | 8.75 | 50,000 | 06/27/13 |
| DE000A1HPZD0 | VST Building Technologies AG | 6 | 8.5 | 15,000 | 10/02/13 |

**Table 8** continued

| ISIN | Borrower name | Maturity (years) | Coupon (%) | Volume (in thousands) | Issue date |
|---|---|---|---|---|---|
| DE000A1HSNV2 | Porr AG | 5 | 6.25 | 50,000 | 11/26/13 |
| DE000A1K0169 | Bastei Luebbe GmbH & Co. KG | 5 | 6.75 | 30,000 | 10/26/11 |
| DE000A1K0FA0 | Eyemaxx Real Estate AG | 5 | 7.5 | 25,000 | 07/26/11 |
| DE000A1K0FF9 | GIF Gesellschaft für Industrieforschung MBH | 5 | 8.5 | 3455 | 09/20/11 |
| DE000A1K0NJ5 | MITEC Automotive AG | 5 | 7.75 | 50,000 | 03/30/12 |
| DE000A1K0QA7 | Royalbeach Spielwaren und Sportartikel Vertriebs GmbH | 5 | 8.125 | 25,000 | 10/28/11 |
| DE000A1K0SE5 | Textilkontor Walter Seidensticker GmbH | 6 | 7.25 | 30,000 | 03/12/12 |
| DE000A1K0U44 | Procar Automobile Finanz Holding GmbH & Co. KG | 5 | 7.75 | 12,000 | 10/14/11 |
| DE000A1KQ367 | Uniwheels Property Germany GmbH | 5 | 7.5 | 44,499 | 04/19/11 |
| DE000A1KQ3C2 | Senivita Sozial Gemeinnuetzige GmbH | 5 | 6.5 | 15,000 | 05/17/11 |
| DE000A1KQ8K4 | Peach Property Group Deutschland GmbH | 5 | 6.6 | 50,000 | 07/18/11 |
| DE000A1KQZL5 | MS Spaichingen GmbH | 5 | 7.25 | 23,000 | 07/15/11 |
| DE000A1KRBM2 | Katjes International GmbH & Co. KG | 5 | 7.125 | 45,000 | 07/19/11 |
| DE000A1MA9E1 | Golfino AG | 5 | 7.25 | 12,000 | 04/05/12 |
| DE000A1MASJ4 | Singulus Technologies AG | 5 | 7.75 | 60,000 | 03/23/12 |
| DE000A1ML257 | KTG Energie AG | 6 | 7.25 | 50,000 | 09/28/12 |
| DE000A1ML4T7 | Fussballclub Gelsenkirchen Schalke 04 EV | 7 | 6.75 | 35,000 | 06/11/12 |
| DE000A1MLSJ1 | Ekosem-Agrar GmbH | 5 | 8.75 | 50,000 | 03/23/12 |
| DE000A1MLWH7 | Eyemaxx Real Estate AG | 5.56 | 7.75 | 15,000 | 04/11/12 |
| DE000A1MLYJ9 | Friedola Gebr Holzapfel GmbH | 5 | 7.25 | 13,000 | 04/11/12 |
| DE000A1PGQL4 | BDT Media Automation GmbH | 5 | 8.125 | 17,380 | 10/09/12 |
| DE000A1PGQR1 | Rene Lezard Mode GmbH | 5 | 7.25 | 15,000 | 11/26/12 |
| DE000A1PGRG2 | Travel24 com AG | 5 | 7.5 | 25,000 | 09/17/12 |
| DE000A1PGUT9 | posterXXL AG | 5 | 7.25 | 15,000 | 07/27/12 |
| DE000A1PGWZ2 | Steilmann Boecker Fashion Point GmbH & Co. KG | 5 | 6.75 | 40,000 | 06/27/12 |
| DE000A1R07C3 | Constantin Medien AG | 5 | 7 | 65,000 | 04/23/13 |
| DE000A1R07G4 | Deutsche Rohstoff AG | 5 | 8 | 100,000 | 07/11/13 |
| DE000A1R09H8 | Timeless Homes GmbH | 7 | 9 | 10,000 | 07/02/13 |
| DE000A1R0RZ5 | Ekosem-Agrar GmbH | 6 | 8.5 | 78,000 | 12/07/12 |
| DE000A1R0VD4 | Homann Holzwerkstoffe GmbH | 5 | 7 | 100,000 | 12/14/12 |
| DE000A1R0YA4 | Rudolf Woehrl AG | 5 | 6.5 | 30,000 | 02/12/13 |
| DE000A1R1A42 | Adler Real Estate AG | 5 | 8.75 | 35,000 | 04/03/13 |
| DE000A1R1BR4 | Alno AG | 5 | 8.5 | 45,000 | 05/14/13 |

**Table 8** continued

| ISIN | Borrower name | Maturity (years) | Coupon (%) | Volume (in thousands) | Issue date |
|---|---|---|---|---|---|
| DE000A1R1CC4 | DF Deutsche Fortfait AG | 7 | 2 | 30,000 | 05/27/13 |
| DE000A1RE1V3 | Berentzen Gruppe AG | 5 | 6.5 | 50,000 | 10/18/12 |
| DE000A1RE5T8 | Laurel GmbH | 5 | 7.125 | 20,000 | 11/16/12 |
| DE000A1RE7P2 | Jacob Stauder GmbH & Co. KG | 5 | 7.5 | 10,000 | 11/23/12 |
| DE000A1RE8B0 | Euroboden GmbH | 5 | 7.375 | 15,000 | 07/16/13 |
| DE000A1REWV2 | Karlsberg Brauerei GmbH | 5 | 7.375 | 30,000 | 09/28/12 |
| DE000A1REXA4 | Eterna Mode Holding GmbH | 5 | 8 | 55,000 | 10/09/12 |
| DE000A1RFBP5 | Immobilien Projekt Salamander Areal Kornwestheim | 7 | 6.75 | 30,000 | 12/06/12 |
| DE000A1TM2T3 | Eyemaxx Real Estate AG | 6 | 7.875 | 15,000 | 03/26/13 |
| DE000A1TM8Z7 | Stern Immobilien AG | 5 | 6.25 | 20,000 | 05/23/13 |
| DE000A1TNA70 | Sanha GmbH Co. & KG | 5 | 7.75 | 37,500 | 06/04/13 |
| DE000A1TNAP7 | German Pellets GmbH | 5 | 7.25 | 72,000 | 07/09/13 |
| DE000A1TND44 | More & More AG | 5 | 8.125 | 13,000 | 06/11/13 |
| DE000A1TND93 | Paragon AG | 5 | 7.25 | 20,000 | 07/02/13 |
| DE000A1TNFX0 | Peine GmbH | 5 | 8 | 15,000 | 07/05/13 |
| DE000A1TNG90 | Karlie Group GmbH | 5 | 6.75 | 30,000 | 06/25/13 |
| DE000A1TNGG3 | Cloud NO 7 GmbH | 4 | 6 | 35,000 | 07/03/13 |
| DE000A1TNHC0 | Bioenergie Taufkirchen GmbH & Co. KG | 7 | 6.5 | 15,000 | 07/30/13 |
| DE000A1TNJY0 | Gamigo AG | 5 | 8.5 | 15,000 | 06/20/13 |
| DE000A1X3HZ2 | Helma Eigenheimbau AG | 5 | 5.875 | 35,000 | 09/19/13 |
| DE000A1X3MA5 | Alfmeier Praezision Baugruppen und Systemloesungen AG | 5 | 7.5 | 30,000 | 10/29/13 |
| DE000A1X3MD9 | Gebr. Sanders GmbH & Co. KG | 5 | 8.75 | 18,000 | 10/22/13 |
| DE000A1X3MS7 | Sympatex Holding GmbH | 5 | 8 | 13,000 | 12/03/13 |
| DE000A1X3VZ3 | Ferratum Capital Germany GmbH | 5 | 8 | 25,000 | 10/21/13 |
| DE000A1YC1F9 | Neue ZWL Zahnradwerk Leipzig GmbH | 5 | 7.5 | 25,000 | 03/04/14 |
| DE000A1YC7Y7 | GEWA 5 TO 1 GmbH & Co. KG | 4 | 6.5 | 35,000 | 03/24/14 |
| DE000A1YCRD0 | Hoermann Finance GmbH | 5 | 6.25 | 50,000 | 12/05/13 |
| DE000A1ZWPT5 | Enterprise Holdings LTD | 5 | 7 | 85,000 | 03/30/15 |
| DE000AB100A6 | Air Berlin PLC | 5 | 8.5 | 200,000 | 11/10/10 |
| DE000AB100B4 | Air Berlin PLC | 7 | 8.25 | 225,000 | 04/19/11 |
| DE000AB100C2 | Air Berlin PLC | 3 | 11.5 | 150,000 | 11/01/11 |

## Appendix 2: List of all variables

See Table 9.

**Table 9** This table describes the variables employed in our study

| Variable name | Abbreviation | Description | Data source |
|---|---|---|---|
| Age of the bond | Age | Time period since the issuance of the bond (in years) | Datastream |
| Bid–ask spread | Bid–ask spread | Calculated as the ask quote minus the bid quote divided by the average of both quotes | Datastream |
| Bond volatility | Bond volatility | Yearly standard deviation of the clean prices of the bond | Datastream |
| DAX return | $\Delta DAX$ | Daily return on the DAX 30 composite stock index | Datastream |
| Debt to assets | Debt/assets | Long-term debt to assets | Dafne/Amadeus |
| Debt to capital | Debt/capital | Total debt to capital | Dafne/Amadeus |
| Duration | $D$ | Modified duration to final date | Datastream |
| Government bond | Government bond | 1-year German Bunds rate | Datastream |
| Income to sales | Income/sales | Operating income to sales | Dafne/Amadeus |
| Interest coverage | Interest coverage | EBIT plus interest to interest | Dafne/Amadeus |
| LOT liquidity estimate | LOT | Liquidity measure based on Lesmond et al. (1999) | Datastream |
| Rating Scale | Rating Scale | Numeric value for each rating class ranging from 1 for A (the best rating in our sample) to 15 for D (default) | Rating reports |
| Risk-free bond | $R_{f,t}$ | 10-year German Bunds rate | Datastream |
| Term slope | Term slope | Difference in rates of 10-year and 2-year German Bunds | Datastream |
| Time to maturity | Maturity | Remaining life of a Mittelstand bond | Datastream |
| Yield spread | Yield spread | Spread of the yield of a Mittelstand bond over an equivalent government benchmark bond | Datastream |

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