The Credit Spread Puzzle - Evidence From Multiple Quasi-Natural Experiments*

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Abstract

Credit spreads are the yield of risky debt securities minus risk-free rates. The finance literature has long argued which share of them is due to credit risk and which share results from other factors. We suggest a novel set of multiple quasi-natural experiments based on the government guarantees for debt securities around the globe during the global financial crisis. The results strongly support arguments that suggest credit spreads to be primarily required to cover credit risk.

Keywords: Credit spread puzzle, credit risk, bond pricing, quasi-natural experiment.

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1. Introduction

Credit spreads of bonds are mark-ups on risk-free interest rates. They are given by the difference of the yield of a risky bond and a risk-free rate. Credit spreads have traditionally been regarded to mainly be a compensation for credit risk. Fundamental work of Merton (1974) or Black and Cox (1976), therefore, models the credit spread based on credit risk. While there is consensus that credit spreads reflect the credit risk of debt securities, literature as early as Jones et al. (1984) has initiated a discussion whether credit risk is sufficient to explain the empirically observed size of credit spreads. The prevailing view of later empirical literature is that structural models are unable to explain a sufficiently large part of empirical bond yield spreads (e.g., Eom et al., 2004; Chen et al., 2009; Huang and Huang, 2012; Huang et al., 2019). This discussion is referred to as the credit spread puzzle. This perception was challenged recently by Feldhütter and Schaefer (2018) for investment-grade bonds, using a wide cross-section of default rates at different maturities and ratings identifying credit risk as the by far largest factor of the credit spread. Bai et al. (2020) respond to Feldhütter and Schaefer (2018), arguing that a more appropriate model lets the credit spread puzzle survive for investment-grade bonds.

This discussion is also present in research that studies the determinants of bond returns which finds liquidity provided by central market makers (e.g., He et al., 2017; He et al., 2020) or loss related aspects (e.g., Elkamhi et al., 2021) to be main drivers of bond returns. Following these lines of argument, considerable disagreement exists about the relative importance of the credit risk component in comparison to other determinants of the credit spread.

In line with the aforementioned literature, we are asking which extent of the credit spread is due to a credit risk component. But from a methodological perspective, there is a fundamental difference. The previous literature mainly relies on (structural) models for predicting the credit risk component of bond yields in order to explain the size of empirical bond yields or identify deviations from these models (the credit spread puzzle). We make use of the government guarantees for debt securities during the financial crisis and directly compare bonds with and without guarantees, i.e., without and with credit risk, of the same issuer, requiring very few assumptions and relying almost entirely on an empirical design for identification.

Terming the large difference between model-based theoretical spreads and empirical credit spreads, a puzzle is based on the normative hypothesis that this difference must be small if other relevant factors are properly accounted for. The size of the credit risk component is important as it translates into expenses for banks, non-financial firms, jurisdictions, and other issuers. It also compensates for the risk-taking of investors, including some being pivotal for financial as well as social stability such as banks, insurance companies, and pension funds. Moreover, the efficacy of several public support programs depends on fitting mark-ups. Expanding the models by additional factors reveals the issue of testing joint hypotheses as the hypothesis of a large difference, the puzzle, might be falsely rejected due to inappropriate models. Therefore, it is appealing to abstain from a theoretical model in favor of an empirical identification.

When assessing the importance of credit risk, there is the difficulty that we do not have a true counterfactual where we could observe the same bond with and without default risk at the same time (Culp et al., 2018). Culp et al. (2018) suggest addressing the issue by creating synthetic bonds from observed risk-free rates and option prices. We approach this issue using a different identification policy: matching bonds that were guaranteed by governments during the global financial crisis to bonds with almost the same characteristics but without guarantees. This comes very close to a situation of hypothetical counterfactuals as described in Culp et al. (2018). Furthermore, it is the first application of causal inference to solve this problem to the best of our knowledge.

Matching is an established method to identify causal relationships but has not been applied in analyses of the credit spread puzzle to date. The key idea here is to compare almost identical bonds with and without credit risk, suggesting that the yield difference is (almost) exclusively due to credit risk. Different issuers may be similar, yet unobserved differences may drive yield differences. Therefore, an ideal identification strategy requires, besides other bond characteristics, in particular matching identical issuers only. Following the financial crisis, some countries, including the United States, the United Kingdom, and Germany (all AAA-rated), provided governmental guarantees for bond issuances to support financial institutions. This created a situation that could be argued to be a quasi-natural experiment by producing coexisting bonds by the same issuer with and without credit risk, which is the basis for our analysis. We compare the credit spread of the risk-free with the risky bonds. In a nutshell, our results are in favor of a very large credit risk component, supporting the more recent literature that is able to attribute most of the credit spread to credit risk.

2. Literature Review

In this way, the paper addresses what determines the interest rate of corporate debt securities and for what risks or costs of holding debt securities investors require a compensation. From a contingent claims perspective, a debt security is a claim on the value of the firm as suggested by Merton (1974) who introduced structural models of credit defaults. In this way, it can be priced as a position in a riskless asset and a short position in a put option on the firm value. Black and Cox (1976) suggests a similar model where the default could occur before maturity. In the Merton and Black-Cox models, the firm value follows a geometric-Brownian motion, and default occurs when the firm value process is below the default barrier. The default barrier is set to match historical default rates and the Sharpe ratio.

Interestingly, Jones et al. (1984) pointed out that observed yield spreads of debt securities as the difference in yield between a corporate bond and a government bond exceeded the level of spread that one would expect based on the structural models. This finding which is labeled the credit spread puzzle is supported by many empirical studies (e.g., Eom et al., 2004; Chen et al., 2009; Huang and Huang, 2012; Huang et al., 2019). These consistent observations sparked a discussion on the design of structural models and what else could then instead determine the level of the credit spread. Collin-Dufresn et al. (2001), Nozawa (2017), or Elkamhi et al. (2021) further study the changes in credit spreads.

Consequently, the explanations to the puzzle could come in two different forms overall. First, there are other aspects of debt securities that investors require compensation for despite the risk inherent in the firm value process. And second, there is some kind of risk in the firm value process that needs to be considered besides the design of earlier structural models.

Regarding the first possibility, probable explanations include the illiquidity of markets for debt securities (e.g., Longstaff et al., 2005; Bao et al., 2011; Dick-Nielsen et al., 2012; Helwege et al., 2014), differential taxation between corporate and government bonds (e.g., Elton et al., 2001; Driessen, 2004), and then closely linked to liquidity the intermediation by central agents in markets for debt securities (e.g., He et al., 2017; He et al., 2020).

Regarding the risk of the firm value process itself that was not covered by early structural models, explanations center around aspects such as jumps in the firm value process and time-varying volatility (Du et al., 2019), and default correlations as discussed in Feldhütter and Schaefer (2018) or Bai et al. (2020). Huang and Huang (2012) further discuss and evaluate a larger number of extensions to the structural models.

While the previous literature often aimed to explain the size of the empirical spread, we address this question from a different angle and aim to identify the default risk component directly, using a quasi-natural experiment. This contributes to the literature on the credit spread puzzle, specifically supporting a very large credit spread component and therefore theoretical models such as Du et al. (2019), Feldhütter and Schaefer (2018) or also Bai et al. (2020). In addition, as credit spreads and bond returns are closely linked (Nozawa, 2017), we also contribute to research that studies the sources of bond returns such as Elkamhi et al. (2021), He et al. (2017), or He et al. (2020). Finally, we also contribute to the still small literature suggesting empirical ways of addressing the credit spread puzzle such as Cremers et al. (2008) or Culp et al. (2018). To the best of our knowledge, this is the first paper that uses causal inference for this issue.

3. Institutional Setting

After the collapse of Lehman Brothers in 2008, access to liquidity for financial institutions worldwide deteriorated severely. To mitigate the effects for banks and the overall economy, governments of many industrialized countries initiated large support programs with measures such as government guarantees, recapitalization of banks, or asset purchases (see, e.g., Levy and Schich, 2010). Several rescue programs also included a government guarantee that could be provided for newly issued debt securities of banks to support banks' liquidity situation. Table 1 gives a brief overview of these guarantee programs. The table lists programs for which official lists of guaranteed bond emissions were publicly available.[1]

[1] A detailed description of the respective programs and their designs is given in Vol. 2 Issue 3 of the Journal of Financial Crises: https://elischolar.library.yale.edu/journal-of-financial-crises/vol2/iss3/.

In principle, all the bonds included in the programs as described in Table 1 could be eligible for our analysis. In order to use guaranteed bonds with very credible government guarantees and considering that some of the countries in the table went through rating downgrades during the course of the global financial crisis, we are specifically interested in bonds from countries that remained a very strong credit profile over the course of the financial crisis.

Table 1: Overview of guarantee programs

Country	Name of programme	Issue Volume (Bn. USD)	Last bond maturity	Relevant rating
Austria	Interbankmarkt-stärkungsgesetz	29.9	2014-06-12	AAA
Denmark	Credit Package Agreement	43.0	2013-07-29	AAA
Germany	Sonderfonds Finanzmarkt-stabilisierung	348.0	2015-02-02	AAA
Ireland	Credit Institutions Act 2008 and Eligible Liabilities Guarantee Scheme 2009	111.0	2015-03-19	BBB+
Netherlands	2008 Credit Guarantee Scheme	61.3	2014-12-02	AAA
New Zealand	Wholesale Funding Guarantee Facility	9.0	2014-11-19	AA+
Portugal	Portuguese State Guarantee Scheme	11.0	2014-07-19	BB
Spain	Royal Decree of 13 October	91.9	2016-12-16	BBB
Sweden	Guarantee Scheme	30.3	2015-03-08	AAA
United Kingdom	Credit Guarantee Scheme	219.4	2012-10-26	AAA
United States	Temporary Liquidity Guarantee Program	267.4	2012-12-28	AAA

This table gives an overview of bond guarantee programs of developed countries for which we could access the official ISIN list of guaranteed bond emissions. The issue volume is the sum of the bonds of the official ISIN lists in billion USD. The last maturity is the maturity date of the last guaranteed bond in the respective country. The relevant rating is the second-best country rating of the three major agencies during the guarantee scheme period. Information is based on Levy and Schich (2010) and accessible bond information from Eikon. Rating information is also collected from Eikon.

We, therefore, exclusively look at bonds with government guarantees that did not suffer from rating downgrades and kept excellent ratings throughout the maturity of the bonds.

The rightmost column of Table 1, lists the lowest rating for the countries throughout the sample period. In order to use the most credible guarantees, we consider guarantee programs of countries that had a consistent credit rating of (AAA) while the guarantees were in place.[2]

4. Methods and Data

4.1. Methods

Our empirical approach aims at comparing the credit spread of bonds from the same issuer with almost the same bond characteristics, one guaranteed and one not guaranteed. This section describes in more detail how the credit spread is determined and how we match bond characteristics.

As our dependent variable, we use the credit spread of the bonds in our sample. Credit spreads are the difference between the yield of a bond and a risk-free rate. Therefore, the size of credit spreads depends on the choice of the risk-free rate. In the later analysis, we report results for two different risk-free rates. The choice of risk-free rates is, for example, discussed in Krishnamurthy and Vissing-Jorgensen (2012) or van Binsbergen et al. (2022). We report results using the rate of government debt securities with similar characteristics and the swap rate, both provided by Datastream.

Traditionally, studies on the credit spread puzzle determined the risk-free rate often by using the yield of government bonds with a similar maturity. Therefore, we calculate the credit spreads based on this risk-free rate in the first step. While this is a common approach, a drawback of using government benchmarks is that government yields have often been argued to be lower than the risk-free rate (e.g., Krishnamurthy and Vissing-Jorgensen, 2012, van Binsbergen et al., 2022). This is due to the convenience of holding government securities, such as money-like characteristics, the possibility to use government bonds as collateral for receiving liquidity, and a preferred treatment in regulatory capital requirements. This could therefore reduce the government rates below the risk-free rate.

Thus, we further use swap rates as risk-free rates. Swap rates are the rates at which floating interest could be exchanged for fixed interest using interest rate swaps. Studies such

[2] We follow regulatory standards and use the second-best rating of the three most important rating agencies: Fitch, Moody's, and Standard & Poor's.

as Nozawa et al. (2019) or van Binsbergen et al. (2022) use this risk-free rate besides the government rate. The argument for using this rate is that in an interest rate swap contract, no principal could be lost, but there is only the possibility that one party is not able to exchange floating for fixed rates at some time in the future. These rates are therefore considered almost free of default risk.[3]

In order to have simple and easily comparable bonds, we only consider plain vanilla fixed coupon bonds without any derivative features. We match bonds of the same issuer, one with and one without credit risk. Our matching approach is closely related to an approach used in Dick-Nielsen et al. (2012), that compares bonds with the same credit risk as controlled by comparing bonds of the same issuer but different liquidity. To compare only bonds with very similar characteristics, for instance, in terms of cash flows, we include as independent variables amongst others the maturity and the coupon of bonds. This approach is useful in ruling out a wide set of observable and unobservable characteristics of the respective issuer such as leverage (e.g., Collin-Dufresn et al., 2001), informational opaqueness (e.g., Dick-Nielsen et al., 2012) or the respective time period such as the business cycle (e.g., Collin-Dufresn et al., 2001, Ericsson and Renault, 2006). In order to produce close matches in each case, we conduct a Mahalanobis matching determining a pairwise distance between bonds based on these characteristics. The Mahalanobis metric is used in such cases as it accounts for differences in variances and correlations between variables using a covariance matrix C. The Mahalanobis distance metric is calculated in the following way

$$d_{MM}(i,j) = (X_i - X_j)' \, C^{-1} \, (X_i - X_j) \,. \tag{1}$$

X_i and X_j are vectors of k characteristics of a bond i that is guaranteed and a bond j that is not guaranteed. For each guaranteed bond, we match the bond of the same issuer with the lowest Mahalanobis distance d_{MM}. The matching is conducted with replacement in

[3] Interestingly, van Binsbergen et al. (2022) estimates the convenience yield of government securities to amount to approximately 40 basis points using the put-call parity of European-style options, which is quite close to the difference between government rates and swap rates in our sample.

order to find closer matches.[4]

4.2. Data

We create the sample *group of guaranteed bonds (treatment group)* based on the official ISIN lists for the guarantee programs published by the seven countries with a AAA rating throughout the period from 2008 to 2014 (Austria, Denmark, Germany, the Netherlands, Sweden, the United Kingdom, and the United States).[5] We also collect bond characteristics for all non-guaranteed bonds from the same issuers for our *group of non-guaranteed bonds (control group)*. Then, we collect information on bond characteristics from Refinitiv Eikon. We restrict the sample to plain vanilla coupon unsecured bonds that are non-callable to assess bonds with similar bond characteristics.[6] Then, we collect daily time-series data for these bonds from Refinitiv Datastream. As filters for the data, we keep only observations with actually traded price data available and require a minimum time to maturity of 180 days. The data period of our final matched sample depends on the specific guarantee program and the available observations, and in total ranges from February 2008 (first issuance) until September 2014 (last maturity).

Table 2 shows the mean characteristics of treatment and control bonds in the unmatched case and after the matching. When looking at the coupon and the maturity, there are considerable differences between the treatment and control sample in the unmatched case. The coupons of guaranteed bonds are initially lower and these bonds have an earlier maturity. This is different for the matched sample. The coupon only differs by 0.001 and the maturity differs by less than two months.

[4] The results are robust for conducting the matching without replacement.

[5] As we cannot find any matches for danish bonds, our analysis is based on the six remaining countries.

[6] For the same reason, we also restrict the sample to bonds of the seniority categories *unsecured* or *senior unsecured*.

Table 2: Matching results

	Total Sample			Matched Sample		
	Treatment	Control	Diff.	Treatment	Control	Diff.
Coupon	2.522	4.188	-1.666***	2.774	2.869	-0.095
			(-28.028)			(-0.65)
Maturity	2012-04-29	2014-11-24	-939.506***	2012-06-21	2012-08-10	-50.425
			(-33.022)			(-0.654)
N	174	3,755		40	40	

This table shows the results of our matching described in Section 4. The table contains the means for the treatment and the control group before and after the matching. We calculate the difference between the two groups and test for its significance with a t-test. The maturity is the average date of maturity, the difference is given in days. Standard errors in parentheses, significance levels are indicated by $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$.

5. Results

5.1. Main analysis

The most central results regarding the share of credit risk in credit spreads are then presented in Table 3. We calculate the mean of the credit spread for the treatment and the control group in the second and the third column. The corresponding mean of the difference between these spreads is then presented in column four, including a pairwise t-test. The table lists results for the case of government debt security yields as risk-free rate CS_{BMK} and the swap rate as risk-free rate CS_{SR}. For CS_{BMK}, the spread over government securities of risk-free bonds is 46.5 basis points and the one for risky bonds at 132.1 basis points. Interestingly, the lower spread corresponds well to the 40 basis points van Binsbergen et al. (2022) estimates as the value of convenience of holding government securities. The credit spreads calculated by using the government benchmark rate might, therefore, be overestimated. The difference between the groups is 85.2 bps or 64.5% of the credit spread for bonds without guarantee. Therefore, if we relate these results to earlier studies that use credit spreads based on government rates as risk-free rates, we would conclude that the share of default risk is relatively high compared to earlier studies. The remaining share of the credit spread of around 35.5% could then result from other factors such as liquidity risk. However, it could also be linked to the convenience of holding government securities.

In order to have results that are cleaner of this convenience effect, as rates for government securities could lie below the risk-free rate, we further present results in the lower part of Table 3. The mean CS_{SR} for the treatment sample is 3.5 bps and, in this way, close to zero. The credit spread for the control sample, in contrast, is 88.9 bps. The difference between these bonds is 85.4 bps or 96.1% of the credit spread. These numbers are quite interesting in multiple ways. If we assume that the swap rate is a choice for the risk-free rate that is less influenced by the convenience of holding government securities, this would indicate that the share of credit risk in these bonds makes up almost the full size of the credit spread. This would empirically support recent studies arguing in this direction such as Feldhütter and Schaefer (2018), Culp et al. (2018), Du et al. (2019), or Elkamhi et al. (2021). In addition, these results could be regarded as empirical support for the government convenience yield as determined by van Binsbergen et al. (2022).

Table 3: Matching results – Outcome

	Treatment	Control	Diff.
Spread BMK	46.546	132.092	-85.546***
			(-121.354)
Spread SR	3.155	88.899	-85.744***
			(-143.055)
N	15,355	15,355	

This table shows the means in the credit spread measures for the treatment and control group, the corresponding differences, and the related test statistics of a pairwise t-test. Standard errors in parentheses, significance levels are indicated by $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$.

In order to have a more detailed analysis of the possible sensitivity of these results, we also calculate these results grouped by time, geography, and the bond issuer rating class. This is done, presenting results grouped by country, year, and rating category, respectively. We present results based on the swap rate.[7] These results are presented in Figures 1 to 3.[8] When assessing the results for individual years, the credit spreads of the guaranteed bonds

[7] Results for the government rate are available on request.

[8] The corresponding tables with means, differences and test statistics similar to Table 3 are shown in the Appendix in Tables A.2, and A.3, and A.4.

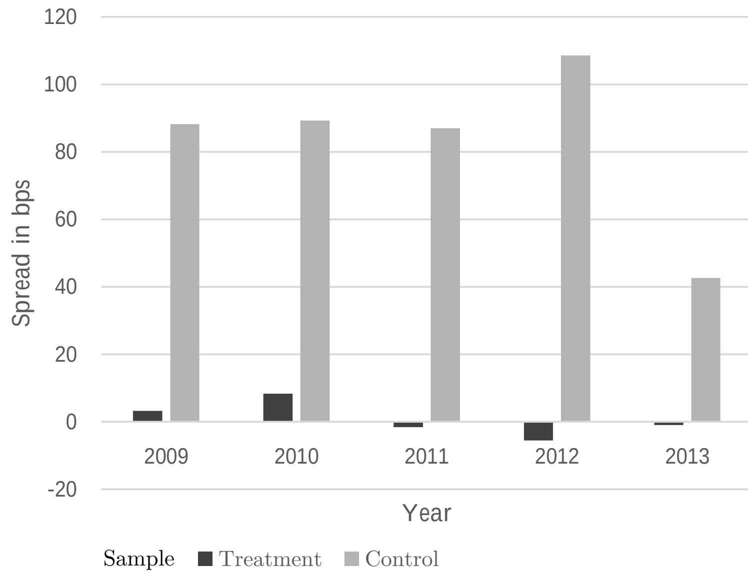

Figure 1: Differences in the credit spread between bonds: different years

This figure displays differences in the credit spread, measured as difference between the bond yield and the corresponding swap rate curve between the treatment (black) and the control (grey) sample for the respective years of the sample.

tend to fluctuate closely around zero. In contrast, the credit spread for the non-guaranteed bonds for the years 2009 to 2012 fluctuates between 80 and 100 bps. The credit spread for the non-guaranteed is lower for the year 2013. However, this effect results from programs in some countries expiring. Following our line of argument, the share of credit spreads in these bonds consistently makes up almost the whole credit spread of the non-guaranteed bonds.

When assessing the results for the individual countries, the spreads for the guaranteed bonds from Austria, the United Kingdom, and the Netherlands are slightly above zero. After all guaranteed bonds had matured, these three countries later went through rating downgrades, at least for some rating agencies. The credit spreads above zero might already indicate some anticipation of these later rating downgrades. The spreads for bonds from Sweden, Germany, and the US are closely below zero on average. The U.S. did later undergo some rating downgrade, at least for Standard & Poor's. However, this could indicate that the U.S. were still perceived as free of default risk by the market. When assessing the results over the individual countries, the guaranteed bonds consistently have a credit spread close to zero. In this way, almost the full size of the credit spreads of the guaranteed bonds could be regarded

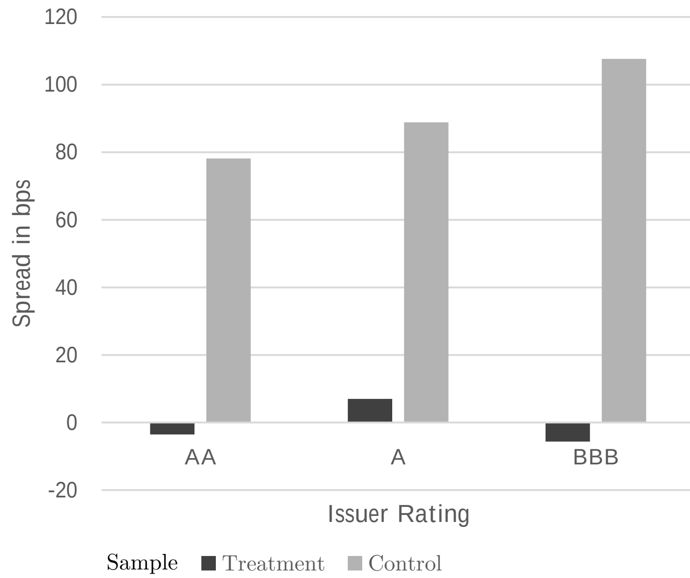

Figure 2: Differences in the credit spread between bonds: different issuer ratings

This figure displays differences in the credit spread, measured as difference between the bond yield and the corresponding swap rate curve, between the treatment (black) and the control (grey) sample for the rating category of the bond issuer.

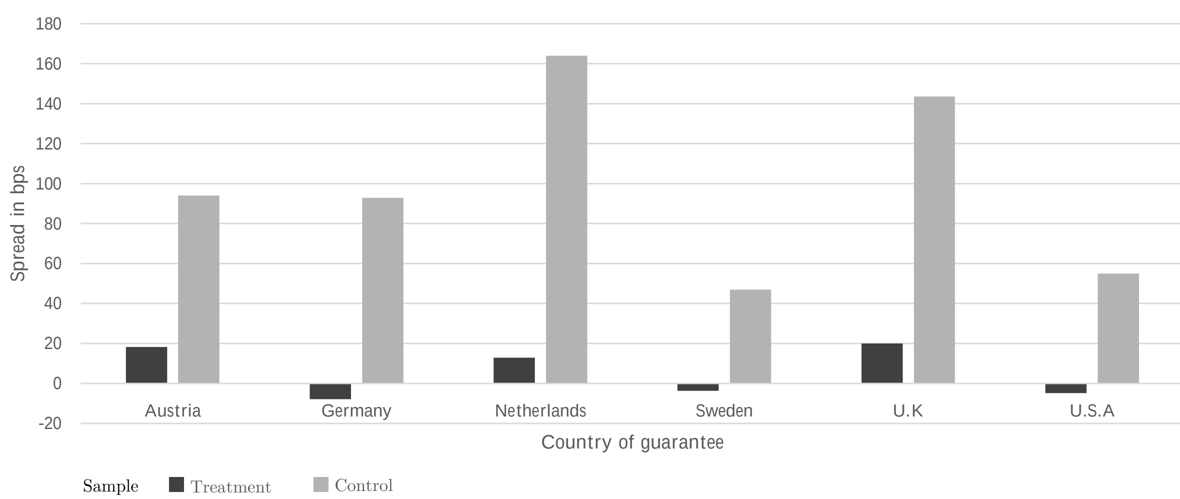

Figure 3: Differences in the credit spread between bonds: different guarantee countries

This figure displays differences in the credit spread measured as difference between the bond yield and the corresponding swap rate curve, between the treatment (black) and the control (grey) sample for the country of the guarantee.

as compensation for default risk. When assessing the credit spreads for individual rating classes, one can observe that the credit spreads for the guaranteed bonds fluctuates around zero and do not correlate with decreasing rating classes. This is an important observation as it indicates that the pricing of these guaranteed bonds is, in fact, considered independent of the credit risk of the individual issuers. The credit risk component again makes up about the total size of the credit spread. As one would expect, the credit spread for the non-guaranteed bonds increases with a decreasing credit quality of the issuers.

5.2. Liquidity

Until this point in the baseline analysis in Section 5, we abstracted to some degree from the influence of liquidity risk, which could influence the credit spreads. Bond liquidity is commonly accepted to be a factor that is priced in credit spreads besides credit risk and presents a possible solution to the credit spread puzzle (e.g., Longstaff et al., 2005, Bao et al., 2011, Dick-Nielsen et al., 2012, Helwege et al., 2014). In this section, we present robustness checks that assess the sensitivity of the results to potential differentials in liquidity.

We do this by presenting the matching analysis as described in Section 4 and Section 5 while further looking at subsamples where the treatment and respective control observations are particularly similar in terms of liquidity. We do this based on the bid-ask spread as a very common measure of liquidity. Summary statistics of the bid-ask spread in the treatment and control sample, including the respective differences, are given in Table 4.

The results for similar liquidity measures are presented in Table 5. The table includes results for increasing levels of similarity in the bid-ask spread starting from -0.12% to 0.03% difference to a -0.01% to 0.01% difference in the closest matching. We find similar results as

Table 4: Summary statistics - bid-ask spread

Variable	N	Mean	Std. Dev.	Min	Max
$bidaskspread_{Treat}$	15,355	0.241	0.157	0	2.036
$bidaskspread_{Control}$	13,114	0.294	0.289	-0.129	2.293
$bidaskspread_{Diff}$	13,114	-0.061	0.329	-1.92	1.792

This table shows summary statistics for the bid-ask spreads in the matched data sample described in Section 4. The bid-ask spread is displayed for the treatment group, the control group and as the difference between each bond pair. The bid-ask-spread is given in percentage of the corresponding mid-price.

Table 5: Results - Control for similar liquidity

	Treatment	Control	Diff.
	$> -0.120 < 0.030$		
Spread BMK	34.524	101.254	-66.730***
			(-76.068)
Spread SR	-1.613	65.285	-66.898***
			(-89.669)
N	6,302	6,302	
	$> -0.100 < 0.100$		
Spread BMK	38.715	105.811	-67.096***
			(-76.451)
Spread SR	0.510	67.696	-67.186***
			(-90.681)
N	6,756	6,756	
	$> -0.050 < 0.050$		
Spread BMK	34.659	97.770	-63.111***
			(-72.556)
Spread SR	-0.851	62.460	-63.311***
			(-83.624)
N	5,599	5,599	
	$> -0.025 < 0.025$		
Spread BMK	29.911	89.617	-59.706***
			(-66.213)
Spread SR	-2.925	56.797	-59.722***
			(-73.438)
N	4,519	4,519	
	$> -0.010 < 0.010$		
Spread BMK	27.550	83.782	-56.232***
			(-58.953)
Spread SR	-3.643	52.585	-56.228***
			(-63.728)
N	3,531	3,531	

This table shows the means of the credit spreads for the treatment and the control group, respectively. We restrict the sample to matched time-series observations which differ only up to a specific level concerning the bid-ask-spread of the bonds. The bid-ask-spread is the spread between bid and ask price, relative to the midprice, in percent. Standard errors in parentheses, significance levels are indicated by $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$.

in the main analysis in Section 5. The overall difference between the treatment and control group is a bit lower between 55 to 65 basis points (compared to 85 bps in the main analysis). The credit spread for the treatment sample is between 27.6 and 34.5 bps and, in this way, in a similar magnitude as in the main analysis. For the credit spread measured by the swap rate, it is quite interesting that this spread is consistently around zero for the treatment sample. In this way, we could interpret these results as about 100% of the credit spread of the control group resulting from credit risk.

6. Conclusion

The question which share of the credit spread is attributable to credit risk has been widely discussed. In particular, many previous studies have investigated it from a conceptual level. Interestingly, the results vary widely, emphasizing the need for empirical identification strategies to determine the share which actually should be assigned to credit risk. Yet only very few papers attempt to provide empirical identification strategies for this problem. We propose a novel approach based on causal inference, using a set of quasi-natural experiments enabling the comparison of bonds with and without default risk from the same issuers with nearly the same features. This setting creates a direct measure of the impact of default risk on the spread. Remarkably, we find that default risk makes up almost the entire spread. In this respect, our study supports arguments and models that assign a very high share of the spread to default risk.

Appendix A. Sample Appendix Section

Table A.1: Description of variables

Variable	Description	Data Source
Static bond characteristics		
Coupon	Coupon rate of the bond, in percent	Eikon
Maturity	Maturity of the bond (date), differences and standard deviations are expressed in days	Eikon
Log issue volume	Logarithm of the issue volume of the bond in USD, if in foreign currencies, we calculate the adequate USD amount by the corresponding exchange rate at issuance day	Eikon
Time series characteristics		
Credit spread (swap rate)	Credit spread measured with the corresponding swap rate	Datastream
Credit spread (government rate)	Credit spread measured with the corresponding government benchmark rate	Datastream
Bid-ask spread	The difference in bid and ask price relative to the mid-price of the bond in percent.	Datastream

This table presents the definitions of the variables used for our analysis and the corresponding data sources.

Table A.2: Matching results – Outcome by year

	Treatment	Control	Diff.
		2009	
Spread BMK	47.556	132.642	-85.086***
			(-40.917)
Spread SR	3.206	88.219	-85.013***
			(-43.272)
N	1,727	1,727	
		2010	
Spread BMK	47.766	128.697	-80.931***
			(-87.779)
Spread SR	8.277	89.262	-80.985***
			(-101.927)
N	7,087	7,087	
		2011	
Spread BMK	43.533	131.404	-87.871***
			(-66.764)
Spread SR	-1.566	87.027	-88.593***
			(-81.016)
N	4,636	4,636	
		2012	
Spread BMK	54.302	168.503	-114.201***
			(-37.396)
Spread SR	-5.552	108.546	-114.098***
			(-46.146)
N	1,448	1,448	
		2013	
Spread BMK	29.800	74.250	-44.450***
			(-20.198)
Spread SR	-0.972	42.585	-43.557***
			(-19.675)
N	457	457	

This table shows the means in the credit spread measures for the treatment and control group, the corresponding differences, and the related test statistics of a pairwise t-test, grouped by the years of the observation period. Standard errors in parentheses, significance levels are indicated by $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$.

Table A.3: Matching results – Outcome by rating

	Treatment	Control	Diff.
		AA	
Spread BMK	24.865	105.951	-81.086***
			(-126.869)
Spread SR	-3.535	78.098	-81.633***
			(-122.45)
N	3,293	3,293	
		A	
Spread BMK	50.877	132.432	-81.555***
			(-82.975)
Spread SR	7.011	88.838	-81.827***
			(-95.226)
N	10,127	10,127	
		BBB	
Spread BMK	60.776	174.796	-114.020***
			(-91.984)
Spread SR	-5.636	107.602	-113.238***
			(-134.505)
N	1,935	1,935	

This table shows the means in the credit spread measures for the treatment and control group, the corresponding differences, and the related test statistics of a pairwise t-test, grouped by the credit rating of the issuer. Standard errors in parentheses, significance levels are indicated by $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$.

Table A.4: Matching results – Outcome by country

	Treatment	Control	Diff.	Treatment	Control	Diff.
	Austria			Germany		
Spread BMK	79.186	153.691	-74.505***	56.175	157.938	-101.763***
			(-44.037)			(-108.815)
Spread SR	18.217	94.063	-75.846***	-7.822	92.875	-100.697***
			(-61.801)			(-143.007)
N	1,570	1,570		1,565	1,565	
	Netherlands			Sweden		
Spread BMK	63.932	214.193	-150.261***	44.728	94.941	-50.213***
			(-73.383)			(-44.595)
Spread SR	12.879	163.957	-151.078***	-3.620	46.965	-50.585***
			(-89.094)			(-76.844)
N	2,159	2,159		1,812	1,812	
	United Kingdom			United States		
Spread BMK	69.218	193.200	-123.982***	23.029	82.634	-59.605***
			(-60.865)			(-85.768)
Spread SR	20.061	143.528	-123.467***	-4.776	55.023	-59.799***
			(-63.158)			(-85.582)
N	2,023	2,023		6,226	6,226	

This table shows the group in the credit spread measures for the treatment and control group, the corresponding differences, and the related test statistics of a pairwise t-test, grouped by the country of guarantee. Standard errors in parentheses, significance levels are indicated by $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$.

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