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Corporate Structure Complexity and Cost of Debt

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Abstract

This paper investigates how a firm's cost of debt is related to the complexity of its corporate structure. Our hand-collected data sample covers 3271 loan-year observations of 815 publicly listed US firms for the period between 2012 and 2017. The results show a positive and significant relationship between corporate structure complexity and cost of debt. More complex firms are also found to have lower debt ratings and more financial covenants enclosed in their loan contracts. These findings suggest that greater corporate structure complexity is associated with increased credit risk. Instrumental variable analysis and a number of additional tests further confirm our results. Our results also hold for corporate bonds.

1. Introduction

As competition for credit continues to increase across financial markets, finding ways to ensure a continual cost-effective supply is paramount for corporate survival (Baumöhl et al., 2019). The extant literature has identified a number of factors that affect financing costs such as taxes (Graham and Tucker, 2006), corporate social performance (Magnanelli and Izzo, 2017), adverse selection (Myers and Majluf, 1984), investment opportunities (Houston and James, 1996), innovation (Mann, 2018), legal structure (Sikoichi, 2020), and size (Graham et al., 2008), among others. One characteristic, however, that has received little attention in the literature is the complexity of the corporate structure.

Organizations, or firms, are entities with a formal autonomous legal status being put under a common control exerted by a parent entity in a network-like hierarchical organization of economic activities, normally referred to as subsidiaries. Specifically, the parent company may own and control several subsidiaries. In turn, each of these subsidiaries may own and control other lower-level subsidiaries, and so on, forming a hierarchical structure. The complexity of the corporate structure increases when subsidiaries are added to the structure at different hierarchical levels.

Why should corporate structure complexity impact financing costs? First, the recovery risk is higher for loans to firms with greater corporate structure complexity. The reason is that the parent company can transfer assets funded by raising debts to

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its subsidiaries (Squire, 2011; Fang et al., 2017; Sikochi, 2020). Lenders can include covenants in loan contracts allowing them to recoup such assets in the case of default, but there are limitations and costs associated with enforcing these covenants (Jensen and Meckling, 1976; Whittred, 1987; Sikochi, 2020). When the corporate structure is more complex, the parent firm can spread the assets among a greater number of subsidiaries and across different hierarchical levels. As a result, it is harder for lenders to recoup the assets, thus the recovery risk is higher. Furthermore, it is more difficult for lenders to effectively analyse and monitor the credit profile of a more complex firm (i.e. monitoring risk). This is because the parent firm may manipulate its consolidated financial reports using complicated financial transactions with and among the subsidiaries (Thomas et al., 2004; Fang et al., 2017; Beuselinck et al., 2019). Increase in the number of hierarchical levels makes it harder to detect these transactions since subsidiary-related financial information can be left out during the consolidation process at each hierarchical level (Demski, 1973; Beaver et al., 2019; Gul et al., 2017). Overall, these reasons suggest that firms with higher corporate structure complexity are associated with greater credit risk. As a result, lenders will charge them higher costs of debt to account for such risk. This is our main hypothesis.

On the other hand, some previous studies indicate that the parent-subsidiaries structure allows the parent firm to access the resource of its subsidiaries when it needs financial support, reducing the risk of default and also lowering the demand for external debts (Desai et al., 2004; Khanna and Yafeh, 2005; Byun et al., 2013; Beaver et al., 2019). In this case, increase in corporate structure complexity should lower the firm's cost of debt. As a result, while our main hypothesis is that the cost of debt is positively associated with corporate structure complexity, the relationship between corporate structure complexity and cost of debt needs empirical inquiry.

To empirically test this relationship, we collect data on the corporate structure, namely the number of subsidiaries at each hierarchical level, of a large sample of publicly listed US firms from the Bureau van Dijk (BvD) database for the period from 2012 to 2017. We then follow Altomonte and Rungi's (2013) method to calculate a continuous variable representing the complexity of the corporate structure[1]. This method estimates the complexity based on node entropy (Emmert-Streib and Dehmer, 2007), taking into account the graph-like hierarchical nature of the corporate structure. Using this data on corporate structure complexity, along with the data on private bank loans extracted from the Thomson Reuters LPC DealScan database, our regression result for 3,271 loan facilities shows that firms with more complex corporate structure are associated with higher costs of debt. Specifically, we find that a one standard deviation rise in corporate structure complexity results in an additional interest charge of $1.04 million for an average loan size of $370 million over a term to maturity of 4 years. In addition, we find that these firms have lower credit ratings and more financial covenants specified in their loan contracts. This further supports our argument that lenders consider credit risk of more complex firms to be greater. We also show that, in addition from private bank debts, our main hypothesis holds for corporate bonds. We conduct several tests to address the endogeneity concern that high costs of debt could be the reason parent firms increase

[1] We discuss the variable in details in the Data and Method section.

the number and layer of subsidiaries in the first place in order to access more subsidiaries' financial resources as an alternative form of funding. First, we include loan deal and firm fixed effects in the regression. Second, we employ audit fees as well as the number of vice presidents as instrumental variables for two-stage-least-squares (2SLS) analyses. The results of these tests support the notion that corporate structure complexity leads to higher cost of debt.

This paper contributes to the literature in several ways. First, it adds to the literature on factors affecting the cost of debt. The literature has examined a wide range of factors including taxes (Graham and Tucker, 2006), corporate social performance (Magnanelli and Izzo, 2017), analyst forecast characteristics (Mansi et al., 2011), adverse selection (Myers and Majluf, 1984), investment opportunities (Houston and James, 1996), innovation (Mann, 2018), legal structure (Sikochi, 2020), ownership structure (Sánchez-Ballesta and García-Meca, 2011), board characteristics (Anderson et al., 2004), and size (Graham et al., 2008). Our paper adds that corporate structure complexity is also a factor that impacts the cost of debt.

Our paper also contributes to the literature on firm complexity. Cetorelli and Goldberg (2014) propose that firm complexity is related to business complexity, which is defined as the number of lines of business conducted by the firm, and structural complexity, which is defined as the extent to which firms are structured through separate affiliated entities (i.e. corporate structure complexity). While it is quite straight forward to estimate business complexity, there has not been a consensus on calculating structural complexity. Cetorelli and Goldberg (2014) use the number of subsidiaries as a simple measure of corporate structure complexity. Most of the subsequent studies in this stream of literature employ this measure (Argimón and Rodríguez-Moreno, 2020; Sikochi, 2020; Li et al., 2023). The simple count of subsidiaries, however, does not take into account the fact that subsidiaries are placed at different hierarchical levels, with varied number of subsidiaries at each level. In this paper, we employ Altomonte and Rungi's (2013) method to calculate a measure that reflects the web-like hierarchical nature of the corporate structure and show that it has a positive relationship with the cost of debt.

The rest of this paper is structured as follows. Section 2 describes the data and research methodology used. Section 3 presents the empirical results. We discuss and conclude this paper in Section 4.

2. Data and Method

2.1 Measure of Corporate Structure Complexity

Corporate structure complexity is jointly determined by the number of hierarchical levels and the number of subsidiaries placed at each level (Colombo and Delmastro, 2008). Based on hierarchical graph theory, each subsidiary can be represented as a node in the structure (Emmert-Streib and Dehmer, 2007). The relationship between higher- and lower-level firms are the edges that connect the nodes. This allows the top node at the highest level to connect to and control other nodes at lower levels through several chains, which is analogous to the case when the parent firm controls and coordinates lower-level subsidiary activities. We employ Altomonte and Rungi's (2013) method and measure the complexity of this graph-like structure as:

$$\text{COMPLEXITY} = \sum_{l}^{L} l * \frac{n_l}{N} * \ln(\frac{N}{n_l}) \quad (1)$$

where l represents the given level of the subsidiary, n_l stands for the number of subsidiaries at each level l; N and L indicate the total number of subsidiaries and the total number of levels in a structure, respectively. Essentially, the measure is the sum of the entropy-based complexity of each level (the product of n_l/N and ln (N/n_l)) weighted by the level l. This measure is continuous, ranging from zero to infinity. A value of zero indicates the simple structure where the parent firm has one or more direct subsidiaries without lower-level subsidiaries.

There are some important characteristics of this measure that suits our investigation. The first is that with the same number of subsidiaries, COMPLEXITY increases when there are more hierarchical levels in the corporate structure. This is consistent with our reasoning that more monitoring effort from lenders is needed when there is a greater number of consolidation layers. Second, given the same number of subsidiaries and levels, the entropy-based measure should be higher when the subsidiaries are distributed more evenly across levels than when they are clustered at some specific levels. This shows the increased number of possible control lines linking the parent company to the subsidiaries (i.e. more options for the parent firm to transfer assets to subsidiaries and coordinate subsidiary financials to mask such activities). Furthermore, the monitoring attention of lenders now needs to span across the hierarchical levels rather than on only some specific levels where the subsidiaries are clustered, leading to more monitoring effort. Appendix A provides an illustration of this corporate structure complexity measure.

2.2 Baseline Regression Model

We employ the following panel regression model:

$$\begin{aligned} SPREAD_{i,t} = \beta_0 \; & + \beta_1 COMPLEXITY_{i,t-1} + \beta_2 NSUB_{i,t-1} + \beta_3 NBSEG_{i,t-1} \\ & + \sum \gamma_1' Loan\ characteristics_{i,t} \\ & + \sum \gamma_2' Firm\ characteristics_{i,t-1} + YEAR + INDUSTRY \\ & + \varepsilon_{i,t} \end{aligned} \quad (2)$$

where cost of debt is proxied by the loan spread (SPREAD), which is the natural logarithm of the amount of the loan interest payment in basis points over LIBOR (or LIBOR equivalent) for each dollar drawn down (i.e. the all-in-drawn-spread) for loan facility i a firm obtains in year t (Graham et al., 2008; Ertugrul et al., 2017). COMPLEXITY is the corporate structure complexity measure as described in Section 2.1. We control for the firm's number of subsidiaries (NSUB) and number of business segments (NBSEG) to ensure that the corporate structure complexity measure is not simply picking up a simple subsidiary count or the business complexity, but rather the complexity of the organizational structure (Cetorelli and Goldberg, 2014; Sikochi, 2020). Following the literature on cost of debt (Graham et al., 2008; Mansi et al., 2011; Hasan et al., 2014; Ertugrul et al., 2017; Sikochi, 2020),

we control for loan characteristics, including loan amount (AMOUNT), loan maturity (MATURITY), loan syndication (SYNDICATION), loan type (TERM), loan purposes (REFINANCE), and rating (RATING). We also control for a number of firm characteristics, including firm size (ASSETS), sales (SALES), leverage (LEVERAGE), market-to-book (MTB), cash holding (CASH), profitability (ROA), growth potential (SALESGROWTH), earnings volatility (EARNVOL), and creditworthiness (ZSCORE). We calculate the complexity-related variables (COMPLEXITY, NUMSUB, NUMBSEG) and firm characteristics using lagged information from the year immediately prior to the inception of a loan facility to partially mitigate potential endogeneity issues. Lastly, we include dummy variables to control for year fixed effects and two-digit Standard Industrial Classification (SIC) industry fixed effects in the regression model. The variables are described in detail in Table 1.

Table 1 Variables Description

Variable	*Description*	*Source*
Dependent variable		
SPREAD	The basis points (bps) a borrower pays in excess of the London Interbank Offered Rate (LIBOR) or LIBOR equivalent for each dollar drawn down (all-in-drawn-spread), in natural logarithm.	DealScan
Complexity-related variables		
COMPLEXITY	Corporate structure complexity.	BvD
NSUB	The number of subsidiaries, in natural logarithm.	BvD
NBSEG	The number of business segments, in natural logarithm.	Compustat
Loan characteristics		
AMOUNT	The loan amount (million USD), in natural logarithm.	DealScan
MATURITY	The number of months between the loan's issue date and the date when the loan matures, in natural logarithm.	DealScan
SYNDICATION	Indicator variable equal to 1 if the loan is issued by a syndicate and 0 if otherwise.	DealScan
TERM	Indicator variable equal to 1 if the loan is a term loan and 0 if otherwise.	DealScan
REFINANCE	Indicator variable equal to 1 if the loan is for refinancing purpose and 0 if otherwise.	DealScan
RATING	Indicator variable equal to 1 if the loan is rated investment grade and 0 if otherwise.	DealScan
Firm characteristics		
ASSETS	Total assets (million USD), in natural logarithm.	Compustat
SALES	Sales (million USD), in natural logarithm.	Compustat
MTB	Market-to-book ratio.	Compustat
CASH	Cash-to-total assets ratio.	Compustat
ROA	Return-on-assets ratio.	Compustat
SALESGROWTH	Change in sales from year *t-1* to year *t*.	Compustat
EARNVOL	Earnings volatility, measured as the standard deviation of firm's quarterly earnings scaled by total assets for the previous five years.	Compustat
LEVERAGE	Leverage, measured by total debt to total assets ratio.	Compustat
ZSCORE	Creditworthiness, indicated by the Z-score, calculated as (1.2×WCAP +1.4×RE + 3.3×PI +0.999×SALE)/AT, where WCAP is working capital, RE is retained earnings, PI is pretax income, SALE is total sales, and AT is total assets.	Compustat

2.3 Data Collection

Our sample is an unbalanced cross-industry panel of private bank loans to publicly traded US firms for the period from 2012 to 2017. We draw on the Bureau van Dijk (BvD) database, which contains detail data and information for the subsidiaries of firms, to construct each firm's hierarchical structure which allows us to calculate the corporate structure complexity measure[2]. We obtain information for loan facilities from the Thomson Reuters LPC DealScan database. DealScan provides comprehensive coverage of US loan facilities including loan spreads, size, maturity, types, purposes, syndication, rating, covenants, and identities of the lending banks. DealScan collects the loan information from Securities and Exchange Commission (SEC) filings and from voluntary disclosures provided by participating banks. The basic unit of loans is a lending facility. A firm can obtain multiple facilities with the same loan package in a contract year, and loan terms could differ across these facilities. Following related studies (Mansi et al., 2011; Hasan et al., 2014; Sikochi, 2020), we treat each loan facility-year as a distinct observation. We match the same firm-year information to multiple loan facility-year observations if a firm obtains multiple loan facilities in a year. The main outcome and control variables are based on data available from the Compustat database. Following existing literature, we remove all firms with the standard industrial classification (SIC) code between 6000-6999 (representing financial firms) and SIC code between 4900-4999 (representing utility firms). After dropping observations with missing values for the control variables, the final sample consists of 3,271 loan facility-year observations of 815 unique firms.

2.4 Summary Statistics and Univariate Analysis

Table 2 provides the summary statistics for the variables. On average, a loan facility in our sample has a spread of about 173.97 bps ($e^{5.1589}$) with the amount of 370 million USD ($e^{5.9152}$) for a maturity term of 50 months ($e^{3.9164}$), which is about 4 years. This is quite similar to that of the data samples described in Hasan et al. (2014) and Sikochi (2020). The average firm has about 75 subsidiaries ($e^{4.3189}$) and a COMPLEXITY measure of 0.0245.

For univariate analysis, we divide the sample into 5 quintiles based on the value of COMPLEXITY. For each variable, we conduct a *t*-test for the difference in means between the top and bottom quintiles to compare the characteristics of firms having high and low corporate structure complexity. Table 3 shows that the average value of SPREAD increases monotonically with COMPLEXITY, from 4.9446 in the bottom quintile to 5.2883 in the top quintile and the difference between the top and bottom quintiles (0.3437) is statistically significant at the 1% level. This is preliminary evidence of a positive relationship between corporate structure complexity and cost of debt. We also find that the average value of RATING decreases monotonically with COMPLEXITY, from 0.9084 in the bottom quintile to 0.3226 in the top quintile and the difference between the top and bottom quintiles (-0.5858) is statistically significant at the 1% level. This is an indication that credit

[2] A subsidiary must be owned at least 20% by the immediate parent firm. The results are qualitatively similar when using a 50% ownership threshold.

rating worsens when corporate structure complexity increases. Table 3 also shows that, on average, firms with higher corporate structure complexity tend to raise debts in smaller amounts with longer maturity.

Table 2 Summary Statistics

Variable	*N*	*Mean*	*Standard deviation*
*SPREAD**	3271	5.1589	5.0398
COMPLEXITY	3271	0.0245	0.0250
*NSUB**	3271	4.3189	1.2906
*NBSEG**	3271	0.4296	0.4768
*AMOUNT**	3271	5.9152	1.2327
*MATURITY**	3271	3.9164	0.4777
SYNDICATION	3271	0.9437	0.2304
TERM	3271	0.3650	0.4815
REFINANCE	3271	0.0321	0.1763
RATING	3271	0.6212	0.4852
*ASSETS**	3271	0.2670	0.2244
*SALES**	3271	7.8564	1.3871
MTB	3271	3.3820	2.6731
CASH	3271	0.0994	0.0944
ROA	3271	0.1463	0.0680
SALESGROWTH	3271	0.0802	0.1528
EARNVOL	3271	0.5065	0.4604
LEVERAGE	3271	0.3067	0.1762
ZSCORE	3271	1.6791	1.0227

Notes: * indicates variables measured in natural logarithm.

We also examine the correlation among the variables and conduct VIF analysis. The results indicate no multicollinearity issue. For brevity we do not report these results[3].

[3] The correlation matrix and VIF results are available upon request.

Table 3 Univariate Analysis

	LOW COMPLEXITY			⟶ *HIGH COMPLEXITY*		*Difference*
Variable	*Quintile 1*	*Quintile 2*	*Quintile 3*	*Quintile 4*	*Quintile 5*	*(Quintile 5 – Quintile 1)*
SPREAD	4.9446	5.1202	5.1908	5.2507	5.2883	0.3437***
COMPLEXITY	0.0018	0.0072	0.0155	0.0306	0.0672	0.0654***
NSUB	4.2746	4.1424	4.3929	4.4393	4.3456	0.0710
NBSEG	0.5382	0.3696	0.4157	0.4438	0.3807	-0.1575***
AMOUNT	6.6832	6.0225	6.0097	5.7266	5.1326	-1.5506***
MATURITY	3.7448	3.8906	3.9711	3.9889	3.9869	0.2421***
SYNDICATION	0.9695	0.9541	0.9557	0.9373	0.9021	-0.0674***
TERM	0.2702	0.3670	0.4113	0.4006	0.3761	0.1059***
REFINANCE	0.0198	0.0306	0.0489	0.0306	0.0306	0.0108
RATING	0.9084	0.7034	0.6177	0.5535	0.3226	-0.5858***
ASSETS	0.4110	0.2752	0.2374	0.1890	0.2221	-0.1889***
SALES	8.9352	7.9791	7.9135	7.5023	6.9501	-1.9851***
MTB	3.1386	3.6396	3.5525	3.4371	3.1427	0.0041
CASH	0.0827	0.1028	0.1058	0.1074	0.0982	0.0155**
ROA	0.1326	0.1572	0.1421	0.1462	0.1533	0.0207***
SALESGROWTH	0.0429	0.1108	0.0723	0.0761	0.0987	0.0558***
EARNVOL	0.6199	0.5535	0.5148	0.4405	0.4037	-0.2162***
LEVERAGE	0.3237	0.3282	0.2979	0.3033	0.2802	-0.0435***
ZSCORE	1.3160	1.5322	1.7491	1.8135	1.9854	0.6694***

Notes: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

3. Empirical Results

3.1 Baseline Results

The first and second columns in Table 4 present the baseline results for the regression specified in Equation (2), without and with control variables, respectively. We discuss the full model result in the second column. The coefficient for COMPLEXITY is positive (1.5872) and is statistically significant at the 1% level. This strongly supports our main hypothesis that firms having higher corporate structure complexity pay more for their debts. The coefficient implies that, a one standard deviation increase in COMPLEXITY (0.0250, see Table 2) would raise SPREAD by 0.0397 (0.0250×1.5872=0.0397). Since SPREAD is a measure in natural logarithm of loan spread, this would mean a rise of 4.05% in loan spread ($e^{0.0397}$-100%=4.05%). As the average loan spread is about 173.97 bps (see Section 2.4), the average rise is 7.05 bps (173.97×4.05%=7.05). For the average loan facility in the sample with the amount of 370 million USD and a maturity term of 4 years

(see the description in Section 2.4), a 7.05 bps increase in loan spread would translate to be an additional 1.04 million USD in interest charge (7.05×370×4×0.01%=1.04). This is a substantial increase in the cost of debt for the borrowing firm.

Table 4 Baseline Regressions

Dependent variable: SPREAD	*Industry FE*		*Firm and Loan deal FE*	
	(1)	*(2)*	*(3)*	*(4)*
COMPLEXITY	1.5965***	1.5872***	1.4575***	1.3932**
	(0.5156)	(0.5168)	(0.5603)	(0.6209)
NSUB		-0.0309**		-0.0145
		(0.0136)		(0.0110)
NBSEG		-0.0628***		-0.0634
		(0.0217)		(0.0393)
AMOUNT		-0.0101		-0.0032
		(0.0108)		(0.0069)
MATURITY		-0.0486**		-0.0065
		(0.0216)		(0.0206)
SYNDICATION		-0.0555*		-0.0135
		(0.0329)		(0.0348)
TERM		0.1879***		0.0726***
		(0.0154)		(0.0090)
REFINANCE		0.1570***		0.1042***
		(0.0459)		(0.0289)
RATING		-0.0498*		-0.0195
		(0.0267)		(0.0393)
ASSETS		-0.1388*		0.1696
		(0.0819)		(0.1791)
SALES		-0.0786***		0.0018
		(0.0157)		(0.0429)
MTB		-0.0201***		0.0033
		(0.0042)		(0.0049)
CASH		-0.0197		0.3768**
		(0.1231)		(0.1710)
ROA		-1.0631***		-0.3647
		(0.2107)		(0.2545)
SALESGROWTH		-0.2827***		-0.0234
		(0.069)		(0.0633)
EARNVOL		0.0930***		0.0076
		(0.0213)		(0.0269)
LEVERAGE		0.6553***		0.2960**
		(0.0765)		(0.1180)
ZSCORE		-0.0451***		-0.0319
		(0.0153)		(0.0387)
Observations	3271	3271	2581	2581
Adjusted R^2	0.2230	0.4859	0.3803	0.8097
Industry FE	Yes	Yes	No	No
Firm FE	No	No	Yes	Yes
Loan deal FE	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Notes: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are reported in parentheses.

The coefficients for the control variables for loan and firm characteristics are mostly statistically significant and have signs that are generally in line with the findings by previous studies (Hasan et al., 2014; Ertugrul et al., 2017; Sikochi, 2020). For example, loans with longer maturity (MATURITY) and lower rating (RATING) are associated with lower costs of debt. Firms with higher profitability (ROA) and growth opportunity (SALESGROWTH) incur lower costs of debt while firms with higher earning volatility (EARNVOL) and higher leverage (LEVERAGE) pay higher cost of debt.

The third and forth columns of Table 4 present the baseline regression results when firm and loan deal fixed effects are included instead of industry fixed effects. This is to account for potential omitted firm and loan deal characteristics that may create a spurious relationship between the corporate structure complexity measure and loan spread, thereby partly addressing the concern about endogeneity (Hasan et al., 2014; Sikochi, 2020). The coefficient for COMPLEXITY in the full model in column 4 remains positive (1.3932) and statistically significant at the 5% level.

3.2 Addressing Potential Endogeneity

It is possible that the high cost of debt induces the parent firm to increase the number and layer of subsidiaries in the first place in order to access subsidiary's financial resources as an alternative form of funding. In this case, there could be reversed causality in the relationship between corporate structure complexity and cost of debt. We partly address this issue by including firm and loan deal fixed effects in the baseline regression, as discussed in Section 3.1 above.

To further alleviate this concern, we use instrumental variable two-stage least squares (2SLS) regressions. The 2SLS analysis relies on choosing an instrumental variable (IV) that is correlated with corporate structure complexity but not related to cost of debt. We employ three IVs for corporate structure complexity. The first being audit fees (AUDITFEES), as auditors tend to raise audit fees for more complex firms since it takes more effort to analyse their financial statements (Gul et al., 2017). On the other hand, Dhaliwal et al. (2008) find no direct relationship between audit fees and cost of debt. The second IV is the number of vice presidents (NUMVP). We posit that more executives are needed to administer and monitor operation of firms with higher corporate structure complexity, but the number of vice presidents (VPs) should not affect how much lenders price their loans to the firm. We obtain the data on audit fees from Compustat and the data on the number of VPs from Execucomp.

The third IV is the average level of corporate structure complexity of firms in the same industry that has a comparable number of subsidiaries as the firm under focus. This is a plausible IV because it is unlikely that the cost of debt of one firm will influence how other firms in the industry organize their corporate structure. On the other hand, firms in the same industry may organize the subsidiaries in a manner that resembles that of the focal firm. This implies that the corporate structure complexity should be positively correlated for firms having similar number of subsidiaries. Thus, this IV meets the exclusion condition and the relevancy for a valid IV. We calculate this IV, INDCOM, as follow. For each fiscal year we first group firms based on their 3-digit SIC code. We then split each group into a high and low cohort based on the group's median number of subsidiaries. Next, we calculate

the average score of COMPLEXITY for each cohort, which becomes the INDCOM value of firms in the cohort. Cohorts with less than three firms are removed from the analysis.

The results of the 2SLS analysis are reported in Table 5. The coefficients for the fitted corporate structure complexity variables ($\widehat{COMPLEXITY}$) are positive and statistically significant at the 1% level for all IVs. This finding endorses the assertion that corporate structure complexity leads to higher cost of debt.

Table 5 2SLS Analysis

Dependent variable:	*Stage 1* *COMPLEXITY*	*Stage 2* *SPREAD*	*Stage 1* *COMPLEXITY*	*Stage 2* *SPREAD*	*Stage 1* *COMPLEXITY*	*Stage 2* *SPREAD*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
$\widehat{COMPLEXITY}$		15.2240***		16.9856***		15.8872***
		(4.2127)		(7.1909)		(6.356)
AUDITFEES	0.0652***					
	(0.0154)					
NUMVP			1.0164***			
			(0.2746)			
INDCOM					0.3512***	
					(0.1132)	
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2022	2022	2180	2180	2996	2996
Adjusted R^2	0.6084	0.3091	0.6201	0.1901	0.5578	0.3313
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are reported in parentheses. For brevity we do not report the results for control variables.

3.3 Additional Tests

We conduct a number of additional tests to further confirm our main hypothesis. First, we regress the debt rating (DEBTRATE), which is a numerical representation of the debt's rating (AAA is 21, AA is 20, … D is 0), on COMPLEXITY using a Poisson regression (Hasan et al., 2014). Second, we regress the natural logarithm of the number of financial covenants (NUMFCOV) attached with a loan on COMPLEXITY. Both DEBTRATE and NUMFCOV are calculated using data extracted from DealScan. The results in the first and second columns of Table 6 suggest that the rating is lower and the number of financial covenants is higher when corporate structure complexity increases. This supports the notion that higher corporate structure complexity is considered to have higher credit risk, as debt rating is a direct measure of the debt quality, while financial covenants indicate efforts by lenders to closely monitor firm performance so that they can act in a more timely manner to protect their debt claims. Finally, in addition to the results on

private bank loans, we also test our main hypothesis on corporate bonds. The regression model is similar to the baseline model specified in Equation 2, except for a few different control variables particular to bonds (for example, we control for whether a bond is a senior one). The result in the last column suggests that our hypothesis holds across debt settings.

Other additional tests include controlling for analyst forecast error as the measure for firm's information environment (Mansi et al., 2011), controlling for the number of foreign countries where the firm's subsidiaries are located as a proxy for another dimension of firm complexity which is geographical complexity (Cetorelli and Goldberg, 2014), and using the 50% ownership threshold instead of 20% when calculating corporate structure complexity. The results, which for brevity we do not report, are qualitatively similar to the baseline results.

Table 6 Additional Tests

	Debt rating	***Number of financial covenants***	***Corporate bond***
Dependent variable:	***DEBTRATE***	***NUMFCOV***	***SPREAD***
	(1)	***(2)***	***(3)***
COMPLEXITY	-10.4840***	1.3519**	4.4568***
	(1.8642)	(0.6375)	(1.3421)
Controls	Yes	Yes	Yes
Observations	3271	3271	1531
R^2	0.2808	0.1216	0.7994
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are reported in parentheses. The R^2 reported in the first column is pseudo R^2 for the Poisson regression while those reported in the second and third columns are adjusted R^2 for panel regressions. For brevity we do not report the results for control variables.

4. Conclusion

In this paper, we examine how the complexity of a firm's corporate structure, which stems from the way it organizes subsidiaries across hierarchical levels, can impact its cost of debt. Increased corporate structure complexity can impede lenders' ability to reclaim their loans in case of default due to the separation of liabilities between the parent firm and its subsidiaries. Furthermore, corporate structure complexity provides opportunities for financial manipulation by the parent firm, making it harder for lenders to assess a firm's credit risk.

Employing data on private bank loans to listed US firms and using a measure of corporate structure complexity calculated based on graph theory that captures the depth and breadth of how subsidiaries are organized within a firm, we provide empirical evidence consistent with our main hypothesis that lenders demand a higher loan interest spread for loans to more complex firms to compensate for higher credit risk. We conduct a number of tests designed to alleviate the concern about the endogenous relationship between corporate structure complexity and cost of debt. Apart from controlling for firm and loan deal fixed effects, we employ audit fees, the

number of vice presidents, and the industry average level of corporate structure complexity as instrument variables for 2SLS analysis. Additional tests show that corporate structure complexity is associated with lower debt ratings and more financial covenants in the loan contract. Our result also holds for corporate bonds.

Overall, our findings show that creditors (i.e. banks and corporate bond holders) recognize the credit risk associated with firms with high corporate structure complexity. Since debt capital is an important source of funding for US firms, stakeholders should beware of corporate structure complexity because it has a significant impact on the cost of borrowing. Furthermore, complex firms should extend their effort to communicate their financial information, especially subsidiary-related ones, to debt holders to alleviate the concern about their credit risk and reduce the cost of debt.

We acknowledge that there are some shortcomings associated with our study. First, due to limited fundings, our data sample only covers the period from 2012 to 2017. Nevertheless, including another two years of data before the COVID-19 outbreak (2018 and 2019) is unlikely to significantly change our results. However, whether the relationship between corporate structure complexity and cost of debt is impacted by the COVID-19 outbreak is worth investigated in future research when more data is available. Second, while our analyses suggest that it is unlikely that the endogenous relationship between corporate structure complexity and cost of debt drives our results, we admit that our instrumental variables may not be the perfect instruments. Thus, readers should exercise caution in taking our study as establishing an absolute causal relation between corporate structure complexity and cost of debt.

APPENDIX

An Example of Entropy-Based Complexity Measure Calculation

The illustration below shows the different levels of complexity within three corporate structures, all having ten subsidiaries but with different hierarchical structures. Structure A only contains two levels of subsidiaries. Structures B and C both contain three levels of subsidiaries, but the subsidiaries in structure B are clustered at one particular level while those in structure C are placed more evenly across the three levels.

Figure A1 Structure A

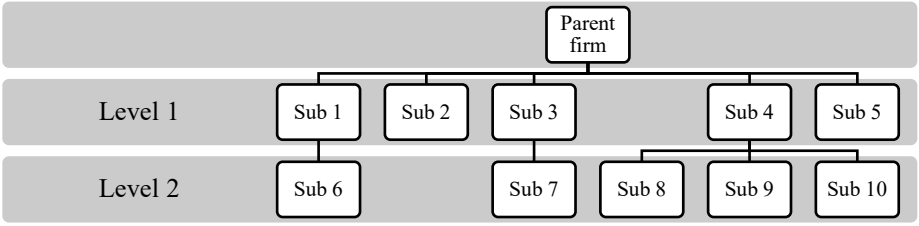


Figure A2 Structure B

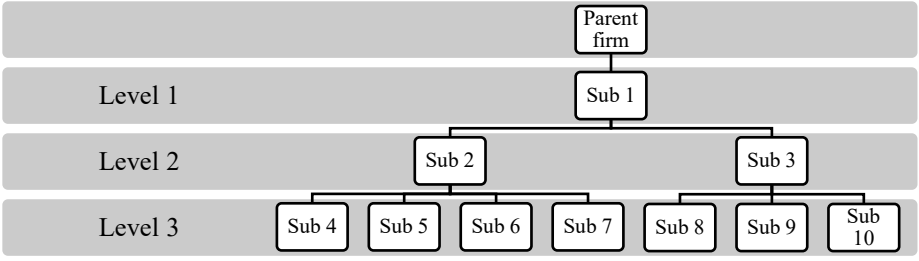
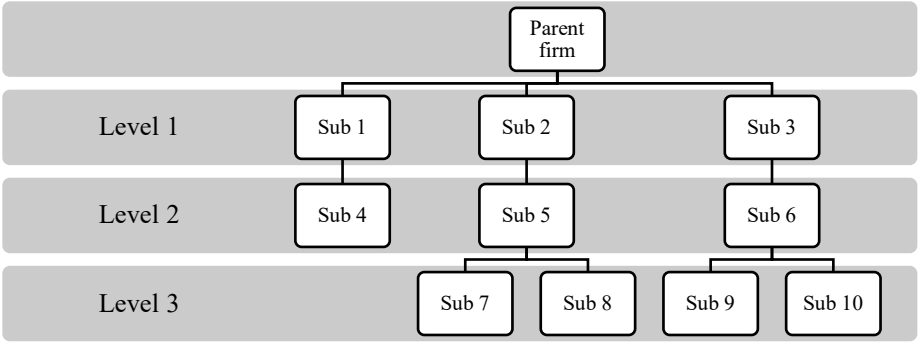


Figure A3 Structure C



The resulting corporate structure complexity of structure A, B, and C calculated using Altomonte and Rungi's (2013) measure is as below:

$$COMPLEXITY = \sum_{l}^{L} l * \frac{n_l}{N} * \ln(\frac{N}{n_l})$$

	Structure A	***Structure B***	***Structure C***
Total number of subsidiaries (*N*)	10	10	10
Total number of levels (*L*)	2	3	3
Number of subsidiaries at level 1	5	1	3
Number of subsidiaries at level 2	5	2	3
Number of subsidiaries at level 3	0	7	4
Corporate structure complexity (COMPLEXITY)	1.040	1.623	2.183

Among the three structures, C is considered the most hierarchically complex with a COMPLEXITY value of 2.183, followed by B (1.623) then A (1.040).

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