Oil Price Shocks and Cost of Debt

Evidence from US Oil Firms

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Motivation and Research Questions

Motivation

- The effects of oil price shocks on the world economy have been extensively studied over the last decade
- It is widely accepted that the oil price is a driving factor for the world economy and vice versa, but mostly focused on the macroeconomy
- e.g. Alquist and Kilian (2010), Bachmeier et al. (2008), Hamilton (2011), Kilian and Vigfusson (2011), Ravazzolo and Rothman (2013) and references therein
- Focus of this paper: Impact the oil price shocks have on a firm level across the oil industry's value chain in the US

Price Development on the Oil Market

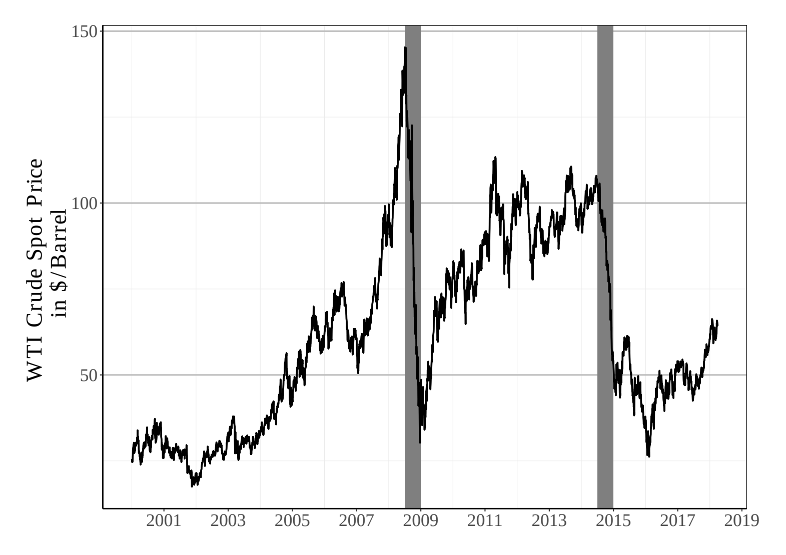

Figure 1: Development of WTI crude oil spot price.

Expected Effects of Oil Price Shocks

- Oil price decline reduces oil firms' revenue and increases uncertainty around future oil prices
- Effects on firm production and investment are uncertain (Sengupta et al. 2017)
- Firms might even increase production due to efficiency gains and cash flow requirements (Cakir Melek 2015)
- Lower profit margins might reduce oil firms' creditworthiness
- Cost of debt should be affected (higher risk of default)

Related Literature

- Price shocks affect the asset liquidation value of a firm and these are important for the pricing of debt contracts (Aghion and Bolton 1992; Bolton and Scharfstein 1996)
- Firms with more illiquid real assets have higher cost of capital, especially when real illiquidity arises from lower within-industry acquisition activity (Ortiz-Molina and Phillips 2014)
- Supply side conditions need to be considered

Research Questions

- How do firms along the oil industry supply chain respond to oil price shocks?
- How did the oil price shocks in 2008 and 2014 affect the cost of debt for companies in the oil industry?
- If there is an effect, does it also vary across the whole oil industry's value chain?

Measure the Cost of Debt

- How to measure the financing costs of firms?
- Measurements based on the balance sheet and income statements are problematic – maturities and interest rates are compounded

  ➔ Usage of credit spreads of newly issued bonds and syndicated loans

  ➔ Secondary market transactions of bonds also allow for continuous measurement of the cost of debt

Industry Classification

- Oil price shocks might affect companies differently
- We break down the supply chain into four industry classifications to explore effects of oil price shocks similar to Sengupta et al. (2017)
    1. Upstream & Support Services (exploration and production)
    2. Midstream (transporters)
    3. Downstream (refiners and marketers)

Data

Four different financial databases

- Syndicated Loans: in the Thomson Reuters' **Dealscan** database
- Corporate Bonds: Trade Reporting and Compliance Engine (**TRACE**) database provided by the Financial Industry Regulatory Authority (FINRA), enhanced with base data from **Bloomberg**
- Financial data of companies: Compustat – **Capital IQ** database

Thomson Reuters' Dealscan Database

- Quarterly Data 1988:Q1 - 2017:Q2
- Contains loan information from public company filings and reporting by banks
- Characteristics of syndicated loans, like pricing, contract details and additional terms and conditions
- Information on borrowing-firm characteristics include firm's senior debt rating provided by Moody's

Capital IQ Database

- Quarterly financial data from 2000:Q2 - 2018:Q1
- Database covers a wide range of publicly listed companies in both the US and Canada
- Information on the financials of the borrowing companies
- Includes for example total assets, liabilities, capital expenditures, EBITDA

TRACE Database

- TRACE database was introduced in 2002 to enhance the transparency in the secondary corporate bond markets
- Price, volume and yield of the reported OTC transactions are available – continuous estimation of the credit spread
- Bloomberg data is used to gather information on the bond issuance
- Data cleaning & aggregating according to previous work by Bessembinder et al. (2008), Dick-Nielsen (2009, 2014) and Li and Richie (2016)

Combining the Datasets – I

- Companies were selected based on their SIC and NAICS classification
- In total, 31 SIC and 22 NAICS codes were used to gather companies' financial data from the Compustat - Capital IQ database
- The combination of CapitalIQ and Dealscan data was facilitated by using the matching table provided by Chava and Roberts (2008)

Combining the Datasets – II

Two different approaches – Bond-level and company-level matching

1. Individual bond and loan level at the time of issuance to which we match company specific variables of the previous quarters.
2. Company-level matching for the continuous TRACE cost of debt variable

Company Sample

The final sample includes 1,682 companies from 2000:Q2 to 2018:Q1

	# Companies
Total Sample	1,682
Dealscan Loans (only)	351
TRACE Bond (only)	22
Both	253

Exploratory Data Analysis

Company Data

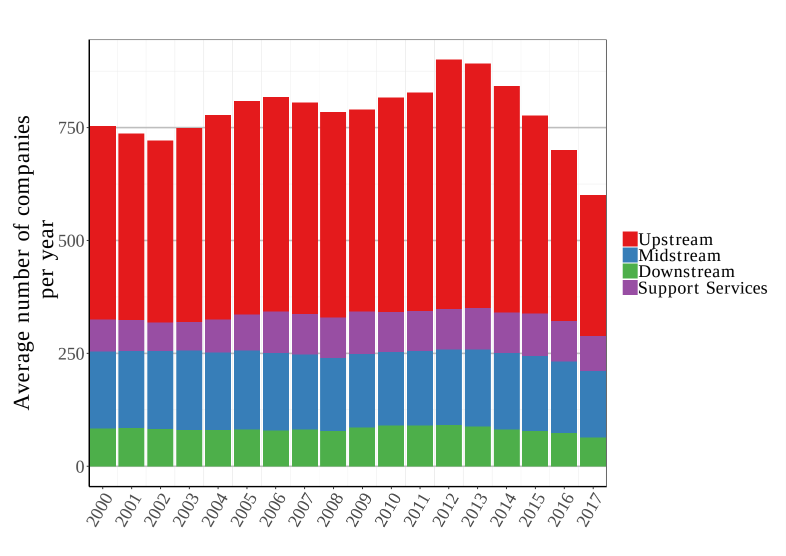

Figure 2: Average number of companies per industry classification and year.

Debt and Assets of the Supply Chain

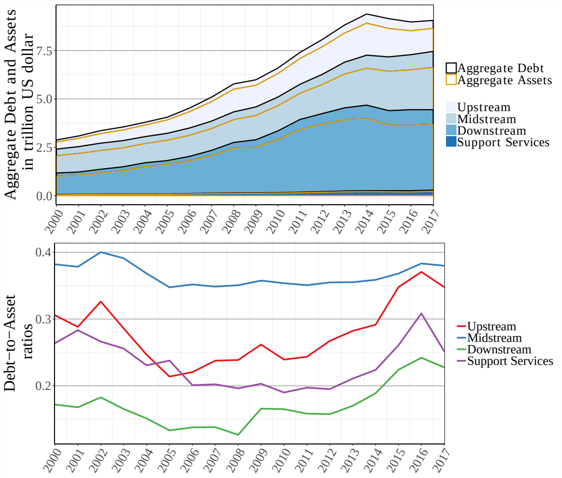

Figure 3: Development of aggregate debt and assets in each part of the value chain and the resulting debt to asset ratio.

Development of the Cost of Debt variables – Issuance

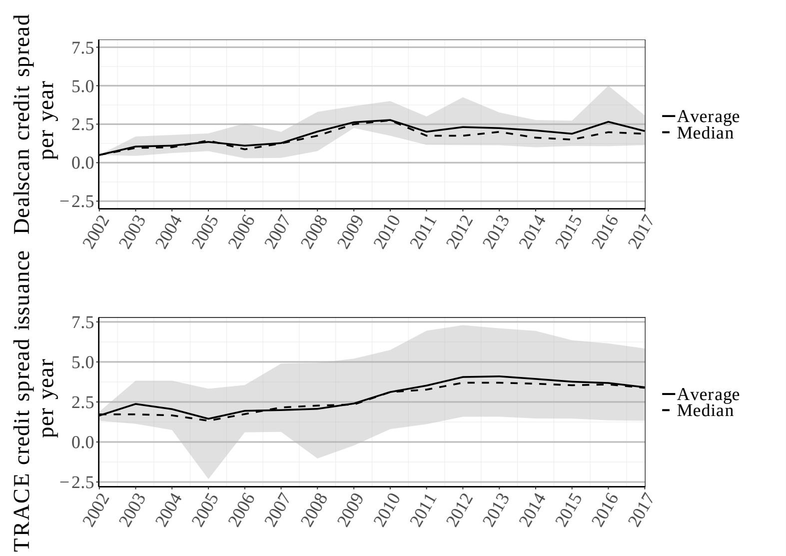

Figure 4: Credit spreads at issuance of loans and bonds. Shaded area indicates upper (90%) and lower (10%) quantile of the credit spread.

Development of the Cost of Debt variables – TRACE

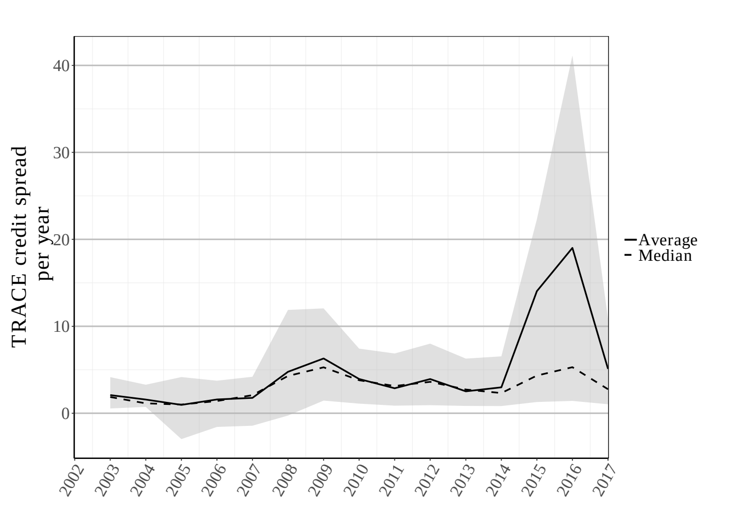

Figure 5: Continiously calculated credit spread of TRACE bonds traded on secondary markets. Shaded area indicates upper (90%) and lower (10%) quantile of the credit spread.

Empirical Strategy and Preliminary Results

Empirical Approach – Distributed Lag Model for Credit Spreads at Issuance

- The initial approach on the loan and bond level is implemented estimating the following model of credit spreads:

$$
\begin{aligned}
Y_{i,j,t} = \beta_0 + \beta_1 DEBT_{i,j,t} + \beta_2 FIRM_{i,t-1} + \beta_3 OIL_{t-1} \\
+ \beta_4 MACRO_{t-1} + D2008_t + D2014_t + \nu_t + \epsilon_{i,j,t},
\end{aligned} \tag{1}
$$

- where $Y_{i,j,t}$ is the (average quarterly) credit spread of a loan or bond j by firm i at time t, $DEBT_{i,j,t}$ is a vector containing loan/bond characteristics
- $D2008_t$ and $D2014_t$ are dummy variables for both oil price shocks

Macroeconomic Risk Environment

- **TED spread** (Federal Reserve Bank of St. Louis 2018a)
- **Credit spread** between Aaa and Baa corporate bond yield (Moody's 2018)
- **Term spread** as the difference between the 10-year Treasury yield and the 3-month T-Bill yield (Federal Reserve Bank of St. Louis 2018b)

Determinants of Credit Spreads – Dealscan

	log(Loan Credit Spread)$_t$			
	Full Sample	Upstream & Support Services	Midstream	Downstream
Leverage$_{t-1}$	0.7036***	0.6751***	1.4045***	0.3779*
Profitability$_{t-1}$	−0.1141	−0.3560*	−3.2115***	1.6051*
log(Total Assets)$_{t-1}$	−0.1736***	−0.1649***	−0.1044***	−0.0888***
log(Loan Amount)$_t$	−0.0398***	−0.0931***	0.0378*	−0.1955***
Maturity$_t$	0.0025***	0.0018**	0.0011	0.0050***
TED Spread$_{t-1}$	0.0457	−0.0464	0.0206	0.0973
Term Spread$_{t-1}$	0.1284***	0.0705***	0.1912***	0.1756***
Oil volatility$_{t-1}$	0.0152**	0.0170**	0.0111	0.0329*
log(Oil Price)$_{t-1}$	−0.0643	−0.0110	−0.0669	−0.0746
log(Oil Exports)$_{t-1}$	−0.0813***	−0.0353	−0.0770**	−0.0989
D2008	0.1162	0.1945	0.1188	−0.0764
D2014	−0.0924	−0.0205	−0.0054	−0.3004
Constant	−144.7794***	−132.3980***	−117.1390***	−125.9147***
Year fixed effects	Yes	Yes	Yes	Yes
Observations	3047	1522	1171	354
R^2	0.3542	0.4457	0.2868	0.4450
Adjusted R^2	0.3515	0.4409	0.2787	0.4238
F-Statistic	127.9779***	93.2829***	35.7812***	20.9681***
	(df = 13; 3033)	(df = 13; 1508)	(df = 13; 1157)	(df = 13; 340)

Note: *p<0.1; **p<0.05; ***p<0.01

Determinants of Credit Spreads – TRACE bonds

	log(Bond Credit Spread)$_t$			
	Full Sample	Upstream & Support Services	Midstream	Downstream
Leverage$_{t-1}$	0.7646***	0.8630***	1.4768***	0.9085***
Profitability$_{t-1}$	−0.7682*	−0.5753	−3.9890***	0.9936
log(Total Assets)$_{t-1}$	−0.2919***	−0.2767***	−0.1420***	−0.3140***
log(Bond Amount)$_t$	0.2294***	0.1472***	0.1524***	0.2550***
Maturity$_t$	−0.0002	0.0000	0.0003*	0.0007**
Credit Spread$_{t-1}$	0.4117***	0.2902***	0.4580***	0.5702***
Term Spread$_{t-1}$	−0.0202	−0.0124	−0.0440**	0.0714
Oil volatility$_{t-1}$	0.0170**	0.0363***	0.0217**	−0.0177
log(Oil Price)$_{t-1}$	0.1520**	0.0871	0.1733**	0.1598
log(Oil Exports)$_{t-1}$	0.0082	−0.0175	0.0189	0.0400
D2008	0.6072***	0.4211	0.7594***	0.1801
D2014	0.0024	−0.0069	0.0533	−0.2406
Constant	−42.1523	−99.4832**	25.4929	−73.1018
Year fixed effects	Yes	Yes	Yes	Yes
Observations	1511	558	746	207
R^2	0.4596	0.4944	0.3815	0.5344
Adjusted R^2	0.4549	0.4823	0.3705	0.5031
F-Statistic	97.9343*** (df = 13; 1497)	40.9151*** (df = 13; 544)	34.7310*** (df = 13; 732)	17.0422*** (df = 13; 193)

Note: *p<0.1; **p<0.05; ***p<0.01

Empirical Approach – Within-Between Effects Estimation for Credit Spreads on the Secondary Market - I

- Panel data approach allows for a joint estimation for all firms and to test for differences across industry classifications
- Industry classification of the individual firm is time-invariant
- Initially proposed by Mundlak (1978) and further developed by Bell and Jones (2015), this within-between approach has the advantage that it allows to decompose the combined effect in the random effect models into between- and within-firm effects.
- Possibility to obtain separate estimates for the effect of an explanatory variable on the dependent variable between firms (between-firm estimator) and the effect within a particular higher-level group (within-firm estimator).

Empirical Approach – Within-Between Effects Estimation for Credit Spreads on the Secondary Market - II

- The model can be expressed in its most general form as:

$$Y_{i,t} = \beta_{0,i} + \beta_1(X_{i,t} - \bar{X}_i) + \beta_2\bar{X}_i + \gamma Z_i + u_{0,i} + \epsilon_{i,t}, \qquad (2)$$

- where $Y_{i,t}$ is the dependent variable, $X_{i,t}$ are time variant explanatory variables, and Z_i are time-invariant variables.
- The interpretation of β_1 is the same as in the fixed effects model, because it measures the effects of within-firm deviations of X on the within-firm deviations of Y
- The β_2 is then indicating how the impact varies with cross-sectional variation in the dependent variable, i.e. across industry classification in our model.

Empirical Approach – Within-Between Effects Estimation for Credit Spreads on the Secondary Market - III

- The second approach utilises the panel structure of the data by estimating the following within-between effects model for the determinants of the average quarterly credit spread of a firm:

$$\begin{aligned} Y_{i,t} = \beta_{0,i} + \beta_1 DEBT_{i,t} + \beta_2 FIRM_{i,t} + \beta_3 OIL_t + \beta_4 MACRO_t \\ + \beta_5 D2008_t + \beta_6 D2014_t + \beta_7 INTER_{i,t} + \gamma Z_i + u_{0i} + \epsilon_{i,t} \end{aligned} \quad (3)$$

- where $Y_{i,t}$ is the (quarterly volume-weighted average) credit spread of the outstanding bonds by firm i at time t, $INTER_{i,t}$ is an interaction terms between the oil price development and the industry classification, u_{0i} are random errors of the model predicting $\beta_{0,i}$, and $\epsilon_{i,t}$ is the error term.

Within-Between Effects Estimation of the Determinants of the Bond Credit Spread on the Secondary Market - I

	Dependent variable:				
	log(Bond Credit Spread)$_t$				
	Est.	Std. Error	t-val.	d.f.	p-Value
Within-Effects					
Leverage	1.01	0.05	18.59	6533	0.00
Profitability	−0.07	0.10	−0.66	6416	0.51
log(Total Assets)	−0.12	0.02	−5.62	6312	0.00
Avg. Months-to-Maturity	0.00	0.00	−1.87	6374	0.06
Credit Spread	0.51	0.02	21.21	6332	0.00
Term Spread	−0.17	0.01	−21.68	6357	0.00
Oil Volatility	0.03	0.00	7.52	6326	0.00
log(Oil Price)	−0.09	0.05	−1.70	6465	0.09
log(Oil Exports)	0.04	0.02	2.08	6334	0.04
D2008	−0.28	0.07	−3.86	6312	0.00
D2014	−0.14	0.06	−2.56	6322	0.01

Within-Between Effects Estimation of the Determinants of the Bond Credit Spread on the Secondary Market - II

	Est.	Std. Error	t-val.	d.f.	p-Value
Between-Effects					
(Intercept)	4.64	3.89	1.19	259	0.23
Leverage	1.48	0.21	7.08	217	0.00
Profitability	−2.42	0.75	−3.22	235	0.00
log(Total Assets)	−0.15	0.03	−5.75	202	0.00
Avg. Months-to-Maturity	0.00	0.00	−5.88	202	0.00
Credit Spread	−2.85	1.89	−1.50	231	0.13
Term Spread	0.49	0.40	1.23	213	0.22
Oil Volatility	0.16	0.43	0.36	259	0.72
log(Oil Price)	−0.23	1.11	−0.21	260	0.83
log(Oil Exports)	−0.04	0.15	−0.26	226	0.80
D2008	17.08	12.09	1.41	236	0.16
D2014	−5.25	7.60	−0.69	233	0.49
Upstream & Support Services	0.44	0.08	5.92	198	0.00
Downstream	0.42	0.10	4.20	196	0.00
Time Fixed Effects	0.00	0.00	0.12	6398	0.91
Cross-Level Interactions					
log(Oil Price)*Upstream & Support Services	−0.40	0.06	−6.97	6496	0.00
log(Oil Price)*Downstream	−0.14	0.06	−2.51	6466	0.01
Random Effects					
Group	Parameter	Std. Dev.			
Firm ID	(Intercept)	0.42			
Residual		0.55			

p-values calculated using Satterthwaite d.f.

Concluding Remarks & Outlook

Concluding Remarks – Results

- Cost of debt in the oil industry increases with the perceived credit risk in the general economy
- Both banks and the bond market seem to consider falling oil prices as well as higher price volatility risks that increase the probability of default and thus reduces the creditworthiness of oil firms. Consequently, banks and the capital market demand higher credit spreads.
- The within-between effects estimation further reveals that the effect of the oil prices differs across sub-sectors (particularly strong for upstream & support services firms).
- Our results on the impact of the oil price shocks in 2008 and 2014 is rather ambiguous.

The End

Thank you for your attention!

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Appendix

Determinants of the Bond Credit Spread at Issuance (Dealscan)

	Dependent variable:			
	log(Loan Credit Spread)$_t$			
	Full Sample	Upstream & Support Services	Midstream	Downstream
Leverage$_{t-1}$	0.7036***	0.6751***	1.4045***	0.3779*
	(0.0675)	(0.0700)	(0.1593)	(0.2037)
Profitability$_{t-1}$	−0.1141	−0.3560*	−3.2115***	1.6051*
	(0.2174)	(0.2072)	(0.7180)	(0.8497)
log(Total Assets)$_{t-1}$	−0.1736***	−0.1649***	−0.1044***	−0.0888***
	(0.0087)	(0.0117)	(0.0174)	(0.0205)
log(Loan Amount)$_t$	−0.0398***	−0.0931***	0.0378*	−0.1955***
	(0.0123)	(0.0156)	(0.0206)	(0.0298)
Maturity$_t$	0.0025***	0.0018**	0.0011	0.0050***
	(0.0006)	(0.0008)	(0.0009)	(0.0011)
TED Spread$_{t-1}$	0.0457	−0.0464	0.0206	0.0973
	(0.0477)	(0.0519)	(0.0907)	(0.1507)
Term Spread$_{t-1}$	0.1284***	0.0705***	0.1912***	0.1756***
	(0.0122)	(0.0146)	(0.0202)	(0.0347)
Oil volatility$_{t-1}$	0.0152**	0.0170**	0.0111	0.0329*
	(0.0066)	(0.0075)	(0.0115)	(0.0179)
log(Oil Price)$_{t-1}$	−0.0643	−0.0110	−0.0669	−0.0746
	(0.0401)	(0.0496)	(0.0637)	(0.1062)
log(Oil Exports)$_{t-1}$	−0.0813***	−0.0353	−0.0770**	−0.0989
	(0.0216)	(0.0270)	(0.0335)	(0.0610)
D2008	0.1162	0.1945	0.1188	−0.0764
	(0.1153)	(0.1361)	(0.1960)	(0.3164)
D2014	−0.0924	−0.0205	−0.0054	−0.3004
	(0.0792)	(0.1017)	(0.1218)	(0.1963)
Constant	−144.7794***	−132.3980***	−117.1390***	−125.9147***
	(14.0601)	(17.8412)	(21.4932)	(39.2094)
Year fixed effects	Yes	Yes	Yes	Yes
Observations	3047	1522	1171	354
R^2	0.3542	0.4457	0.2868	0.4450
Adjusted R^2	0.3515	0.4409	0.2787	0.4238
F-Statistic	127.9779***	93.2829***	35.7812***	20.9681***
	(df = 13; 3033)	(df = 13; 1508)	(df = 13; 1157)	(df = 13; 340)

Note: *p<0.1; **p<0.05; ***p<0.01

Determinants of the Loan Credit Spread at Issuance (TRACE)

	Dependent variable:			
	log(Bond Credit Spread)$_t$			
	Full Sample	Upstream & Support Services	Midstream	Downstream
Leverage$_{t-1}$	0.7646***	0.8630***	1.4768***	0.9085***
	(0.1085)	(0.1362)	(0.2009)	(0.3452)
Profitability$_{t-1}$	−0.7682*	−0.5753	−3.9890***	0.9936
	(0.4255)	(0.4501)	(1.3527)	(1.7294)
log(Total Assets)$_{t-1}$	−0.2919***	−0.2767***	−0.1420***	−0.3140***
	(0.0119)	(0.0213)	(0.0188)	(0.0394)
log(Bond Amount)$_t$	0.2294***	0.1472***	0.1524***	0.2550***
	(0.0187)	(0.0383)	(0.0215)	(0.0900)
Maturity$_t$	−0.0002	0.0000	0.0003*	0.0007**
	(0.0001)	(0.0003)	(0.0002)	(0.0003)
Credit Spread$_{t-1}$	0.4117***	0.2902***	0.4580***	0.5702***
	(0.0459)	(0.0684)	(0.0588)	(0.1338)
Term Spread$_{t-1}$	−0.0202	−0.0124	−0.0440**	0.0714
	(0.0168)	(0.0267)	(0.0204)	(0.0555)
Oil volatility$_{t-1}$	0.0170**	0.0363***	0.0217**	−0.0177
	(0.0066)	(0.0100)	(0.0087)	(0.0172)
log(Oil Price)$_{t-1}$	0.1520**	0.0871	0.1733**	0.1598
	(0.0599)	(0.0986)	(0.0730)	(0.1699)
log(Oil Exports)$_{t-1}$	0.0082	−0.0175	0.0189	0.0400
	(0.0405)	(0.0655)	(0.0487)	(0.1253)
D2008	0.6072***	0.4211	0.7594***	0.1801
	(0.1408)	(0.3191)	(0.1456)	(0.6104)
D2014	0.0024	−0.0069	0.0533	−0.2406
	(0.0954)	(0.1492)	(0.1268)	(0.2198)
Constant	−42.1523	−99.4832**	25.4929	−73.1018
	(25.8792)	(42.6232)	(31.2679)	(79.5069)
Year fixed effects	Yes	Yes	Yes	Yes
Observations	1511	558	746	207
R^2	0.4596	0.4944	0.3815	0.5344
Adjusted R^2	0.4549	0.4823	0.3705	0.5031
F-Statistic	97.9343***	40.9151***	34.7310***	17.0422***
	(df = 13; 1497)	(df = 13; 544)	(df = 13; 732)	(df = 13; 193)

Note: *p<0.1; **p<0.05; ***p<0.01

Standard errors in parentheses.

SIC and NAICS Codes

SIC	NAICS	Industry Classification	SIC	NAICS	Industry Classification
1311	211111	Upstream	4619	486990	Midstream
1321	211112	Downstream	4922	486210	Midstream
1381	213111	Upstream	4923	221210	Midstream
1382	213112	Support Services	4923	486210	Midstream
1382	541360	Support Services	4924	221210	Midstream
1389	213112	Support Services	4925	221210	Midstream
1389	237120	Support Services	4931	221210	Midstream
1389	238910	Support Services	4932	221210	Midstream
1623	237120	Support Services	4939	221210	Midstream
1629	237120	Support Services	5171	424710	Downstream
2819	211112	Upstream	5171	454310	Downstream
2865	325110	Downstream	5172	424720	Downstream
2869	325110	Downstream	5900		Downstream
2911	324110	Downstream	5983	454310	Downstream
2990		Downstream	5984	454310	Downstream
2992	324191	Downstream	5989	454310	Downstream
2999	324199	Downstream	6792	523910	Downstream
3533	333132	Support Services	6792	533110	Downstream
4612	486110	Midstream	7373		Support Services
4613	486910	Midstream	8741	237120	Support Services

Median Credit Spread – TRACE Bonds

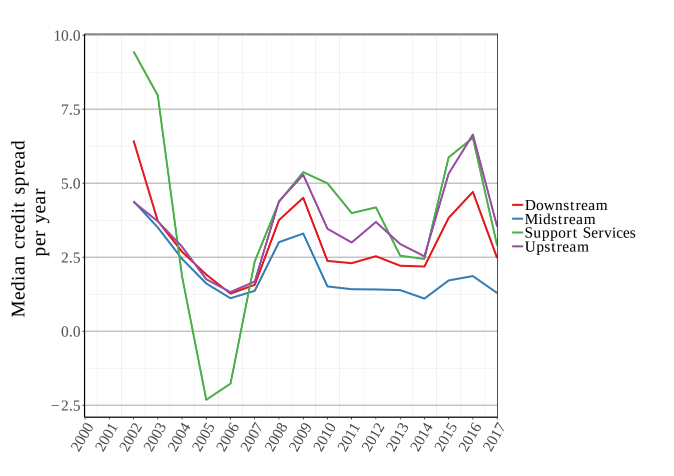


Figure 6: Median credit spread of TRACE bonds per industry.

Average Loan Spread and Maturity – Dealscan Loans

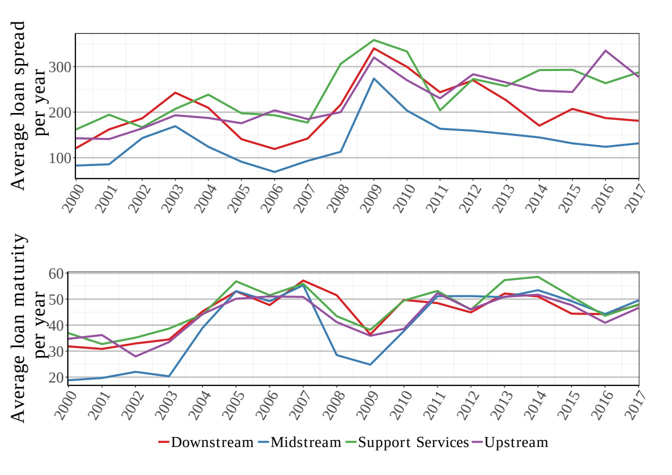
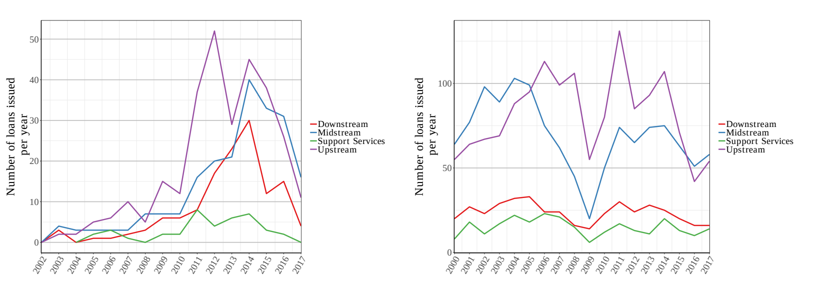


Figure 7: Development of the average loan spread and average maturity of facilities from the Dealscan database starting in 2000.

Number of TRACE Bonds and Dealscan Loans



(a) Number of TRACE bonds **(b)** Number of Dealscan loans

Figure 8: Number of TRACE bonds and Dealscan loans issued per year and per industry classification.

Average Loan Spread and Maturity

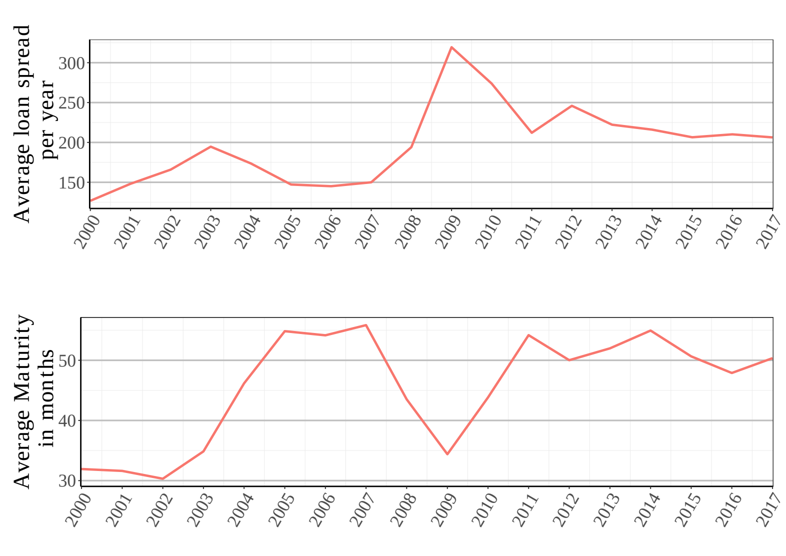


Figure 9: Development of the average loan spread and average maturity of facilities from the Dealscan database starting in 2000

Average Capital Expenditure

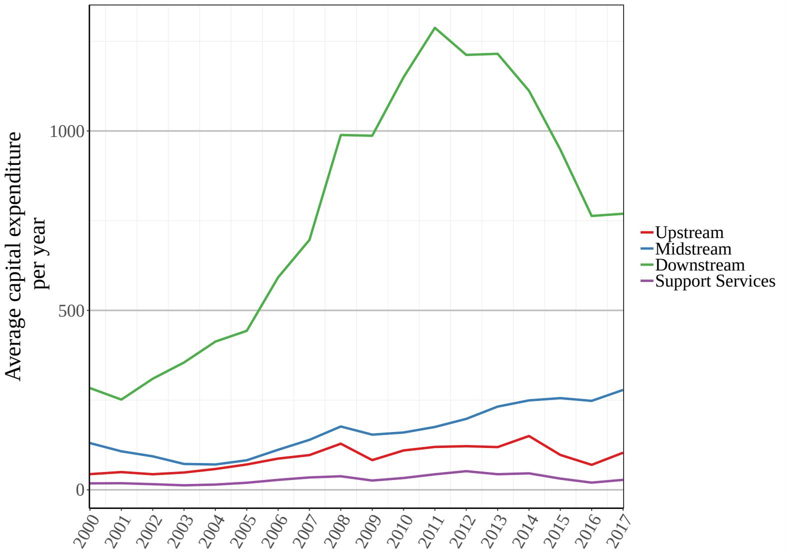


Figure 10: Average capital expenditure of companies per industry classification and per year.

Median Capital Expenditure

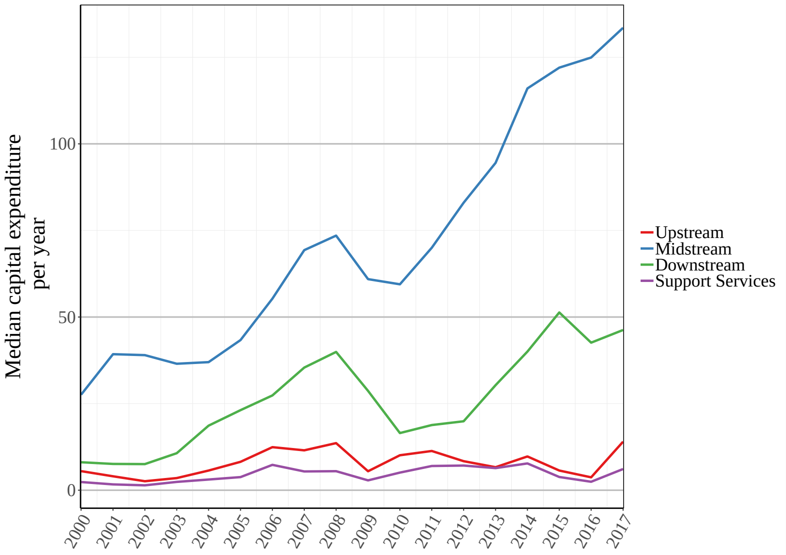


Figure 11: Median capital expenditure of companies per industry classification and per year.