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Quantitative Easing, Banks' Funding Costs, and Credit Line Prices

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Quantitative Easing, Banks' Funding Costs, and Credit Line Prices*

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Abstract

Cooperman et al. (2025) show that the covariance of banks' funding costs and credit line drawdowns is debt overhang cost to the bank's equity holders (Myres, 1974). In this paper, we start from this important result and extend it by showing that central banks' quantitative easing (QE) can mitigate this cost. We focus on the COVID-19 shock. We show empirically that funding costs generate frictions related to banks' shareholders (debt overhang cost), and banks transfer the cost to the credit lines' prices. Our novel econometric analysis, event studies, and theory suggest and formalise its mechanism. Our findings shed further light on the intricate relationship between banks' funding costs and related debt overhang (Andersen et al. 2019), but, crucially, focusing on an important source of credit for firms: credit lines.

Keywords: Quantitative Easing, Central Bank, Debt Overhang, Credit Line

Classification codes: G01, G21, G28, G32, E44, E58

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1 Introduction

Recently Cooperman et al. (2025) show that the covariance of banks' funding costs and credit line drawdowns is the debt overhang cost for banks' equity holders (Myers 1977). This happens as the covariance effect introduces a wedge in the (expected) price of lines. They also documented empirically that the covariance between banks' funding costs and credit line drawdowns, has been positive (and large) during the COVID-19 shock.

In this paper, we extend that result in many distinct ways. Firstly, we empirically test the theoretical predictions in Cooperman et al. (2025) on credit line prices. Are the prices affected by debt overhang cost? We focus on funding costs. Secondly and more importantly, can central banks' quantitative easing (QE) help to mitigate debt overhang costs? Finally, is the beneficial effect from QE (if any) transferred to final clients (i.e. the firms)? We are not aware of previous papers that have studied these important questions.

As in Andersen et al. (2019), we show that banks' funding costs introduce debt overhang costs for the equity holder of the bank. But, we also document that they are pervasive and affect the price of credit lines to firms. Cooperman et al. (2025) discuss funding costs and credit line drawdowns under the switch from LIBOR to SOFR rate). Finally, crucially, we argue empirically and theoretically that central banks' QE can mitigate debt overhang costs and ensure a (cheap) credit supply to the economy.

Our results are supported by a battery of regressions, event studies, and difference-in-difference analysis, confirming that central banks' quantitative easing (QE), in March 2020, was effective in reducing banks' funding costs (and shareholders' debt overhang costs as discussed in Andersen et al. (2019)). This had a positive effect on credit lines' prices. In our analysis, funding costs (or funding spreads to be more precise) are approximated by the difference between the LIBOR minus OIS spread as well as the bank's own credit spread, measured by the 5-year CDS spread (Burnside & Cerrato 2023, Cerrato & Mei 2024). As discussed in Andersen et al. (2019) as well as in Burnside & Cerrato (2023), these spreads represent funding value adjustments (debt overhang) for the equity holder.

We show, theoretically, using a balance sheet approach for a risk-neutral bank, that QE reduces the bank's credit spreads, and funding costs, leading to a wealth shift in equity holders. This positive shift in wealth can explain why banks provide cheaper credit line prices. As in Cooperman et al. (2025) and Andersen et al. (2019), the effect of regulatory costs on the covariance, is small enough and therefore, the covariance effect is largely attributed to funding costs. We also document it in a calibrated exercise. These are new and important results.

We proxy funding costs following Burnside & Cerrato (2023) and use the 5-year CDS spreads for the 12 largest (European and US) dealers. We also supplement the results using market-based spreads such as LIBOR minus OIS spread. Banks' CDS spread is widely used in the industry as a measure of costs and funding value adjustment (FVA) and, therefore, a good proxy for shareholders' debt overhang costs[1]. Thereafter, we document the causal impact of QE on credit lines' prices using an instrumental variable approach (Online Appendix) as well as a novel DID design using off-balance sheet items (unused credit lines) and term loans.

To mitigate the possibility that the FED effect on lines' prices is specific to the US, we also run the same tests using European firms' credit line prices and the QE conducted by the ECB and report very similar results.

Over the past decade, credit lines have channelled a significant amount of credit from banks to US and European enterprises. For example, Cerrato et al. (2023) estimate that European firms (the euro area), during the COVID-19 shock, drew down over €87bn in a short time to stay afloat. This was an unprecedented flight to liquidity on a macroeconomic scale during which the average credit line to total assets ratios rose from 4.72% in 2020:Q1 to 5.15% in 2020:Q2 (average of 7.00% during 2020:Q2-Q3). Acharya & Steffen (2020) show similar results for US firms.

There is extensive literature on firms' liquidity risk management using credit lines (for example, Campello et al. (2011), Acharya et al. (2013), and more). This paper departs from this literature as it mainly focuses on banks' increasing funding costs post-2008, its effect on banks' shareholders (debt overhang cost) and credit line prices.

We build on Cooperman et al. (2025), but document that the central bank's quantitative easing can be effective in mitigating shareholders' costs (debt overhang cost) and providing cheaper loans to firms, particularly in the presence of significant shocks. In this paper, we study the 2020 COVID-19 shock.

What is a credit line? Credit lines are financial contracts enabling firms to draw liquidity insurance from their bank accounts and have financing available as contingent liquidity provisions to offset shocks (Holmström & Tirole 1998). Hence, they are contingent liquidity lines which can be seen as insurance against unexpected future liquidity shocks. This funding vehicle is crucial in the US and Europe, given the high reliance of European firms on bank-based financing, further

[1]For the banks, see also discussion in Burnside & Cerrato (2023). They have also used other proxies for FVA, such as banks' asset swaps and others, and their empirical results are unchanged.

We start with a high-frequency event study, followed by regression analysis, and show that when the FED started quantitative easing (QE) in March 2020, credit spreads dropped quickly (debt overhang cost declined), and credit line prices followed.

underscoring its significance relative to alternative capital market-based financing channels in the US.

There is a vast literature for US firms on using credit lines for liquidity risk management (Sufi 2009, Acharya & Steffen 2020, Brown et al. 2021) as well as credit lines' prices (Berg et al. 2016, 2017). While this literature is abundant for the US, it is rather scarce for Europe (Cerrato et al. 2023). Our paper also speaks to this part of the literature, adding a novel message: Central banks' QE can mitigate liquidity risk and ensure cheaper funding for European and US firms. On top of that, our paper also extends the literature cited earlier to study cross-country differences in credit lines' prices as in Berg et al. (2016) and Berg et al. (2017).

Aside from that literature, our paper also speaks to the recent literature studying banks' funding frictions and debt overhang costs to explain some observed empirical facts such as deviations in covered interest rate parity (CIP) post-2008, interest rate future and more (for example, Du et al. (2018), Andersen et al. (2019), Fleckenstein & Longstaff (2020), Du et al. (2023), Burnside & Cerrato (2023), Cerrato et al. (2024) and Cerrato & Mei (2024)). We focus on credit lines and credit lines' prices and introduce a new dimension, central banks' QE.

As we mentioned, the closest paper to ours is Cooperman et al. (2025), who show that credit line drawdowns increase when banks' funding costs are high. This positive correlation between banks' funding costs and credit line drawdowns poses a significant cost for banks' shareholders (debt overhang costs). While that paper mainly focused on important friction (funding costs following the switch from LIBOR to SOFR) but did not discuss ways (if any) to mitigate the covariance effect (debt overhang) of the bank, we focus on this new dimension. From an empirical viewpoint, our paper complements the theory in Cooperman et al. (2025) by empirically studying the association of banks' funding costs (as shareholders' debt overhang costs) and credit line prices, in two critical markets, the European and US markets.

The empirical evidence we provide is economically sizeable. For example, our benchmark analysis, in Section 3 and Section 4, suggests that one basis point increase in funding spreads (proxied by the difference between the LIBOR minus OIS spread) leads to a 2-3 basis point increase in All In Spread Drawn (AISD) spread for US firms and a 3-6 basis point increase for European firms—the opposite is true for the All In Spread Undrawn (AISU). This significant cost is completely absorbed by firms (customers).

Our DID analysis in Section 5 reports an even stronger impact. It suggests that QE reduces the drawdown prices by 37 basis points (or 26 basis points by controlling the characteristics of borrowers and loans).

Our DID specifications employ some novel strategies to mitigate the effect of confounding factors on the estimated impact of QE on credit line prices via funding costs and using the COVID-19 shock. We use two different difference-in-difference (DID) strategies. In the first one, we use the undrawn price of credit lines to control for confounding factors. In fact, undrawn credit lines are off-balance sheet items and, therefore, should be less exposed to funding and regulatory costs. Our empirical analysis supports this conjecture. Using undrawn prices, we estimate the impact of QE on drawn prices and quantify the effect.

Our second empirical strategy uses the prices of term loans. Term loans differ from credit lines in their structure, offering fixed amounts and repayment terms rather than unpredictable drawdowns. As also noted in Cooperman et al. (2025), banks do not face significant funding costs to finance term loans. In fact, the covariance between funding costs and drawdown size is constant. We shall also provide a simple proof of this. Using the prices of term loans to control for confounding factors, we report evidence suggesting that QE was indeed effective in reducing the line prices.

In sum, higher banks' funding costs, especially during adverse shocks, may introduce significant frictions that impact credit lines' prices across Europe and the US. However, central banks' QE can mitigate this cost. The message is that central banks' asset purchase programs can mitigate banks' debt overhang costs with beneficial effects on lines' fees. Of course, there is a political economy discussion related to our results about whether QE is beneficial for financial markets in the long run (for example, Acharya et al. (2023), Acharya & Rajan (2022), and Greenwood et al. (2016)). Although this is an important issue, it is left on the agenda for future research, but our paper clearly points in the direction that borrowers can benefit from QE. This is a new and important result.

The rest of the paper is as follows. Section 2 introduces the data we employ in our analyses and an event study. Section 3 presents panel regression analyses linking central bank intervention with credit spread and credit line drawdown costs using the US sample. Section 4 then further analyzes these patterns using the European sample. Section 6 introduces a simple theoretical model to explore the mechanism of how central bank intervention affects borrowers' drawdown cost through bank equity holders' debt overhang cost. Section 7 concludes.

2 Data and Statistics

2.1 Data

We use data on individual loan facilities from the WRDS-Reuters' DealScan database (Loan Pricing Corporation DealScan). DealScan provides information on US firms as well as global non-U.S. firms. In this paper, we focus on loans to European and US corporations. We define European and US loans based on the borrowers' countries[2]. Following Acharya et al. (2013), we do not consider utilities, quasi-public, and financial firms with SIC codes greater than 5999 and lower than 7000, greater than 4899 and lower than 5000, and greater than 8999 from our sample. Our sample covers the period from the beginning of January 2015 to the end of December 2022, including the COVID-19 pandemic crisis. We focus on the COVID-19 shock.

We also collect information on 3-month, 6-month and 12-month London Interbank offered rate (LIBOR) and overnight indexed swap (OIS) rates from Bloomberg[3]. The difference between these two rates is commonly regarded as a proxy for the wholesale bank funding spread (Cooperman et al. 2025). Following Burnside & Cerrato (2023), we also collect from Bloomberg 5-year credit default swap (CDS) spreads of the 12 representative banks across the two markets. Appendix A provides details of these 12 banks. Our study uses monthly data unless specified otherwise.

Following the literature on credit lines' prices, we use the *All In Spread Drawn* or AISD as the key proxy for the loan price, Berg et al. (2016), and Berg et al. (2017). This is the spread over benchmark interest rates, in our case, the LIBOR, and the facility fee. It is the borrowers' cost of drawing down the credit line. We collect information such as loan size, maturity, loan purpose, and creditor number from the DealScan database to capture the loan characteristics across the European and the US loan markets. These variables are widely used in the literature studying the US and European loan markets (see Carey & Nini (2007), Berg et al. (2016), Berg et al. (2017), and Ma et al. (2024)). In addition, we design several indicators, *Maturity 1-3Y*, *Maturity 3-6Y*, and *Maturity >6Y*, denoting different maturities of loan facilities. The rest are loans with maturities within one year.

Table 1 presents the summary statistics of all variables. Panel A shows 6-month and 12-month LIBOR-OIS spreads. Over our sample period, funding costs are, on average, about 35 basis points (6-month) and 50 basis points (1-year). We also use banks' CDS spreads as an alternative measure

[2]In DealScan, we use a variable *Country* which describes borrowers' motherlands to define the US and European countries. Our sample includes firms from the European Union (EU) and the United Kingdom (UK). Figure C1 in Appendix C shows that European banks mainly lend to European firms and US banks mainly lend to US firms.

[3]To save space, we only report results using six and one-year LIBOR, results using three-month LIBOR are similar and available upon request

of banks' funding costs (see Burnside & Cerrato (2023)) and average them to form an Index. Burnside & Cerrato (2023) show that this is also a proxy for the dealers' funding costs (this proxy for the so-called funding value adjustments), as opposed to market spreads. CDS spread is, on average, 66 basis points over the same sample period. Panels B and C show summary statistics of the variables employed in this study. The spread of *All In Spread Drawn* is nearly 20 basis points lower for European loans than US ones, close to 35 basis points in Berg et al. (2017). However, the spread of *All In Spread Undrawn* is 38 basis points higher for European loans. The US market has a higher fraction of credit lines (47%) than the European market (35%). Meanwhile, the loan size is also larger in the US market (1,626 million USD) than in the European market (1,270 million USD). Loans to European firms have longer maturity than the ones to US firms (5.3 years compared to 4.8 years). These results are, overall, consistent with Berg et al. (2017).

2.2 Preliminary Statistics

Figure 1 shows the average price of credit lines in the US before (after) the FED implemented QE. We selected 20 March as the FED started QE on 23 March 2020. There is a significant slope change following the implementation of QE. The change suggests that the line of credit is cheaper.

In Figure 2, we fit the relationship of the price-funding cost before (after) the FED implemented QE. As an alternative measure of funding costs, we use the average CDS spread of the largest 12 (US/European)banks. Results are, in general, consistent when using LIBOR-OIS spread. The analysis uses daily data. We note a slope change following the implementation of QE.

In Figure OA4.1 in the Online Appendix OA4, we fit the same relationship as above, but we first match lines' prices with the CDS of the bank and use a smaller set of data. Again, the slope of the line falls after the FED has implemented QE. Figure OA4.2 supports this conclusion for March 2020. Finally, the results we have presented suggest that, following QE, the price of credit lines is cheaper. In the next sections, we shall test it empirically.

Cooperman et al. (2025) show theoretically that credit line prices are driven by the covariance between credit line drawdowns and banks' funding costs. They show that this covariance introduces a wedge in the price of lines, which represents compensation for the equity holder of the bank for funding a new line to a client. We provide a short analysis of Cooperman et al. (2025) in Section 6. The main driver of covariance is the bank's funding cost, which is proxied by its credit spread.

We plot banks' funding costs over our (full) sample period. Figure 3 shows funding spreads at 6-month and 1-year maturity (following Cooperman et al. (2025), we use 6-month and 12-month LIBOR-OIS spreads). We can see that at the time when the WHO declared the outbreak of

Table 1. **Summary Statistics**

This table shows the summary statistics for our sample. Panel A shows the 6-month LIBOR-OIS spread, 12-month LIBOR-OIS spread, and the CDS index measured from the average of 12 banks' 5-year CDS spreads. Panel B shows the European sample of 92,899 facilities-month with loan characteristics. Panel C shows the US sample of 111,104 facilities-month with loan characteristics. The period covers 2015-2022. All variables are winsorized at 1% and 99%. Appendix A contains all variable definitions.

Variable	N	Mean	Std. Dev.	Min	0.25	Median	0.75	Max
Panel A: Bank Funding Cost								
LIBOR-OIS 6M (bps)	102,944	34.507	17.898	6.773	23.990	29.800	44.265	101.000
LIBOR-OIS 12M (bps)	102,944	49.852	20.109	13.553	39.715	47.363	61.399	99.218
CDS Index 5Y (bps)	102,944	66.027	19.688	36.198	47.985	62.715	81.224	115.142
Panel B: Europe								
All In Spread Drawn (bps)	22,774	280.374	149.216	2.500	165.000	275.000	375.000	1,450.000
All in Spread Undrawn (bps)	2,185	64.790	56.469	0.350	25.000	50.000	90.000	400.000
Revolver	92,899	0.354	0.478	0.000	0.000	0.000	1.000	1.000
Facility Amount (million USD)	92,653	1,269.504	3,816.877	0.000	141.290	400.000	1,128.800	75,000.000
Maturity	89,145	5.319	3.066	0.083	4.000	5.000	6.000	40.000
Maturity 1-3Y	92,899	0.135	0.342	0.000	0.000	0.000	0.000	1.000
Maturity 3-6Y	92,899	0.518	0.500	0.000	0.000	1.000	1.000	1.000
Maturity >6Y	92,899	0.279	0.449	0.000	0.000	0.000	1.000	1.000
Secured	92,899	0.382	0.486	0.000	0.000	0.000	1.000	1.000
Number of Lenders	92,899	9.332	7.656	1.000	4.000	7.000	12.000	55.000
Panel C: US								
All In Spread Drawn (bps)	90,938	301.379	185.981	30.000	150.000	250.000	410.000	1,100.000
All In Spread Undrawn (bps)	30,028	26.538	19.510	1.750	12.500	25.000	37.500	225.000
Revolver	111,104	0.472	0.499	0.000	0.000	0.000	1.000	1.000
Facility Amount (million USD)	111,031	1,625.904	3,164.691	7.200	185.500	600.000	1,790.000	38,000.000
Maturity	108,775	4.772	1.726	0.167	4.917	5.000	5.000	13.500
Maturity 1-3Y	111,104	0.101	0.301	0.000	0.000	0.000	0.000	1.000
Maturity 3-6Y	111,104	0.644	0.479	0.000	0.000	1.000	1.000	1.000
Maturity >6Y	111,104	0.174	0.379	0.000	0.000	0.000	0.000	1.000
Secured	111,104	0.426	0.494	0.000	0.000	0.000	1.000	1.000
Number of Lenders	111,104	9.466	7.444	1.000	4.000	7.000	13.000	44.000

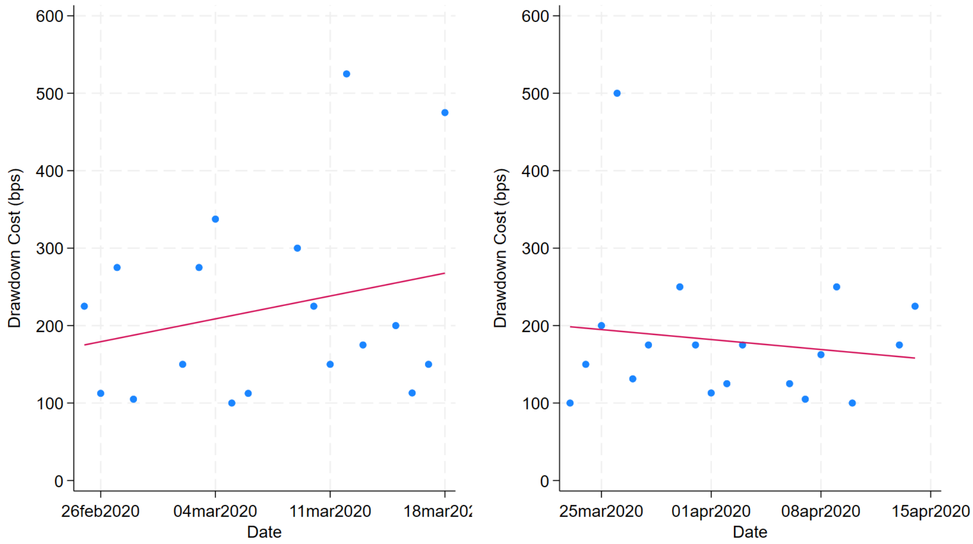


Figure 1. Drawdown price. This figure plots the daily average drawdown price (*All In Spread Drawn*) in the US market. The blue spots indicate the observed daily prices. The red solid line indicates the fitted line. The left plot shows the daily prices one month before the FED's QE, while the right plot shows the daily price one month after the QE.

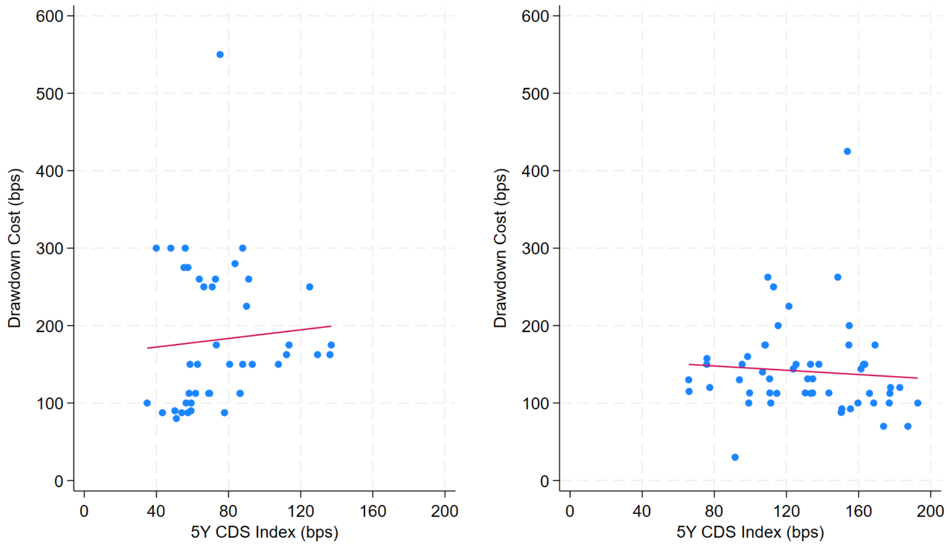


Figure 2. Drawdown Price versus CDS Spread. This figure plots the daily average drawdown price (*All In Spread Drawn*) against the average 5-year CDS spreads in the US market. The blue spots indicate the observed daily price against daily CDS spreads across the date. The red solid line indicates the fitted line. The left plot shows one month before the FED's QE, while the right plot shows one month after the QE.

COVID-19 (March 2020), the 6-month LIBOR-OIS spreads (solid blue line) reached a peak at 100 basis points, while 12-month spreads (dashed red line) also approached 90 basis points. Spreads dropped quickly soon after central banks' QE [4].

To shed further light on the dynamics behind the LIBOR and OIS rates after the QE, we also show the 6-month (12-month) LIBOR and related OIS rates. Figure 4 shows the 6-month LIBOR (solid blue line) and the OIS rates (dashed red line). We note, indeed, a sharp fall in the OIS rate, which is consistent with investors moving to safe assets like Treasury Bills (He et al. 2022).

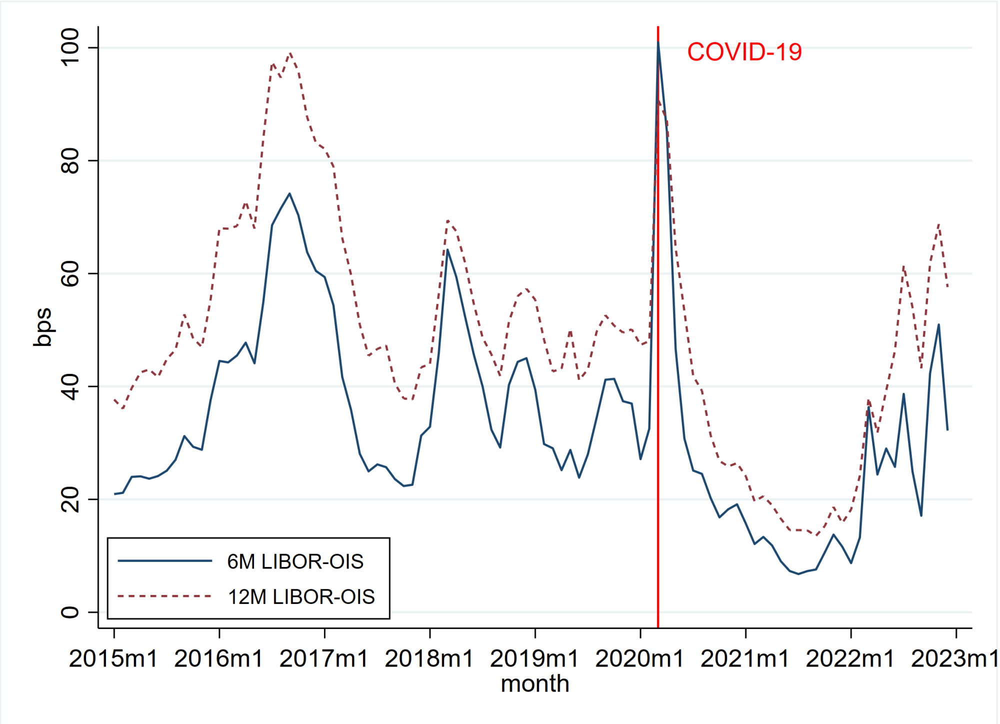


Figure 3. LIBOR-OIS Spread. This figure plots the monthly LIBOR-OIS spread. The blue solid line represents the spread between the 6-month LIBOR-OIS rate. The red dashed line represents the spread 12-month LIBOR-OIS rate. The solid red line represents when the WHO announced the COVID-19 pandemic.

We complement these results by using the CDS spread as an alternative measure of banks' funding costs. The 5-year CDS spread of the largest US and European banks. This data is collected from Bloomberg for the 12 primary US and European dealers across Europe and US[5]. Figure 5 plots the CDS spread against the sampling period. Similar to Figure 3, we find a peak in March 2020, followed by a significant drop. The evidence points in the direction that QE was effective in reducing banks' funding costs.

[4]According to ECB (2020, Mar 18) and Federal Reserve (2020, Mar 23), European and US central banks announced a vast asset purchase programme to support financial markets. Particularly, the FED started a large QE on 23 March 2020

[5]These 12 banks include JP Morgan, Morgan Stanley, Wells Fargo, Citi, BofA, Goldman Sachs, BNP Paribas, Societe Generale, Barclays, NatWest, Credit Agricole, and Banco Santander.

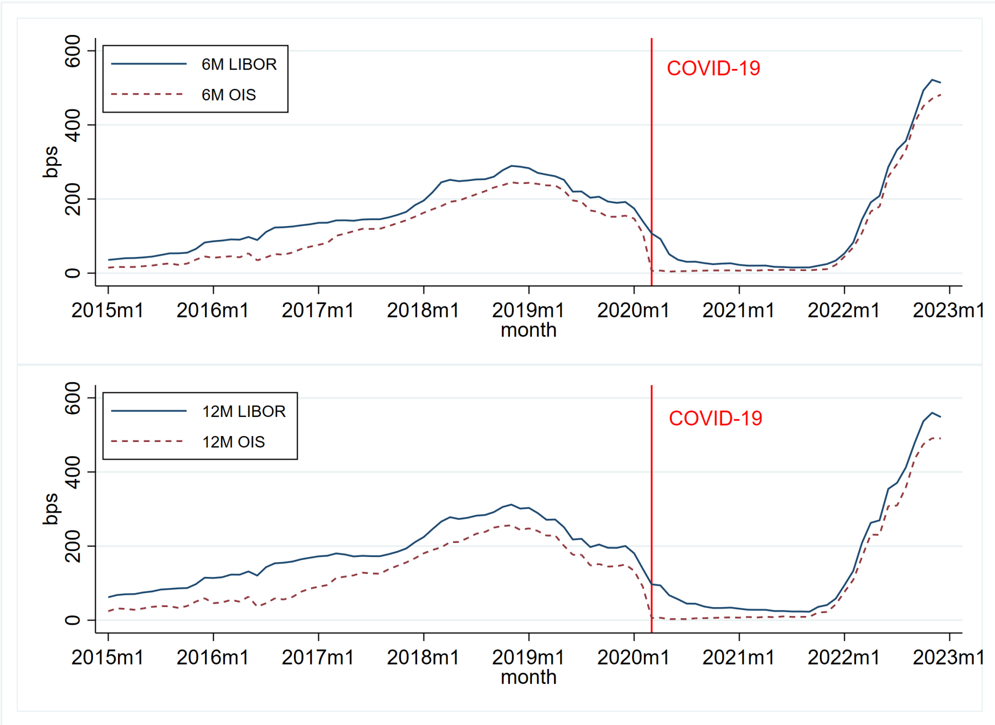


Figure 4. LIBOR and OIS Rates. This figure plots monthly LIBOR and OIS rates. The upper plot shows the rates of 6-month LIBOR (blue solid line) and OIS (red dashed line). The lower plot shows the rates of 12-month LIBOR (blue solid line) and OIS (red dashed line). The solid red line refers to the period when the WHO announced the COVID-19 pandemic.

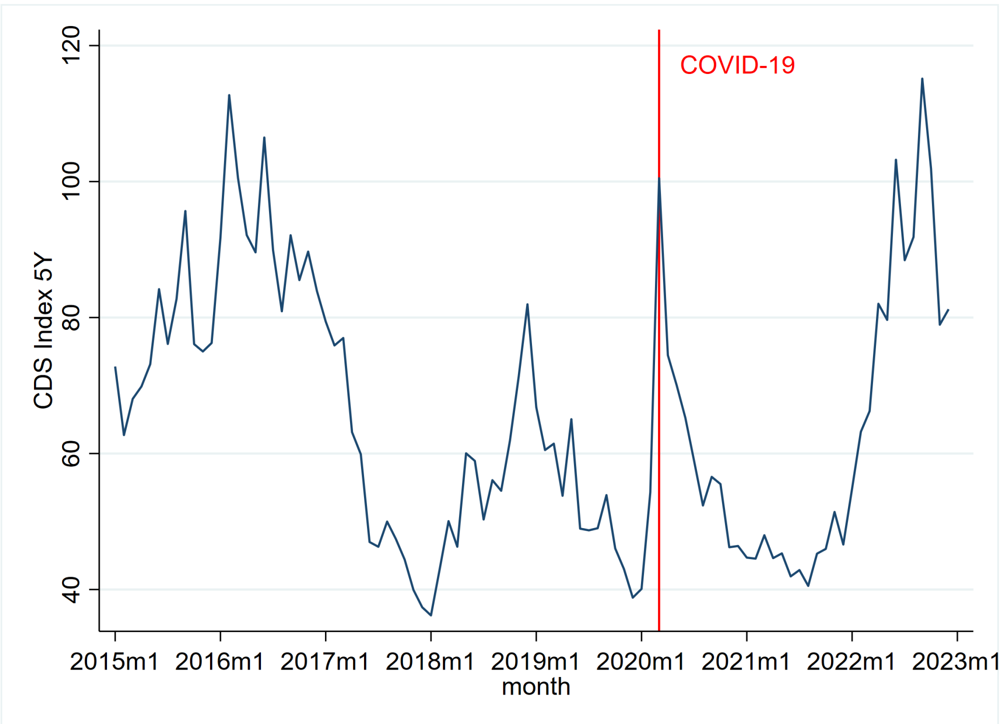


Figure 5. CDS Index. This figure plots the monthly 5-year CDS index. The index is a monthly average of 12 representative banks' 5-year CDS spread. The solid red line represents when the WHO announced the COVID-19 pandemic.

2.3 Event Study

The evidence above indicates that following QE, banks' funding costs declined, and credit lines were cheaper.

In this section, as a first step, we focus on the impact of QE on banks' funding costs. To do this, we design a high-frequency event study using the CDS price of the 12 banks in the appendix as a measure of banks' funding costs (Burnside & Cerrato 2023, Cerrato & Mei 2024). We consider a narrow window around the ECB's and the FED's QE (17 March to 26 March) to account for the possibility of confounding factors affecting the results. We use hourly banks' CDS data from Bloomberg [6].

Figure 6 shows the intraday CDS index scatter plot and fitted line around the window. Consistent with the previous results, banks' funding costs increased during the COVID-19 shock and quickly reversed after central banks' QE. The slope coefficients before 23 March are 6.42 basis points with a t-statistic of 1.8 for the European market and 13.34 basis points with a t-statistic of 11.40 for the US market. After QE, the slope coefficients are -22.79 basis points with t-statistic of -9.46 in Europe and -23.30 basis points with t-statistic of -17.77 for the US. These results point further to the effectiveness of QE in reducing banks' funding costs.

2.4 The Effect of Central Bank Intervention

In this section, we use econometric analysis to test whether the central bank's QE was effective in reducing banks' funding costs. We use a simple regression analysis and daily data, where we regress the changes in LIBOR-OIS (CDS) spreads on a dummy equal to one if the period is associated with QE (March 2020 and May 2020). Equation 1 details the specification.

$$\Delta LIBOR\text{-}OIS_t \quad = \quad \alpha_0 + \alpha_0 CB_t + \epsilon_t \tag{1}$$

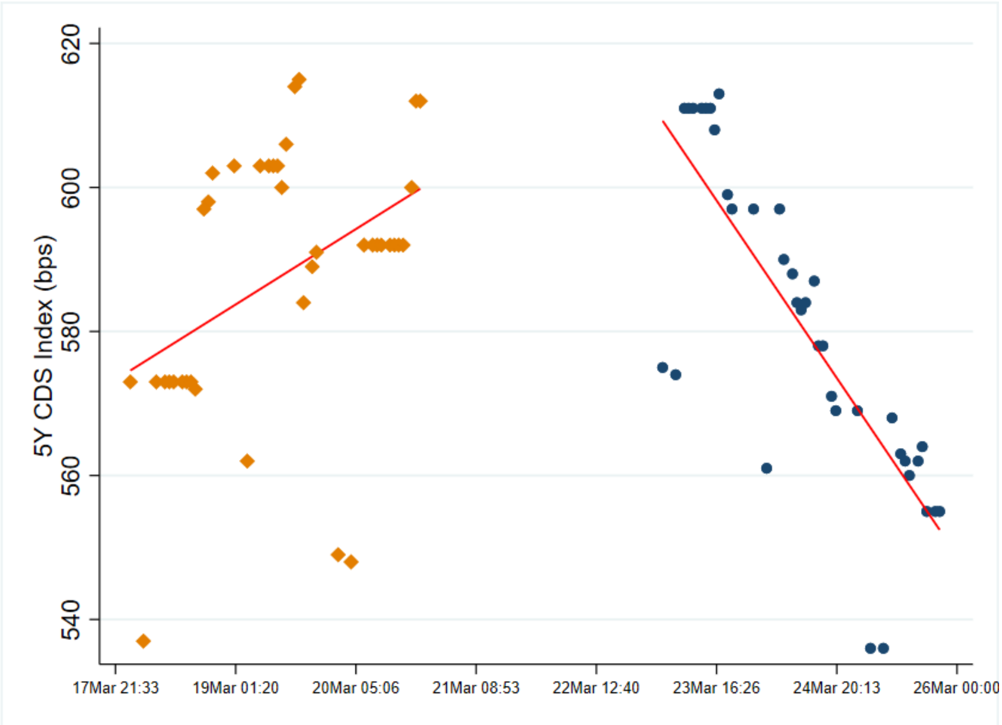
where $Spread_t$ denotes different measures of banks' funding costs, including 6-month LIBOR-OIS spread, 12-month LIBOR-OIS spreads, and the CDS index at time t[7]. CB_t is a dummy equal to one indicating the period after central banks' QE.

Table 2 shows the results. The significant and negative coefficients in columns (1) and (2) suggest that central bank intervention effectively reduced funding costs. For example, we note a 13 basis point decrease in the 6-month LIBOR-OIS spread and a 20 basis point decrease in the

[6] The ECB announced the Pandemic Emergency Purchase Programme (PEPP) around the 20 March (ECB 2020, Mar 18), and the Federal Reserve announced the policy rate cut on 23 March Federal Reserve (2020, Mar 16).

[7] CDS index is a monthly average of 12 representative banks' 5-year CDS spreads.

Panel A: Europe



Panel B: US

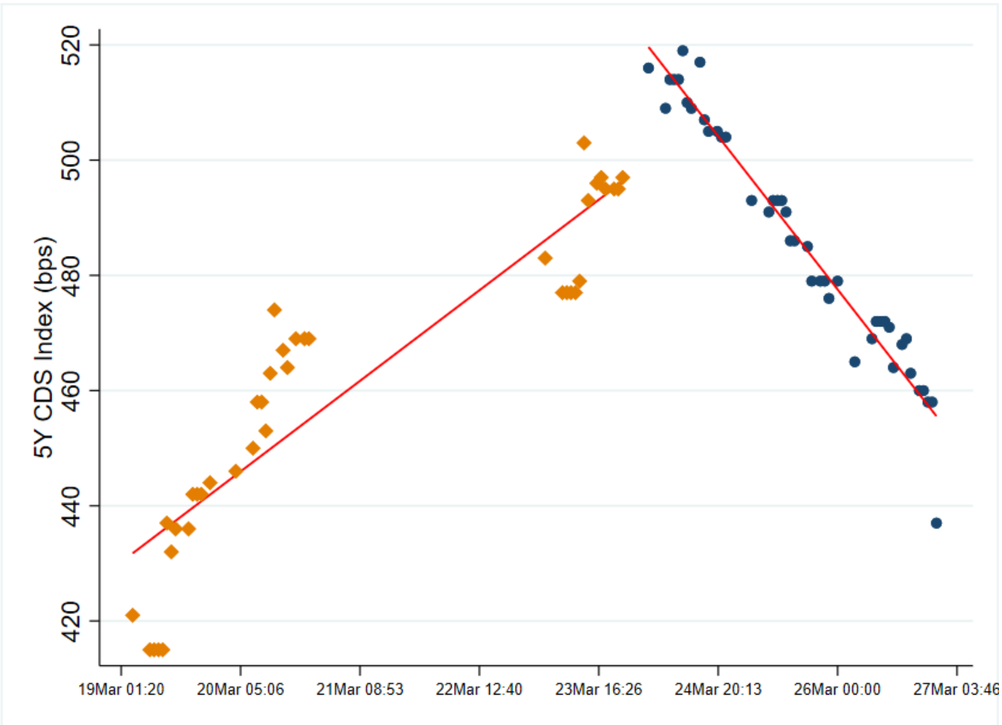


Figure 6. Intraday CDS Index. This figure plots the intraday 5-year CDS index in a narrow window during the ECB and the Federal Reserve QE. Panel A plots the intraday data for European banks, while Panel B plots the data for US banks. The diamond-yellow scatter represents the CDS spread before central bank intervention. The circle blue scatter represents the CDS spread after the intervention. The red solid lines are fitted lines.

12-month LIBOR-OIS spread. In sum, our results suggest that following the QE, banks' funding costs decreased.

We also consider funding costs proxied by the CDS spread using the equation 1:

$$\Delta CDS\ Index_t \quad = \quad \alpha_0 + \alpha_0 CB_t + \epsilon_t \tag{2}$$

The results are reported in column (3) of Table 2. Central banks' QE reduced funding costs.

Table 2. **Funding Costs and Central banks' QE**

This table estimates banks' funding costscosts at the start of QE. The dependent variables are changes in 6-month LIBOR-OIS spread (column (1)), 12-month LIBOR-OIS spread (column (2)), and 5-year CDS Index (column (3)) representing banks' funding costs. The independent variable is a dummy equal to one after the central banks' intervention in March 2020. Standard errors are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively. Variable definitions can be found in Appendix A.

	ΔLIBOR-OIS 6M	ΔLIBOR-OIS 12M	ΔCDS Index 5Y
	(1)	(2)	(3)
CB	-1.896**	-1.591*	-2.070**
	(0.909)	(0.883)	(0.905)
Constant	1.318*	1.246*	1.519**
	(0.722)	(0.702)	(0.720)
Observations	125	125	125
R^2	0.034	0.026	0.041

3 US Market

The results in Section 2 suggest that QE effectively reduced banks' funding costs and that credit lines' prices fell following QE. In the next sections, we shall provide empirical evidence. We start with a simple panel regression analysis. Results in this section will be informative as they will set a benchmark for the empirical analysis we present and discuss in the rest of the paper[8].

Can the central bank's QE mitigate the covariance between funding costs and credit line drawdowns? Based on the theoretical results in Cooperman et al. (2025), we conjecture that this is the case and that the effect should also extend to the lines' prices. However, we are not aware of papers that have tested it formally. Furthermore, we also provide some theory to explain the dynamics.

To strengthen our case that QE can affect lines' prices by reducing funding costs, we also extend our analysis to cross-country and consider ECB QE in Europe. By considering two very different countries and different ways to conduct QE, we can control for factors which are specific to a given geographic area or QE implementation. Furthermore, this should also help us to understand credit line price dynamics in the US and Europe. In this sense, our results extend Berg et al. (2016) and Berg et al. (2017) by considering QE. We also present results for undrawn fees as they are off-balance sheet items.

3.1 Baseline specification

We start with the US market and use pooled OLS. We study whether banks' funding costs are associated with credit lines' prices[9]. We employ the following regression:

$$\begin{aligned} Y_{i,t} \quad = \quad & \beta_0 + \beta_1 \mathit{LIBOR\text{-}OIS}_t + \beta_2 \mathit{LIBOR\text{-}OIS}_t \times \mathit{CB}_t + \beta_3 \mathit{ln(Loan\ Amount)}_{i,t} \\ & + \beta_4 \mathit{Maturity\ 1\text{-}3yr}_{i,t} + \beta_5 \mathit{Maturity\ 3\text{-}6yr}_{i,t} + \beta_6 \mathit{Maturity\ {>}6yr}_{i,t} + \beta_7 \mathit{Secured}_{i,t} \\ & + \beta_8 \mathit{ln(\#Lenders)}_{i,t} + \gamma X_{i,t} + \epsilon_{i,t} \end{aligned} \tag{3}$$

where $Y_{i,t}$ denotes corporate borrowing fees, and $\mathit{LIBOR\text{-}OIS}_t$ is LIBOR-OIS spread, proxying for borrowing costs. CB_t is a time dummy equal to one after March 2020, when central banks' QE was implemented. $\mathit{ln(Loan\ Amount)}_{i,t}$ denotes the natural logarithm of facility amount. Under the context of revolving credit facilities, this facility amount represents the total committed amount of credit lines. A set of dummies, $\mathit{Maturity\ 1\text{-}3yr}_{i,t}$, $\mathit{Maturity\ 3\text{-}6yr}_{i,t}$, and $\mathit{Maturity} > \mathit{6yr}_{i,t}$, control

[8] Note that the evidence reported so far, that is, lower funding banks' costs affecting the price of credit lines, is established theoretically in Cooperman et al. (2025)

[9] Following Burnside & Cerrato (2023), we use LIBOR minus OIS spreads to proxy for funding costs, and in the Appendix, we also report results when using banks' CDS spreads. Table B1 in Appendix B.1 shows the results.

for different maturities of the loan facility. $Secured_{i,t}$ is a dummy indicating the facility has collateral, and $ln(\#Lenders)_{i,t}$ denotes the natural logarithm of the number of lenders. $X_{i,t}$ indicates fixed effects, including time, industry, and loan purpose.

Columns (1) across (8) in Table 3 show the empirical results using OLS regressions 3. We start with credit lines' prices (columns (1) to (4)). The coefficients on the LIBOR-OIS spread are significant and positive, suggesting that US banks transfer the increasing funding costs to borrowers (i.e. firms) by increasing the prices of credit lines. For example, a 1 basis point increase in 6-month (12-month) LIBOR-OIS spreads leads to a 3.2 basis points (1.8 basis points) increase in drawdown fees. This result is in line with Cooperman et al. (2025)'s theoretical model.

The positive coefficient of LIBOR-OIS spread (columns (5) across (8)) on the price of undrawn credit lines is also consistent with an increase in funding costs having a positive impact on undrawn fees. The undrawn fee increases by 0.4 basis points (0.2 basis points), given a 1 basis point increase in 6-month (12-month) LIBOR-OIS spreads. Note that the impact of funding costs on undrawn prices is much smaller (and sometimes insignificant) than drawdown prices. This is reasonable given that undrawn credit lines are off-balance sheet items, and therefore, the price is less responsive to increases in funding (regulatory) costs.

Following the results in Section 2.4, we include an interaction term of funding costs with the dummy to capture the effect of central bank intervention. We set the dummy equal to one in March 2020. As pointed out in Cooperman et al. (2025), higher funding costs are debt overhang costs for banks' shareholders. Cooperman et al. (2025) and our theory in Section 6 suggests that this cost is related to the covariance between banks' funding costs and drawdown size. Banks will price this cost proportionally based on the lines' fees.

Columns (2), (4), (6), and (8) of Table 3 show the estimated coefficients of the interaction in equation 3. The combined coefficients on LIBOR-OIS spread and the interaction term can capture the effect of the central banks' QE. The results suggest that QE does mitigate banks' funding costs, and this benefit is, in part, transferred to lines' prices.

Our results reinforce our conjecture that the FED asset purchase program may have contributed to the increase in credit to the real economy [10]. Our results are new and very important as they suggest that 1) central bank's QE is associated with a reduction of banks' funding costs and that the covariance between funding costs and credit line drawdowns is mitigated via QE; and 2) central banks' QE may not only be effective to stabilise financial markets, but it can also help credit markets to convey credit to the real economy. In Section 6, we provide a simple theoretical framework to

[10] Similarly, we complement these results in Table B1 of Appendix B.1.

explain the mechanism.

Table OA1.1 in the Online Appendix OA1 uses FEB asset purchase as a proxy for the QE effect and tests how QE reduces credit line prices via funding costs. Tables OA3.1 and OA3.2 in the Online Appendix OA3 apply cross-sectional analysis for this test. Although we use a battery of econometric approaches (FED asset purchase and cross-sectional analysis), the results remain largely unchanged. In Table OA4.1 in the Online Appendix OA4, we also do the analysis in this section but after matching the CDS spread of the specific bank, (therefore not the index) with the price of the credit line provided by that bank. We also control for various credit line characteristics. The results are in line with what we have presented in this section.

Although the literature on loan facilities' fees uses All In Spread Drawn as a crucial proxy for the loan price, following Berg et al. (2017), we also employ a comprehensive measure of borrowing fee, which is "usage-weighted spread (UWS)". UWS consists of two parts: 1) All In Spread Drawn, measuring borrowers' cost of drawing down credit lines, and 2) All In Spread Undrawn, measuring borrowers' cost of keeping the undrawn amount of credit lines. This is defined as follows:

$$\mathit{UWS(p)} \quad = \quad p \cdot \mathit{All\ In\ Spread\ Drawn} + (1-p) \cdot \mathit{All\ In\ Spread\ Undrawn} \tag{4}$$

where p represents the probability of a firm drawing down credit lines, and $1-p$ represents the probability that this firm withdraws nothing from credit facilities. As Berg et al. (2016) and Berg et al. (2017) measure the average credit line drawdown rate (or credit line usage) is around 20%-30% across European and US firms, we apply this range and approximate the drawdown probability p as 30%, 25%, and 20%, respectively. We construct a comprehensive borrowing cost, UWS, based on the following assumptions: *UWS 30%*, *UWS 25%*, and *UWS 20%*. Substituting $Y_{i,t}$ in equation 3 with UWSs, we report the results in Table 4.

In Table 4, the coefficients on LIBOR-OIS spreads for UWS are similar to those in Table 3. Columns (1) to (12) are based on OLS specifications as in equation 3, holding positive coefficients and suggesting that, without central banks' asset purchase programs, banks would have increased lines' fees. The drawdown assumption of 30% leads to the largest coefficients in which a 1 basis point increase in 6-month (12-month) LIBOR-OIS spreads leads to a 0.9 basis points (0.5 basis points) increase in borrowing fees.

Columns (2), (4), (6), (8), (10), and (12) in Table 4 show the estimation of the interaction term in equation 3. In line with the results presented earlier, QE does help to mitigate banks' funding

Table 3. **Credit Line Prices and Funding Costs (US)**

This table estimates corporate borrowing fees and banks' short-term funding costs. The dependent variable is *All In Spread Drawn (AISD)* in columns (1) across (4), and *All In Spread Undrawn (AISU)* in columns (5) across (8). The independent variables include a shock dummy equal to one indicating central bank intervention (QE), 6-month and 12-month LIBOR-OIS spreads. The controls contain a logarithm of facility amount, dummies indicating 1-3 years, 3-6 years, and over 6 years maturities, a dummy indicating whether a facility is secured, and a logarithm of lender numbers. All columns include year-month, two-digit SIC industry, and loan purpose fixed effects. Standard errors are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively. All variables are winsorized at 1% and 99%. Variable definitions can be found in Appendix A.

Sample	Credit Lines							
Dependent Variable	AISD				AISU			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LIBOR-OIS 6M	3.211***	3.211***			0.380***	0.380***		
	(0.811)	(0.811)			(0.113)	(0.113)		
LIBOR-OIS 6M×CB		-1.801***				-0.070		
		(0.563)				(0.079)		
LIBOR-OIS 12M			1.812***	1.812***			0.215***	0.215***
			(0.458)	(0.458)			(0.064)	(0.064)
LIBOR-OIS 12M×CB				-0.424*				0.089***
				(0.221)				(0.031)
ln(Loan Amount)	-39.628***	-39.628***	-39.628***	-39.628***	-3.945***	-3.945***	-3.945***	-3.945***
	(0.582)	(0.582)	(0.582)	(0.582)	(0.092)	(0.092)	(0.092)	(0.092)
Maturity 1-3Y	6.768**	6.768**	6.768**	6.768**	8.357***	8.357***	8.357***	8.357***
	(2.696)	(2.696)	(2.696)	(2.696)	(0.363)	(0.363)	(0.363)	(0.363)
Maturity 3-6Y	16.206***	16.206***	16.206***	16.206***	6.816***	6.816***	6.816***	6.816***
	(2.126)	(2.126)	(2.126)	(2.126)	(0.261)	(0.261)	(0.261)	(0.261)
Maturity >6Y	74.968***	74.968***	74.968***	74.968***	14.865***	14.865***	14.865***	14.865***
	(5.104)	(5.104)	(5.104)	(5.104)	(0.978)	(0.978)	(0.978)	(0.978)
Secured	52.900***	52.900***	52.900***	52.900***	10.676***	10.676***	10.676***	10.676***
	(1.189)	(1.189)	(1.189)	(1.189)	(0.182)	(0.182)	(0.182)	(0.182)
ln(#Lenders)	-10.687***	-10.687***	-10.687***	-10.687***	-0.360**	-0.360**	-0.360**	-0.360**
	(1.045)	(1.045)	(1.045)	(1.045)	(0.171)	(0.171)	(0.171)	(0.171)
Time FE	yes	yes	yes	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes	yes	yes	yes	yes
Purpose FE	yes	yes	yes	yes	yes	yes	yes	yes
Observations	42880	42880	42880	42880	27314	27314	27314	27314
R^2	0.502	0.502	0.502	0.502	0.500	0.500	0.500	0.500

costs and this benefit was transferred, in part, to borrowers [11].

[11] In Table B2 of Appendix B.1, we also show similar results when banks' CDS spread is considered.

Table 4. **Credit Line Fees and Funding Costs (US)**

This table estimates corporate borrowing fees on banks' short-term funding costs. The dependent variable is usage-weighted spreads in different drawdown assumptions, including 30% (columns (1) across (4)), 25% (columns (5) across (8)), and 20% (columns (9) across (12)). The independent variables include a shock dummy equal to one indicating central bank intervention (QE), 6-month and 12-month LIBOR-OIS spreads. The controls are the logarithm of facility amount, dummies indicating 1-3 years, 3-6 years, and over 6 years maturities, a dummy indicating whether a facility is secured, and a logarithm of lender numbers. All columns include year-month, two-digit SIC industry, and loan purpose fixed effects. Standard errors are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively. All variables are winsorized at 1% and 99%. Variable definitions can be found in Appendix A.

Sample	Credit Lines											
Specification	UWS 30%				UWS 25%				UWS 20%			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
LIBOR-OIS 6M	0.874***	0.874***			0.701***	0.701***			0.528***	0.528***		
	(0.261)	(0.261)			(0.227)	(0.227)			(0.196)	(0.196)		
LIBOR-OIS 6M×CB		-0.365**				-0.263*				-0.161		
		(0.181)				(0.158)				(0.136)		
LIBOR-OIS 12M			0.493***	0.493***			0.396***	0.396***			0.298***	0.298***
			(0.148)	(0.148)			(0.128)	(0.128)			(0.111)	(0.111)
LIBOR-OIS 12M×CB				0.007				0.034				0.062
				(0.071)				(0.062)				(0.053)
ln(Loan Amount)	-13.239***	-13.239***	-13.239***	-13.239***	-11.274***	-11.274***	-11.274***	-11.274***	-9.311***	-9.311***	-9.311***	-9.311***
	(0.183)	(0.183)	(0.183)	(0.183)	(0.159)	(0.159)	(0.159)	(0.159)	(0.137)	(0.137)	(0.137)	(0.137)
Maturity 1-3Y	8.440***	8.440***	8.440***	8.440***	8.027***	8.027***	8.027***	8.027***	7.589***	7.589***	7.589***	7.589***
	(0.845)	(0.845)	(0.845)	(0.845)	(0.734)	(0.734)	(0.734)	(0.734)	(0.633)	(0.633)	(0.633)	(0.633)
Maturity 3-6Y	10.865***	10.865***	10.865***	10.865***	9.930***	9.930***	9.930***	9.930***	8.970***	8.970***	8.970***	8.970***
	(0.649)	(0.649)	(0.649)	(0.649)	(0.564)	(0.564)	(0.564)	(0.564)	(0.486)	(0.486)	(0.486)	(0.486)
Maturity >6Y	26.331***	26.331***	26.331***	26.331***	22.409***	22.409***	22.409***	22.409***	18.596***	18.596***	18.596***	18.596***
	(1.630)	(1.630)	(1.630)	(1.630)	(1.416)	(1.416)	(1.416)	(1.416)	(1.221)	(1.221)	(1.221)	(1.221)
Secured	19.449***	19.449***	19.449***	19.449***	16.968***	16.968***	16.968***	16.968***	14.477***	14.477***	14.477***	14.477***
	(0.382)	(0.382)	(0.382)	(0.382)	(0.332)	(0.332)	(0.332)	(0.332)	(0.286)	(0.286)	(0.286)	(0.286)
ln(#Lenders)	0.804**	0.804**	0.804**	0.804**	1.598***	1.598***	1.598***	1.598***	2.385***	2.385***	2.385***	2.385***
	(0.332)	(0.332)	(0.332)	(0.332)	(0.289)	(0.289)	(0.289)	(0.289)	(0.249)	(0.249)	(0.249)	(0.249)
Time FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Purpose FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	43667	43667	43667	43667	43667	43667	43667	43667	43667	43667	43667	43667
R^2	0.492	0.492	0.492	0.492	0.475	0.475	0.475	0.475	0.445	0.445	0.445	0.445

4 European Market

In this section, we focus on the European market to strengthen our case that QE can affect lines' prices by reducing funding costs and we extend our previous analysis to Europe. By considering two different countries and different ways of conducting QE, we can mitigate the effect of factors specific to a geographic area or QE implementation. Furthermore, this should also help us to understand credit line price dynamics in the US and Europe.

We use the same econometric framework as before. We regress LIBOR-OIS spreads on credit line drawdown prices and undrawn prices by using equation 3 specification.[12] Table 5 shows the empirical results.

In line with the US market, we note positive and significant coefficients on LIBOR-OIS spreads versus drawdown prices (columns (1) across (4)) using the OLS specification. Lines' prices in Europe are more sensitive to banks' funding costs (see columns 1 and 3) if compared with the US. Furthermore, the impact of QE on funding costs is larger in Europe (see columns (2) and (4)).

These results suggest that the ECB asset purchase programs also contributed to mitigating banks' funding costs with a beneficial effect on lines' prices, Table 5). Banks raise the price on undrawn credit lines (columns (6) and (8)).[13]

Combining drawdown cost and undrawn fee, we use UWS to study if banks' funding costs are associated with lines' prices. Table 6 shows the results using equation 3 specification. We find similar results as for the US market (Table 4) on funding costs and their interaction with the COVID-19 shock.[14]

[12] In Table B4 of Appendix B.2, we regress corporate borrowing prices of credit lines on bank funding costs.
[13] Table B4 in Appendix B.2 reports the results by using banks' CDS spreads.
[14] In Table B5 of Appendix B.2, we support these results using banks' CDS spreads.

Table 5. **Credit Line Prices and Funding Costs (Europe)**

This table estimates corporate borrowing prices on banks' funding costs. The dependent variable is *All In Spread Drawn (AISD)* in columns (1) across (4), and *All In Spread Undrawn (AISU)* in columns (5) across (8). The independent variables include a shock dummy equal to one indicating central bank intervention (QE), 6-month and 12-month LIBOR-OIS spreads. The controls contain a logarithm of facility amount, dummies indicating 1-3 years, 3-6 years, and over 6 years maturities, a dummy indicating whether a facility is secured, and a logarithm of lender numbers. All columns include year-month, two-digit SIC industry, and loan purpose fixed effects. Standard errors are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively. All variables are winsorized at 1% and 99%. Variable definitions can be found in Appendix A.

Sample	Credit Lines							
Dependent Variable	AISD				AISU			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LIBOR-OIS 6M	5.828***	5.828***			-4.067***	-4.067***		
	(1.301)	(1.301)			(0.569)	(0.569)		
LIBOR-OIS 6M×CB		-4.460***				2.960***		
		(0.934)				(0.401)		
LIBOR-OIS 12M			3.289***	3.289***			-2.295***	-2.295***
			(0.735)	(0.735)			(0.321)	(0.321)
LIBOR-OIS 12M×CB				-1.932***				1.200***
				(0.387)				(0.162)
ln(Loan Amount)	-15.047***	-15.047***	-15.047***	-15.047***	-8.753***	-8.753***	-8.753***	-8.753***
	(1.071)	(1.071)	(1.071)	(1.071)	(0.956)	(0.956)	(0.956)	(0.956)
Maturity 1-3Y	51.166***	51.166***	51.166***	51.166***	0.815	0.815	0.815	0.815
	(5.060)	(5.060)	(5.060)	(5.060)	(3.699)	(3.699)	(3.699)	(3.699)
Maturity 3-6Y	43.254***	43.254***	43.254***	43.254***	6.472**	6.472**	6.472**	6.472**
	(4.629)	(4.629)	(4.629)	(4.629)	(3.071)	(3.071)	(3.071)	(3.071)
Maturity >6Y	73.271***	73.271***	73.271***	73.271***	9.061**	9.061**	9.061**	9.061**
	(5.697)	(5.697)	(5.697)	(5.697)	(4.519)	(4.519)	(4.519)	(4.519)
Secured	69.379***	69.379***	69.379***	69.379***	7.631***	7.631***	7.631***	7.631***
	(2.478)	(2.478)	(2.478)	(2.478)	(2.009)	(2.009)	(2.009)	(2.009)
ln(#Lenders)	-27.293***	-27.293***	-27.293***	-27.293***	3.627**	3.627**	3.627**	3.627**
	(2.010)	(2.010)	(2.010)	(2.010)	(1.564)	(1.564)	(1.564)	(1.564)
Time FE	yes	yes	yes	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes	yes	yes	yes	yes
Purpose FE	yes	yes	yes	yes	yes	yes	yes	yes
Observations	7064	7064	7064	7064	1995	1995	1995	1995
R^2	0.609	0.609	0.609	0.609	0.774	0.774	0.774	0.774

Table 6. **Credit Line Prices and Funding Costs (Europe)**

This table estimates corporate borrowing prices on banks' funding costs. The dependent variable is usage-weighted spreads in different drawdown assumptions, including 30% (columns (1) across (4)), 25% (columns (5) across (8)), and 20% (columns (9) across (12)). The independent variables include a shock dummy equal to one indicating central bank intervention (QE), 6-month and 12-month LIBOR-OIS spreads. The controls contain a logarithm of facility amount, dummies indicating 1-3 years, 3-6 years, and over 6 years maturities, a dummy indicating whether a facility is secured, and a logarithm of lender numbers. All columns include year-month, two-digit SIC industry, and loan purpose fixed effects. Standard errors are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively. All variables are winsorized at 1% and 99%. Variable definitions can be found in Appendix A.

Sample	Credit Lines											
Specification	UWS 30%				UWS 25%				UWS 20%			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
LIBOR-OIS 6M	1.248**	1.248**			0.919*	0.919*			0.590	0.590		
	(0.567)	(0.567)			(0.537)	(0.537)			(0.514)	(0.514)		
LIBOR-OIS 6M×CB		-0.808**				-0.546				-0.283		
		(0.407)				(0.385)				(0.369)		
LIBOR-OIS 12M			0.705**	0.705**			0.519*	0.519*			0.333	0.333
			(0.320)	(0.320)			(0.303)	(0.303)			(0.290)	(0.290)
LIBOR-OIS 12M×CB				-0.270				-0.151				-0.031
				(0.169)				(0.160)				(0.153)
ln(Loan Amount)	-3.873***	-3.873***	-3.873***	-3.873***	-3.066***	-3.066***	-3.066***	-3.066***	-2.258***	-2.258***	-2.258***	-2.258***
	(0.467)	(0.467)	(0.467)	(0.467)	(0.442)	(0.442)	(0.442)	(0.442)	(0.423)	(0.423)	(0.423)	(0.423)
Maturity 1-3Y	13.091***	13.091***	13.091***	13.091***	10.323***	10.323***	10.323***	10.323***	7.554***	7.554***	7.554***	7.554***
	(2.205)	(2.205)	(2.205)	(2.205)	(2.087)	(2.087)	(2.087)	(2.087)	(1.997)	(1.997)	(1.997)	(1.997)
Maturity 3-6Y	11.450***	11.450***	11.450***	11.450***	9.183***	9.183***	9.183***	9.183***	6.917***	6.917***	6.917***	6.917***
	(2.017)	(2.017)	(2.017)	(2.017)	(1.910)	(1.910)	(1.910)	(1.910)	(1.827)	(1.827)	(1.827)	(1.827)
Maturity >6Y	16.150***	16.150***	16.150***	16.150***	12.115***	12.115***	12.115***	12.115***	8.081***	8.081***	8.081***	8.081***
	(2.483)	(2.483)	(2.483)	(2.483)	(2.350)	(2.350)	(2.350)	(2.350)	(2.249)	(2.249)	(2.249)	(2.249)
Secured	22.202***	22.202***	22.202***	22.202***	18.798***	18.798***	18.798***	18.798***	15.395***	15.395***	15.395***	15.395***
	(1.080)	(1.080)	(1.080)	(1.080)	(1.022)	(1.022)	(1.022)	(1.022)	(0.978)	(0.978)	(0.978)	(0.978)
ln(#Lenders)	-10.364***	-10.364***	-10.364***	-10.364***	-9.113***	-9.113***	-9.113***	-9.113***	-7.861***	-7.861***	-7.861***	-7.861***
	(0.876)	(0.876)	(0.876)	(0.876)	(0.829)	(0.829)	(0.829)	(0.829)	(0.793)	(0.793)	(0.793)	(0.793)
Time FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Purpose FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	7064	7064	7064	7064	7064	7064	7064	7064	7064	7064	7064	7064
R^2	0.482	0.482	0.482	0.482	0.443	0.443	0.443	0.443	0.395	0.395	0.395	0.395

5 Additional Analysis

The empirical evidence so far suggests that the central bank's QE reduces banks' funding costs and helps to provide cheaper credit lines. However, we cannot fully exclude the results not driven by confounding factors, making it difficult to disentangle the effect of QE from other things affecting funding costs and credit line prices.

On top of our instrumental variable approach in the Online Appendix OA1, in the next sections, we propose two novel empirical strategies based on difference-in-differences (DID) and propensity score matching (PSM), to mitigate this concern. Additional tests can be found in the Online Appendix.

5.1 Difference-in-Differences (DID) Analysis

Our first DID specification uses undrawn prices as a control group. Undrawn prices are associated with maintaining access to credit without actively drawing down funds. Since they are off-balance-sheet items for banks, one would expect that QE has a relatively lesser (or insignificant) impact on undrawn prices if compared to drawdown prices, which are on-balance-sheet items. Our earlier results also point in this direction.

By comparing the relative changes in drawdown and undrawn prices before and after the implementation of QE, we can more accurately isolate the specific impact of QE on drawdown prices.

We design the following difference-in-differences (DID) analysis:

$$\begin{aligned} \textit{Loan Prices}_{i,t} \;&=\; \alpha + \beta_1 \textit{Post QE}_t + \beta_2 \textit{Treatment}_i + \beta_3(\textit{Post QE}_t \times \text{Treatment}_i) \\ &\quad + \gamma' \mathbf{X}_{i,t} + \lambda_t + \mu_i + \eta_i + \epsilon_{i,t} \end{aligned} \tag{5}$$

where *Loan Prices*$_{i,t}$ represents the price for borrower i at time t, combining both credit line drawdown price (AISD) and undrawn fee (AISU). *Post QE*$_t$ is a time dummy that equals 1 for six months after March 2020 (the onset of QE) and 0 for six months before that time. *Treatment*$_i$ is a dummy that equals one if it is a drawdown price. *Post QE*$_t$ $\times$ Treatment$_i$) is the interaction term that captures the differential effect of QE on Drawdown and Undrawn Prices. $\mathbf{X}_{i,t}$ is a vector of control variables, including *ln(Loan Amount)*$_{i,t}$, *Maturity 1-3yr*$_{i,t}$, *Maturity 3-6yr*$_{i,t}$, *Maturity* $>$ *6yr*$_{i,t}$, *Secured*$_{i,t}$, and *ln(#Lenders)*$_{i,t}$. λ_t represents time-fixed effects to control for time-specific shocks, μ_i represents borrower-fixed effects to control for borrower-specific industrial characteristics, and η_i represents the loan-fixed effects to control for loan purposes.

β_3 is the coefficient of interest. A significant β_3 suggests that QE has a differential impact on drawdown prices. We expect this coefficient to be negative, as QE should mitigate the bank's funding costs and reduce drawdown prices more than the undrawn prices. Columns (1) - (4) in Table 7 shows the estimates. Regardless of controls and fixed effects, β_3 has an estimate of -36, which means that following QE, drawdown prices, on average, dropped by 36 bp compared to undrawn prices. Considering controls and fixed effects, the drawdown prices still fell 22 basis points.

We now consider the same DID framework as the previous section but use term loans as a control. Term loans differ from credit lines in their structure, offering fixed amounts and repayment terms rather than unpredictable drawdowns. As also noted in Cooperman et al. (2025), banks do not face significant funding costs to finance term loans. In fact, the covariance between funding costs and drawdown size is constant. We shall also provide a simple proof of this in the next sections. By incorporating term loan prices into the DID framework, we aim to control for confounding factors driving our earlier results.

We replace our control group in Equation 5 with term loan prices. β_3 is still our main interest to capture the differential impact on drawdown prices compared to term loan prices. We expect this coefficient to be significant and negative. Columns (5) - (8) in Table 7 shows the results. The estimated coefficient of β_3 is -37 basis points without controls and fixed effects and -26 basis points with all controls and fixed effects. It suggests that the QE reduced the drawdown prices by 37 basis points (or 26 basis points by controlling the characteristics of borrowers and loans), similar to the previous case. This large reduction is likely to have an economically significant impact on the price of credit to the real economy.

Table 7. **DID Analysis (US)**

This table shows differences-in-differences estimates. The sampling period contains six months before the central bank's QE in March 2020 and six months after. The dependent variable is loan price. The time dummy is equal to one, indicating the period after March 2020 and zero otherwise. The treatment dummy is equal to one indicating the treatment group and drawdown price across all columns, and zero indicating the control group, which is the undrawn fee in columns (1) - (4) and the term loan price in the rest columns. The control variables contain a logarithm of facility amount, dummies indicating 1-3 years, 3-6 years, and over 6 years maturities, a dummy indicating whether a facility is secured, and a logarithm of lender numbers. Columns (2), (4), (6), and (8) include year-month, two-digit SIC industry, and loan purpose fixed effects. Standard errors are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively. All variables are winsorized at 1% and 99%. Variable definitions can be found in Appendix A.

Treatment Group	Drawdown Price							
Control Group	Undrawn Fee				Term Loan Price			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post QE	0.571	2.260	14.250***	4.346	1.440	49.456***	21.663***	45.787***
	(0.590)	(8.542)	(2.038)	(8.173)	(7.028)	(13.778)	(5.668)	(11.670)
Treatment	220.525***	193.260***	194.358***	181.813***	-103.005***	-57.986***	-65.912***	-39.871***
	(3.220)	(2.661)	(2.740)	(2.523)	(5.269)	(4.602)	(4.723)	(4.458)
Post QE×Treatment	-36.002***	-24.460***	-32.059***	-22.194***	-36.871***	-35.608***	-21.539***	-25.732***
	(4.361)	(3.749)	(3.922)	(3.549)	(8.250)	(7.101)	(6.653)	(6.118)
ln(Loan Amount)			-22.993***	-19.347***			-26.829***	-25.263***
			(1.586)	(1.509)			(1.968)	(1.949)
Maturity 1-3Y			-7.315**	-13.233***			-40.461***	-47.041***
			(3.402)	(3.392)			(5.433)	(5.383)
Maturity 3-6Y			10.905***	-13.596***			12.971***	-15.819***
			(2.733)	(2.780)			(4.968)	(5.129)
Maturity >6Y			91.930***	90.106***			20.812**	16.237**
			(24.681)	(25.194)			(8.548)	(8.282)
Secured			60.510***	35.608***			135.841***	92.170***
			(3.185)	(3.586)			(4.184)	(4.319)
ln(#Lenders)			-21.240***	-14.915***			-51.213***	-46.616***
			(2.928)	(2.811)			(3.868)	(3.802)
Constant	23.671***	2.709	210.832***	179.747***	347.201***	320.913***	530.975***	547.304***
	(0.416)	(14.490)	(7.138)	(16.305)	(4.192)	(23.076)	(9.725)	(21.698)
Time FE	no	yes	no	yes	no	yes	no	yes
Industry FE	no	yes	no	yes	no	yes	no	yes
Purpose FE	no	yes	no	yes	no	yes	no	yes
Observations	7616	7616	7615	7615	8261	8261	8258	8258
R^2	0.446	0.648	0.586	0.695	0.105	0.417	0.422	0.567

5.2 Propensity Score Matching (PSM) Analysis

Next, we use PSM to construct a matched sample using the nearest-neighbor propensity score match. The scores are given by a logit model where the dependent variable *Treatment* is an indicator variable that is equal to one indicating the treated group and zero indicating the control group. In the PSM model, we include all firm-level control variables from the DID model of Equation 5 as well as fixed effects.

Similar to the previous sections, we first adopt undrawn fees as a control group. We use the predicted probabilities of the logit model as the propensity scores and employ the kernel density matching method. The kernel densities of the treated and the control groups before and after matching are shown in Figure 7. Compared with the upper panel in the figure, a smaller difference was observed between the control and the treated groups after matching.

Table 8 shows the results of the PSM analysis. Particularly, Panel A reports parameters estimated from the logit model used in evaluating the propensity scores for drawdown prices versus undrawn fees. Panel B shows the efficiency of the propensity score matching process. The differences between the two groups are significant for many variables before matching (Column (3)), while they turn insignificant for all variables after the matching process (Column (6)), suggesting our matching is efficient. Panel C of Table 8 reports the estimate of Equation 5 by using the matched sample. We start with the DID model without control variables and fixed effects in Column (1) and add them up in the rest of the columns. The variable of interest is the interaction term *Post QE* $\times$ *Treatment*, which is significant and negative in all columns. It leads to similar inferences as in the DID analysis (Table 7). Together, these PSM results further suggest that our results are highly likely to be driven by the differential QE effects between drawdown prices and undrawn fees.

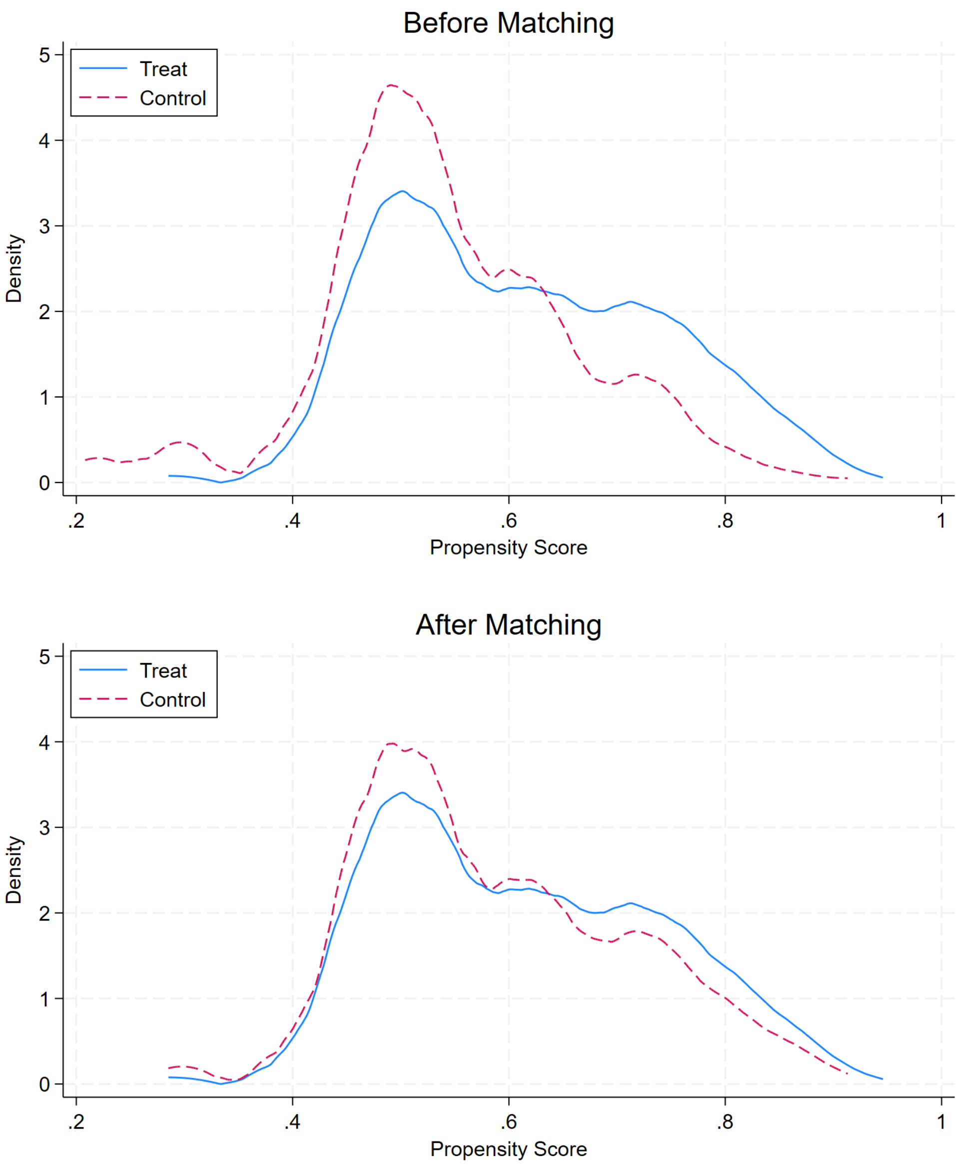


Figure 7. Kernel Density Before and After Matching. This figure plots the kernel density before (the upper plot) and after matching (the lower plot). The horizontal axis represents the propensity scores, and the vertical axis represents the kernel density. The solid blue line represents the treated group (drawdown prices), while the dashed red line represents the control group (undrawn fees).

Table 8. **PSM-DID Analysis (Drawdown Price versus Undrawn Fee)**

This table shows propensity score matching estimates. The sampling period contains six months before the central bank's QE in March 2020 and six months after. In Panel A, the dependent variable is a dummy equal to one indicating the treated group, drawdown price, and zero indicating the control group, undrawn fee. The covariate variables contain a logarithm of facility amount, dummies indicating 1-3 years, 3-6 years, and over 6 years maturities, a dummy indicating whether a facility is secured, and a logarithm of lender numbers. Panel B shows the descriptive statistics before and after matching. Panel C shows the DID estimates based on the matched sample. The dependent variable includes drawdown prices and undrawn fees. The time dummy is equal to one, indicating the period after March 2020 and zero otherwise. Columns (2) and (4) include year-month, two-digit SIC industry, and loan purpose fixed effects. Standard errors are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively. All variables are winsorized at 1% and 99%. Variable definitions can be found in Appendix A.

Panel A: Determinants Model of Drawdown Price (Logit)	
Treatment = 1	Drawdown Price
Treatment = 0	Undrawn Fee
	(1)
ln(Loan Amount)	-0.142***
	(0.033)
Maturity 1-3Y	0.149
	(0.100)
Maturity 3-6Y	0.139*
	(0.079)
Maturity >6Y	1.324***
	(0.490)
Secured	0.096
	(0.073)
ln(#Lenders)	-0.291***
	(0.060)
Time FE	yes
Industry FE	yes
Purpose FE	yes
Observations	7,564
Pseudo R^2	0.052

Panel B: Descriptive Statistics Before and After Matching						
Sample	Pre-Match			Post-Match		
	Drawdown Price	Undrawn Fee	Difference	Drawdown Price	Undrawn Fee	Difference
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Loan Amount)	6.521	7.035	-0.514***	6.527	6.549	-0.022
Maturity 1-3Y	0.103	0.097	0.006	0.103	0.108	-0.005
Maturity 3-6Y	0.660	0.598	0.062***	0.660	0.653	0.007

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Table 8 – continued from previous page

Maturity >6Y	0.008	0.002	0.006***	0.008	0.007	0.001
Secured	0.309	0.226	0.083***	0.308	0.292	0.016
ln(#Lenders)	2.125	2.423	-0.298***	2.129	2.155	-0.026
Observations	4419	3145	7564	4406	3065	7471

Panel C: PSM-DID

Treatment Group	Drawdown Price			
Control Group	Undrawn Fee			
	(1)	(2)	(3)	(4)
Post QE	1.667***	0.633	10.830***	4.661
	(0.594)	(8.441)	(2.055)	(8.168)
Treatment	218.219***	192.943***	193.231***	181.170***
	(3.224)	(2.655)	(2.748)	(2.514)
Post QE×Treatment	-34.947***	-22.839***	-27.907***	-18.651***
	(4.369)	(3.764)	(3.935)	(3.561)
ln(Loan Amount)			-23.966***	-20.402***
			(1.597)	(1.516)
Maturity 1-3Y			-5.672*	-12.080***
			(3.422)	(3.423)
Maturity 3-6Y			11.002***	-12.771***
			(2.777)	(2.845)
Maturity >6Y			98.988***	95.662***
			(24.804)	(25.433)
Secured			59.132***	34.728***
			(3.187)	(3.590)
ln(#Lenders)			-20.059***	-14.694***
			(2.913)	(2.804)
Constant	23.671***	6.102	215.052***	195.839***
	(0.416)	(14.536)	(7.294)	(16.269)
Time FE	no	yes	no	yes
Industry FE	no	yes	no	yes
Purpose FE	no	yes	no	yes
Observations	7471	7471	7471	7471
R^2	0.443	0.640	0.583	0.690

Next, we use term loan prices as a control group. As mentioned in the DID analysis, using term loan prices as a counterpoint can help to understand whether the QE has a unique impact on the price of flexible loans (that is, drawdown prices). Again, we apply the logit model to proxy for the propensity scores, along with the kernel density matching method. Figure 8 depicts the kernel densities of the treated and the untreated groups before and after matching. The difference between these two groups becomes smaller after matching.

Table 9 presents the results of the PSM analysis. Panel A displays the parameters estimated from the logit model used to calculate propensity scores for comparing drawdown prices with term loan prices. Panel B assesses the efficiency of the propensity score matching process, showing that the differences between the two groups are significant for many variables before matching (Column (3)) but become insignificant for all variables after matching (Column (6)), indicating effective matching. Panel C of Table 9 provides the estimates of Equation 5 using the matched sample. The analysis begins with the DID model without control variables and fixed effects in Column (1), adding these factors in the subsequent columns. The main variable of interest, the interaction term *Post QE* × *Treatment*, is consistently significant and negative across all columns, leading to similar conclusions as in the DID analysis (Table 7). Overall, these PSM results further support the conclusion that our findings are likely driven by the differential effects of QE on drawdown prices versus term loan prices.

To sum up, the range of tests presented in Tables 7, 8, and 9 collectively address potential endogeneity issues in our baseline setting in Table 3. The consistent results across all these tests enhance our confidence in concluding that the central bank's QE drove the reduction in credit line drawdown prices during the pandemic.

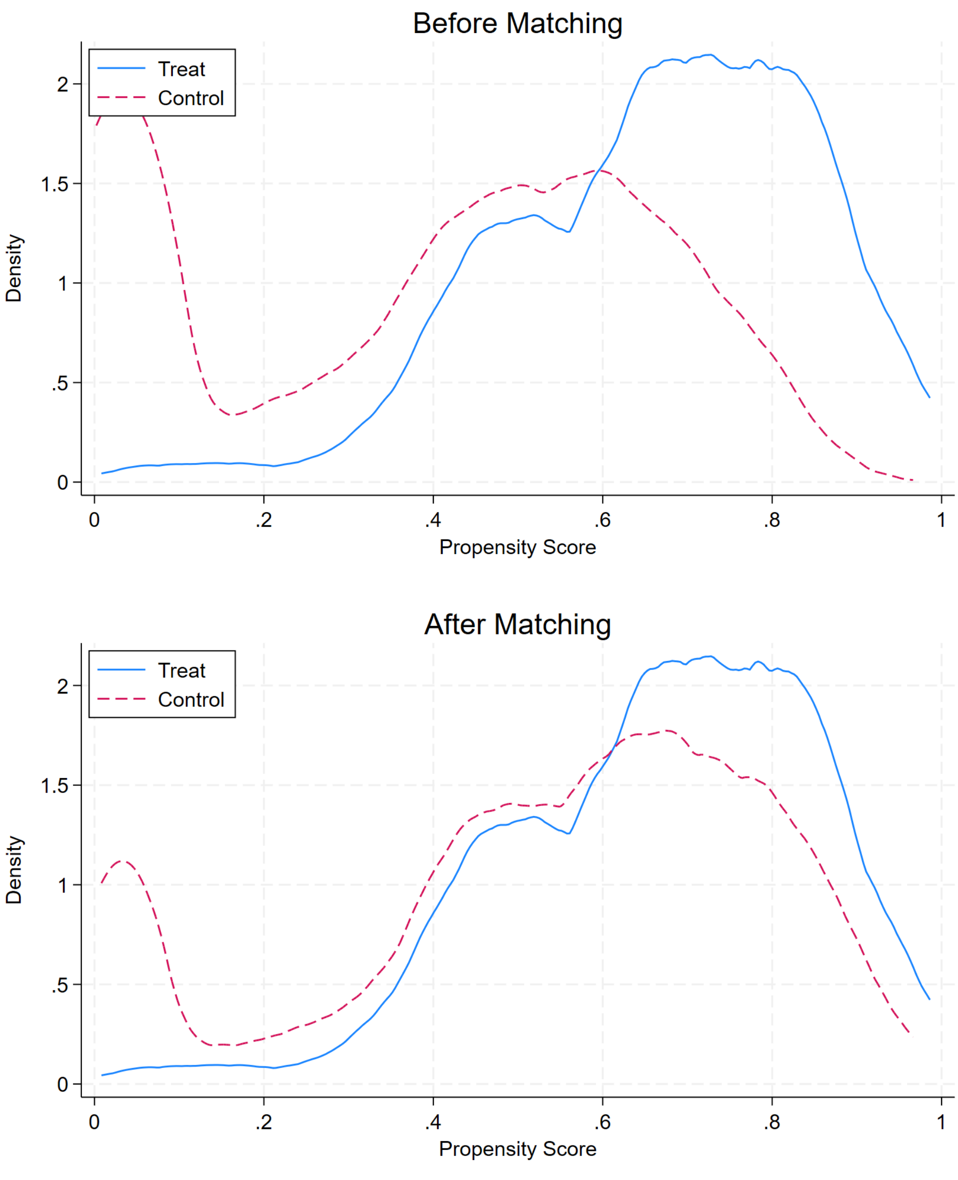

Figure 8. Kernel Density Before and After Matching. This figure plots the kernel density before (the upper plot) and after matching (the lower plot). The horizontal axis represents the propensity scores, and the vertical axis represents the kernel density. The solid blue line represents the treated group (drawdown prices), while the dashed red line represents the control group (term loan prices).

Table 9. **PSM-DID Analysis (Drawdown Price versus Term Loan Price)**

This table shows propensity score matching estimates. The sampling period contains six months before the central bank's QE in March 2020 and six months after. In Panel A, the dependent variable is a dummy equal to one indicating the treated group, drawdown price, and zero indicating the control group, term loan prices. The covariate variables contain a logarithm of facility amount, dummies indicating 1-3 years, 3-6 years, and over 6 years maturities, a dummy indicating whether a facility is secured, and a logarithm of lender numbers. Panel B shows the descriptive statistics before and after matching. Panel C shows the DID estimates based on the matched sample. The dependent variable includes drawdown prices and term loan prices. The time dummy is equal to one, indicating the period after March 2020 and zero otherwise. Columns (2) and (4) include year-month, two-digit SIC industry, and loan purpose fixed effects. Standard errors are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively. All variables are winsorized at 1% and 99%. Variable definitions can be found in Appendix A.

Panel A: Determinants Model of Drawdown Price (Logit)	
Treatment = 1	Drawdown Price
Treatment = 0	Term Loan Price
	(1)
ln(Loan Amount)	0.122***
	(0.032)
Maturity 1-3Y	-0.994***
	(0.108)
Maturity 3-6Y	-0.132
	(0.097)
Maturity >6Y	-4.290***
	(0.206)
Secured	0.064
	(0.070)
ln(#Lenders)	0.099*
	(0.056)
Time FE	yes
Industry FE	yes
Purpose FE	yes
Observations	8,211
Pseudo R^2	0.235

Panel B: Descriptive Statistics Before and After Matching						
Sample	Pre-Match			Post-Match		
	Drawdown Price	TL Price	Difference	Drawdown Price	TL Price	Difference
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Loan Amount)	6.508	6.382	0.126***	6.512	6.250	0.262***
Maturity 1-3Y	0.104	0.124	-0.020***	0.106	0.101	0.005
Maturity 3-6Y	0.657	0.507	0.150***	0.659	0.683	-0.024

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Table 9 – continued from previous page

Maturity >6Y	0.008	0.278	-0.27***	0.008	0.010	-0.002
Secured	0.313	0.506	-0.193***	0.312	0.333	-0.021**
ln(#Lenders)	2.115	1.883	0.232***	2.115	1.894	0.221***
Observations	4429	3782	8211	4351	3714	8065
Panel C: PSM-DID						
Treatment Group			Drawdown Price			
Control Group			Term Loan Price			
			(1)	(2)	(3)	(4)
Post QE			-1.403	39.427***	19.528***	40.304***
			(7.056)	(12.909)	(5.740)	(11.282)
Treatment			-	-57.940***	-64.728***	-39.753***
			101.945***			
			(5.349)	(4.622)	(4.751)	(4.448)
Post QE×Treatment			-38.071***	-34.268***	-20.907***	-24.255***
			(8.315)	(7.160)	(6.729)	(6.179)
ln(Loan Amount)					-27.829***	-25.742***
					(1.998)	(2.014)
Maturity 1-3Y					-40.687***	-46.711***
					(5.461)	(5.435)
Maturity 3-6Y					13.322***	-16.769***
					(5.042)	(5.270)
Maturity >6Y					28.140***	17.471**
					(8.794)	(8.587)
Secured					135.808***	92.902***
					(4.272)	(4.432)
ln(#Lenders)					-48.858***	-46.003***
					(3.939)	(3.917)
Constant			349.936***	315.148***	533.565***	546.550***
			(4.261)	(22.880)	(9.878)	(21.708)
Time FE			no	yes	no	yes
Industry FE			no	yes	no	yes
Purpose FE			no	yes	no	yes
Observations			8065	8065	8065	8065
R^2			0.105	0.415	0.422	0.564

6 A Theoretical Model

This section presents a bank's balance sheet model to study the mechanism behind our empirical results. We first present a summary of the main theoretical result in Cooperman et al. (2025). This will define the general framework of our model.

6.1 Baseline Model from Cooperman et al. (2025)

Figure 9 summarises the model. At the start date ($t = 0$), the bank and the corporate borrower start negotiation on the fixed spread $s(L) > 0$ of the total committed amount of credit lines L, over the variable reference rate $R = r + S$, where r and S represent the risk-free rate and the bank's credit spread respectively.

In this model, there is a risk-neutral bank. At $t = 1$, the information of risk-free rate (r) and credit spread (S) is revealed, and the borrower draws down an amount of q, where. $q = q(L)$. We assume that at $t = 1$, $-\varphi q + \delta(1 + r)\varphi q = 0$, where $\delta = 1/(1 + r)$[15]. Given the deposit fraction, the bank needs to fund the undeposited fraction $(1 - \varphi)$ in the wholesale market (we assume the unsecured market) at the credit spread S over risk-free rate r[16]. Assume also a risk-based capital requirement for bank shareholders to fund the asset[17]. The bank funds the quantity $(1+C)(1-\varphi)q$, where C is a constant capital ratio. Therefore, Cooperman et al. (2025) also preserves the possibility of regulatory frictions such as leverage ratio requirements.

At $t = 2$, the borrower's credit line and the bank's wholesale funding mature. The borrower needs to pay back to the bank q with a fee s over the reference rate $r + S$; the bank needs to repay the cost of wholesale funding $(1 + C)(1 - \varphi)q$ with the spread S. In Cooperman et al. (2025), the bank can pay the depositor and the wholesale funding market only if it stays solvent at $t = 2$. Again, as in Cooperman et al. (2025), we shall assume that the bank will not default before the loan's maturity.

Andersen et al. (2019) and Cooperman et al. (2025) define the risk-neutral value of the equity to the bank's shareholders at time $t = 1$ as

$$G = \underbrace{p_1[\delta(1 + r + S + s)q - q]}_{\textit{Profit on Drawdowns}} - \underbrace{p_1\delta(1 + C)(1 - \varphi)qS}_{\textit{Debt Overhang Costs}} \tag{6}$$

[15]This assumption also states that bank receiving deposit at $t = 1$ and repaying at $t = 2$ costs nothing for the deposited fraction of corporate drawn funds, φq.

[16]note that our bank is of LIBOR-quality as we do not study in this paper the effect of risk insensitive rate as the new SOFR on funding costs

[17]See Favara et al. (2022) and Basel Committee on Banking Supervision (2018).

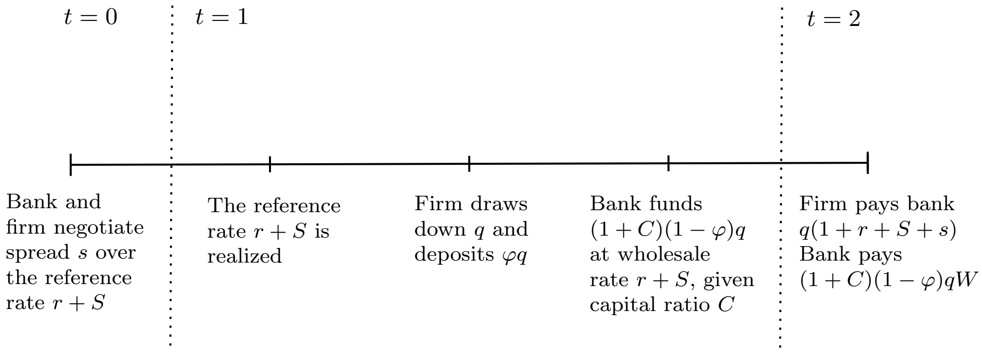

Figure 9. Timeline of model

where p_1 is the bank's probability of survival at time $t = 2$ conditional on the information at time $t = 1$ and $\delta = 1/(1 + r)$ is the discount factor. For the largest banks $p_1 \sim 1$. The first term in the above equation is the bank's discounted marginal profit on the credit line drawdowns. The last term is bank shareholders' debt-overhang cost for financing via the wholesale market $(1 - \varphi)q$ at the spread S. Let π and τ define the profit and debt overhang cost, respectively, as

$$\pi = p_1[\delta(1 + r + S + s)q - q]$$

and

$$\tau = p_1\delta(1 + C)(1 - \varphi)qS.$$

Bank shareholders' break-even value implies $\mathbb{E}(G) = 0$. It turns out that the expected profit would include debt overhang costs for funding the drawdowns. That is, $\mathbb{E}[\pi] = \mathbb{E}[\tau]$. Note that for large banks, $\delta p_1 qS(1 + C) \sim 1$, and the largest part of debt overhang cost is a consequence of funding costs. Rearranging equation 6, we obtain the credit line price function as:

$$s = \frac{\mathbb{E}[\delta p_1 qS((1 + C)(1 - \varphi) - 1)]}{\mathbb{E}[\delta p_1 q]}. \tag{7}$$

Since the covariance between the drawdowns q and the credit spread S dominates the change of the debt overhang cost, with the rest parameters constant, it also determines the change of credit line price s in equation 7.

Note that the key equation, in our context, is the one associating debt overhang cost for shareholders (τ) to the covariance between the bank's credit spread and drawdowns. The larger (more positive) the covariance, the larger the price of the credit line will be. Our empirical analysis supports this prediction.

What happens when central banks implement QE? Our empirical results suggest that QE is affecting (reducing) funding costs and banks' credit spreads. This will have a beneficial effect on credit line prices. We report robust empirical evidence in support of this. In the next section, we use a bank's balance sheet approach to show the mechanism.

6.2 Shareholders' Debt Overhang

We only consider two time spots $t = 1, 2$, which are when the drawdowns occur (and the bank faces funding costs) and when the loan is repaid (and the bank pays back its short-term bond). The price of the bank's asset is A_1 at time $t = 1$. In the survival scenario (probability p_1), the asset price is A_2^+ at $t = 2$. We assume that the bank issues a credit-risky zero-coupon bond at time $t = 1$ with a 1-year maturity. At time $t = 2$, the bank repays the bond whose value is D_2. Suppose that no credit line drawdowns have occurred. In this case, the bank shareholders will receive the residual of the assets after the bank pays the debt D_2

$$E_1 = \frac{(A_2^+ - D_2)p_1}{1 + r} \tag{8}$$

where E_1 is the equity value when there is no credit line drawdown. The shareholders receive zero in the default scenario, with probability $1 - p_1$.

Consider, instead, the case when the firm draws down from the credit line at time $t = 1$. In this case, the funding cost for this new asset is $(1 + C)(1 - \varphi)q$, which consists of regulatory cost and the fraction of drawdowns that the bank's client chooses to deposit into the same bank account. Let $F_1 = (1 + C)(1 - \varphi)q$. It follows that $F_2 = (1 + r + S)F_1$ is the bank's amount at time $t = 2$.

Cooperman et al. (2025) and Andersen et al. (2019) show that the majority of the debt overhang cost originates from funding costs, which is the number of undeposited drawdowns $(1 - \varphi)q$ and the funding spread S. To understand this, consider this simple example where the funding cost per dollar is 100 basis points, and the capital ratio requirement is 6%. In this case, the regulatory costs to the bank, on top of funding costs, is 6% of 100 basis points. That is 6 basis points per dollar. This amount is small compared with funding costs.

Therefore, we can reasonably assume that $F_1 \sim (1-\varphi)q$, where $(1-\varphi)q$ is related to the bank's funding costs when issuing new debt to finance drawdowns. We assume that the new debt of the bank ranks *pari passu* with the bank's existing debt D_2 (or legacy debt) and the volume of the new debt is sufficiently small, it has little impact on the bank's survival probability p_1. The face value of the new debt, that is, a fair price to new creditors (that is, the net present value (NPV) of this debt is zero), should satisfy

$$\frac{F_2}{1+r+S} = \frac{F_2^*}{1+r}, \tag{9}$$

where F_1^* is the face value of the risk-free new debt to the creditors at time $t = 1$ and $F_2^* = F_1^*(1+r)$ is the payoff to them at time $t = 2$, with $F_2^* < F_2$. Rearranging the above equation provides:

$$F_2 - F_2^* = \frac{F_2^* S}{1+r}. \tag{10}$$

How does the new debt issuance affect bank shareholders' equity value? At time $t = 2$, the bank will receive the payment of the loan, F_2^*. Shareholders' equity value will be non-zero only if the bank stays solvent. Let $\widehat{E}_1$ and $\widehat{E}_2$ denote the equity value at time $t = 1, 2$, respectively, and suppose they satisfy $\widehat{E}_2 = \widehat{E}_1(1+r)$. In the solvent state, the shareholders receive the residual after the bank pays the new and legacy creditors

$$\widehat{E}_1 = \frac{\widehat{E}_2}{1+r} = \frac{(A_2^+ + F_2^* - D_2 - F_2)p_1}{1+r}. \tag{11}$$

Compared to the case of no credit line drawdowns, the change in shareholders' wealth is

$$\Delta W_E = \widehat{E}_1 - E_1 = \frac{(F_2^* - F_2)p_1}{1+r}. \tag{12}$$

where ΔW_E denotes the change in the shareholders' equity value of the bank. Considering the difference between F_2 and F_2^* in Equation 10, we can rewrite it as

$$\Delta W_E = -\frac{F_2^* S p_1}{(1+r)^2}. \tag{13}$$

One can easily see that ΔW_E is negative. This implies that the shareholders face a wealth loss when providing a new credit line. This wealth loss is what we define as debt overhang costs.

Plugging this wealth shift term into the credit line price function, we can see how QE affects credit line prices via debt overhang costs:

$$\begin{aligned}
\frac{\partial s}{\partial S} &= \frac{\partial s}{\partial \Delta W_E} \cdot \frac{\partial \Delta W_E}{\partial S} \\
&= \left(-\frac{(1+r)^2\,\mathbb{E}\left[\delta q\left((1+C)(1-\varphi)-1\right)\right]}{F_2^*\,\mathbb{E}[\delta p_1 q]}\right) \cdot \left(-\frac{F_2^* p_1}{(1+r)^2}\right) \\
&= \frac{p_1\,\mathbb{E}\left[\delta q\left((1+C)(1-\varphi)-1\right)\right]}{\mathbb{E}[\delta p_1 q]}.
\end{aligned} \tag{14}$$

Appendix D provides a proof. Therefore, as changes in the credit spread lead to a wealth loss for banks' shareholders and, consequently, change credit line prices, by mitigating funding costs via QE, central banks can mitigate that cost and affect the prices of credit lines. Our empirical results strongly support it.

Is shareholder's wealth loss debt overhang cost? To see this, let us re-call F_1, that is, $F_1 = (1 + C)(1 - \varphi)q$, and plug it into the ΔW_E. In Appendix D, we provide evidence that the loss amount of the shareholders' equity value (that is, $|\Delta W_E|$) is indeed debt overhang cost τ.

6.3 Calibration

In this section, we calibrate our model to a set of parameters to study how debt overhang costs affect the contractual spread of credit lines. We start by parameterizing the baseline models. In our baseline model, the capital requirement ratio is set up as $C = 5\%$ [18], the discount factor is $\delta = 0.95$, the bank's survival probability is set to $p_1 = 0.99$, $F_1^* = 20\%$, and the firms' deposited fraction is $\varphi = 0\%$.

Figure 10 illustrates the results. Given the baseline model, the credit line price s is positively associated with credit spread S (top left panel), but it is negatively correlated to debt overhang cost ΔW_E (top right panel). Particularly, debt overhang cost is negatively correlated to credit spread (bottom left panel).

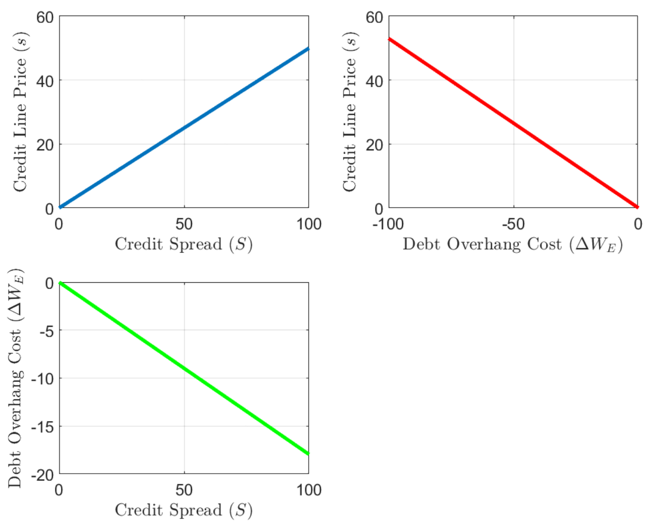

Figure 10. Simulation. This figure plots the calibrated model of credit line price correlated to credit spread. The parameterization is $\{\delta, C, p_1, F_1^*, \varphi\} = \{0.95, 5\%, 0.99, 20\%, 0\%\}$. The top left panel plots the relationship between credit line prices and credit spreads. The top right panel plots the credit line prices against debt overhang costs. The bottom left panel plots debt overhang costs against credit spreads.

The leverage ratio requirement is a regulatory cost to the dealer. At the beginning of the

[18] According to Favara et al. (2022), U.S. global systemically important banks (GSIBs) must hold a ratio of Tier 1 capital to total leverage exposure of at least 5%.

pandemic, the Federal Reserve froze it. We can see the impact of this regulatory cost, τ. It's evident that an increase in C can also increase debt overhang costs. Back to the credit line price model, we plot different levels (3% to 6%) of capital requirement in Figure 11. We show that decreasing the capital requirement by 1% will cause an average 5 basis points fall in credit line prices. The size looks much smaller than the one we reported for funding costs.

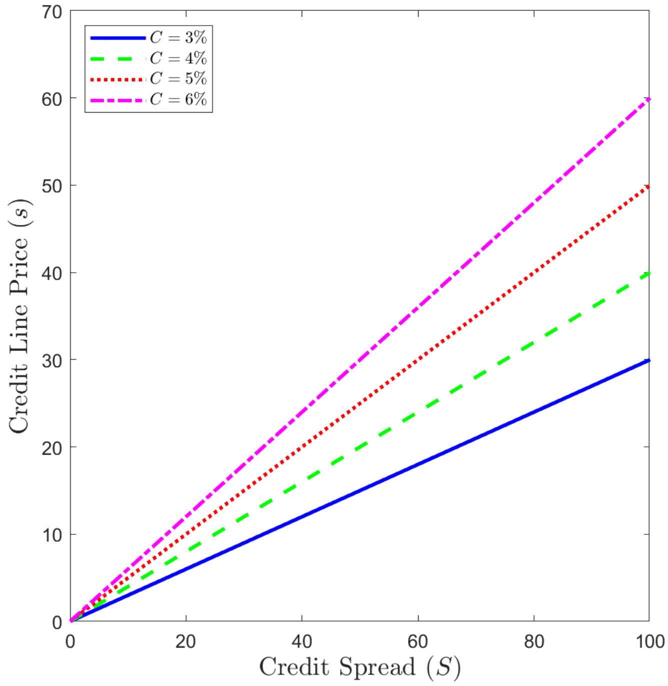

Figure 11. Capital Requirement Sensitivity. This figure plots the calibrated model of corporate drawdown cost correlated to credit spread in which central banks intervene in the markets. The parameterization is $\{\delta, p_1, F_1^*, \varphi\} = \{0.99, 0.99, 20\%, 0\%\}$. The solid blue line represents the case in which the capital requirement is 3%. The dashed green line represents the capital requirement of 4%. The dotted red line represents the capital requirement is 5%. The dash-dot pink line represents the capital requirement of 6%.

7 Conclusion

This paper empirically and theoretically studies the price credit lines and their association with banks' funding costs following the COVID-19 shock and central banks' QE. Recently, Cooperman et al. (2025) show that banks' funding costs are debt overhang costs for banks' shareholders and are associated with lines of credit drawdowns. They focus on the switch from LIBOR to SOFR rates. This paper complements and extends that important result empirically and theoretically. First, we document empirically, across two important markets (Europe and the US), that debt overhang costs are indeed essential and incorporated in the price of the line of credit. This was the case during the COVID-19 shock and not only. Our results also add further light on cross-market lines price discussed in Berg et al. (2017). Additionally, we report evidence suggesting that at the peak of the COVID-19 shock, central banks' QE mitigated debt overhang costs, and banks transferred this benefit to firms via lower credit line fees. Finally, we present and discuss a theoretical framework which suggests why QE effectively mitigates debt overhang costs and reduces lines' prices.

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Appendices

A Description of Variables

Table A1. **Description of Variable**

Variable	**Description**	**Source**
All In Spread Drawn	The sum of the spread over LIBOR or EURIBOR plus the facility fee.	DealScan
All In Spread Undrawn	The sum of the commitment fee plus the facility fee.	DealScan
Asset Purchases	The logarithm of the Federal Reserve's monthly asset amount.	BIS Central Bank Total Assets Dataset
Revolver	A dummy that equals one indicating revolving credit facilities or credit lines, and zero otherwise. Include loan types as "Revolver/Line >= 1 Yr.", "364-Day Facility", "Revolver/Line < 1 Yr.", and "Revolver/Term Loan" within *Tranche Type* in DealScan.	DealScan
Facility Amount	Facility amount with unit million USD. It is indicated in the field *Deal Amount Converted* which converts other currencies into USD.	DealScan
Maturity	Loan maturity measured in years, equal to *Tenor Maturity* divided by 12.	DealScan
Maturity 1-3yr	A dummy that equals to one indicating loan maturity between 1 and 3 years, and zero otherwise.	DealScan
Maturity 3-6yr	A dummy that equals to one indicating loan maturity between 3 and 6 years, and zero otherwise.	DealScan
Maturity >6yr	A dummy that equals to one indicating loan maturity greater than 6 years, and zero otherwise.	DealScan

(Continued on next page)

Table A1 – continued from previous page

Variable	Description	Source
Purpose: General	A dummy that equals to one indicating the loan facility is for general purpose, and zero otherwise. It includes "General Purpose" as indicated within *Deal Purpose* in DealScan.	DealScan
Purpose: Acquisition	A dummy that equals to one indicating the loan facility is for acquisition purpose, and zero otherwise. It includes "Acquisition", "Leveraged Buyout", "Sponsored Buyout", and "Takeover" as indicated within *Deal Purpose* in DealScan.	DealScan
Purpose: Investment	A dummy that equals to one indicating the loan facility is for acquisition purpose, and zero otherwise. It includes "Project Finance", "Working capital", and "Capital expenditure" as indicated within *Deal Purpose* in DealScan.	DealScan
Purpose: Ship	A dummy that equals to one indicating the loan facility is for ship, plane, and SPV finance purpose, and zero otherwise. It includes "Ship finance" and "Aircraft & Ship finance" as indicated within *Deal Purpose* in DealScan.	DealScan
Purpose: Refinancing	A dummy that equals to one indicating the loan facility is for refinancing purpose, and zero otherwise. It includes "General Purpose/Refinance" as indicated within *Deal Purpose* in DealScan.	DealScan
Purpose: Real Estate	A dummy that equals to one indicating the loan facility is for refinancing purpose, and zero otherwise. It includes "Real estate loan" as indicated within *Deal Purpose* in DealScan.	DealScan

(Continued on next page)

Table A1 – continued from previous page

Variable	Description	Source
Purpose: Dividend	A dummy that equals to one indicating the loan facility is for dividend recapitalization purpose, and zero otherwise. It includes "Dividend Recapitalization" as indicated within *Deal Purpose* in DealScan.	DealScan
Secured	A dummy that equals to one indicating the loan facility is secured by collateral, and zero otherwise. It includes "Yes" as indicated within *Secured* in DealScan.	DealScan
ln(#Lenders)	The natural logarithm of the number of lenders from *Number of Lenders* in DealScan.	DealScan
LIBOR-OIS 6M	The spread between 6-month LIBOR rate and 6-month overnight index swap rates (OIS).	Bloomberg
LIBOR-OIS 12M	The spread between 12-month LIBOR rate and 12-month overnight index swap rates (OIS).	Bloomberg
CDS Index	The average of 12 banks' monthly 5-year CDS spreads. The 12 banks include JP Morgan, Morgan Stanley, Wells Fargo, Citi, BofA, Goldman Sachs, BNP Paribas, Societe Generale, Barclays, NatWest, Credit Agricole, and Banco Santander which are representative European and US banks.	Bloomberg

B Debt Overhang Costs

B.1 US Market

In Section 3, we find that the positive correlation between banks' short-term debt overhang cost and corporate borrowing cost can be weakened given central bank intervention. This section provides further analysis.

Similar to equation 3, we construct an OLS specification to regress borrowing costs on a CDS index, measuring banks' long-term overhang cost as follows:

$$\begin{aligned} Y_{i,t} = \; & \beta_0 + \beta_1 \textit{CDS Index}_t + \beta_2 \textit{CDS Index}_t \times CB_t + \beta_3 \textit{ln(Loan Amount)}_{i,t} \\ & + \beta_4 \textit{Maturity 1-3yr}_{i,t} + \beta_5 \textit{Maturity 3-6yr}_{i,t} + \beta_6 \textit{Maturity} > \textit{6yr}_{i,t} + \beta_7 \textit{Secured}_{i,t} \\ & + \beta_8 \textit{ln(\#Lenders)}_{i,t} + \gamma X_{i,t} + \epsilon_{i,t} \end{aligned} \quad (15)$$

where $Y_{i,t}$ denotes the outcome of interest, including credit line drawdown cost (*All In Spread Drawn*), undrawn fee (*All In Spread Undrawn*), and comprehensive borrowing costs (*UWS*). *CDS Index* represents long-term debt overhang pressure in the banking system, measured by the cross-sectional average of 12 representative banks' 5-year CDS spreads[19]. CB_t is a time dummy indicating the shock in March 2020 when central banks' QE happened. A set of control variables includes the loan amount, dummies indicating loan facilities' different maturities, a dummy indicating whether loan facilities have collateral and the number of lenders. Fixed effects of time, industry, and loan purpose are considered.

Columns (1) across (4) in Table B1 show the estimation of corporate borrowing costs on the 5-year CDS index in OLS specification of equation 15. Similarly, a 1 basis point increase in the CDS index results in a 4.3 basis point increase in drawdown costs (AISD) and a 0.5 basis point increase in commitment fee (AISU), consistent with the results of short-term debt overhang costs. Moreover, these two numbers are greater than the ones of LIBOR-OIS spreads in Table 3.

Columns (2) and (4) of Table B1 show the estimate of the interaction between long-term debt overhang cost and central banks' QE on drawdown costs and undrawn fees. Using OLS specification in equation 15, the coefficient of the interaction on drawdown cost (AISD) is significant and negative (columns (2)). Regarding the commitment fee (AISU) in column (4), the coefficient on interaction is still significant and negative.

Similarly, we study how debt overhang costs drive firms' comprehensive borrowing costs. We

[19] See Appendix A for more details of variable construction.

use the usage-weighted spread (UWS) and run the panel regression in equation 15. Columns (1) across (6) in Table B2 show the results of firms' comprehensive borrowing costs (UWS) on the 5-year CDS index, also in OLS specification. Positive coefficients reveal that banks' debt overhang costs increase their overall lending prices to corporate borrowers. Moreover, the comprehensive cost with a 30% drawdown assumption has the greatest value, suggesting that a 1 basis point increase in the 5-year CDS index leads to a 1.2 basis point rise in the borrowing cost.

Columns (2), (4), and (6) of Table B2 report the regression results of the interaction term in the OLS specification. Given central bank intervention, banks' long-term debt overhang cost, measured by the 5-year CDS index, has less effect on firms' general cost of borrowing credit lines. A 1 basis point increase in the 5-year CDS index merely causes a 0.856 basis points rise in the borrowing cost, compared with the 1.2 basis points before.

To sum up, confronting debt overhang costs in banking systems, US banks moved drawn and undrawn costs in the same direction but to a very different degree. When the central bank intervenes, it reduces these two costs.

Similar to Section 3, we also estimate cross-section regression in the form of equation OA2.1, using CDS spreads as a proxy for funding costs. Table B3 reports the results. Although all coefficients are insignificant, the negative signs still support that central banks intervening in the US financial market via QE mitigated the funding costs and then reduced credit line fees shared by corporate borrowers.

B.2 European Market

In Section 4, we find that European banks facing a rising short-term debt overhang cost pass the pressure on firms by increasing drawdown cost and decreasing undrawn fees. Given central bank intervention, banks reduce drawdown costs and increase undrawn fees. This section studies whether this situation holds for long-term debt overhang cost.

Using the specification in equation 15, we regress the proxy for banks' long-term debt overhang cost, a CDS index, on borrowing cost of credit line drawdowns (*All In Spread Drawn*) and the fee of retaining undrawn credit lines (*All In Spread Undrawn*). Table B4 reports the estimation. In OLS specification, the CDS index has positive and significant correlations with drawdown cost and negative and significant ones with undrawn fees (columns (1) across (4)), suggesting that European banks transferred long-term debt overhang pressure to borrowers through drawdown fees and mitigated the undrawn fees. Interacted with central bank intervention (columns (2) and (4)), banks cut the drawdown cost but inversely increase the undrawn fees.

Table B1. **Credit Line Prices and Long-Term Funding Costs (US)**

This table estimates corporate borrowing costs on banks' funding costs. The dependent variable is *All In Spread Drawn (AISD)* in columns (1) across (2), and *All In Spread Undrawn (AISU)* in columns (3) across (4). The independent variables include a shock dummy equal to one indicating central bank intervention (QE) and an index averaging 12 representative banks' 5-year CDS spreads. The controls contain a logarithm of facility amount, dummies indicating 1-3 years, 3-6 years, and over 6 years maturities, a dummy indicating whether a facility is secured, and a logarithm of lender numbers. All columns include year-month, two-digit SIC industry, and loan purpose fixed effects. Standard errors are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively. All variables are winsorized at 1% and 99%. Variable definitions can be found in Appendix A.

Sample	Credit Lines			
Dependent Variable	AISD		AISU	
	(1)	(2)	(3)	(4)
CDS Index 5Y	4.287***	4.287***	0.508***	0.508***
	(1.083)	(1.083)	(0.150)	(0.150)
CDS Index 5Y×CB		-1.016***		-0.101***
		(0.261)		(0.036)
ln(Loan Amount)	-39.628***	-39.628***	-3.945***	-3.945***
	(0.582)	(0.582)	(0.092)	(0.092)
Maturity 1-3Y	6.768**	6.768**	8.357***	8.357***
	(2.696)	(2.696)	(0.363)	(0.363)
Maturity 3-6Y	16.206***	16.206***	6.816***	6.816***
	(2.126)	(2.126)	(0.261)	(0.261)
Maturity >6Y	74.968***	74.968***	14.865***	14.865***
	(5.104)	(5.104)	(0.978)	(0.978)
Secured	52.900***	52.900***	10.676***	10.676***
	(1.189)	(1.189)	(0.182)	(0.182)
ln(#Lenders)	-10.687***	-10.687***	-0.360**	-0.360**
	(1.045)	(1.045)	(0.171)	(0.171)
Time FE	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes
Purpose FE	yes	yes	yes	yes
Observations	42880	42880	27314	27314
R^2	0.502	0.502	0.500	0.500

Table B2. **Comprehensive Credit Line Prices on Debt Overhang Cost (US)**
This table estimates comprehensive corporate borrowing costs on banks' long-term debt overhang costs. The dependent variables are usage-weighted spread in different drawdown assumptions, including 30% (columns (1) and (2)), 25% (columns (3) and (4)), and 20% (columns (5) and (6)). The independent variables include a shock dummy equal to one indicating central bank intervention (QE) and an index averaging 12 representative banks' 5-year CDS spreads. The controls contain a logarithm of facility amount, dummies indicating 1-3 years, 3-6 years, and over 6 years maturities, a dummy indicating whether a facility is secured, and a logarithm of lender numbers. All columns include year-month, two-digit SIC industry, and loan purpose fixed effects. Standard errors are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively. All variables are winsorized at 1% and 99%. Variable definitions can be found in Appendix A.

Sample	Credit Lines					
Dependent Variable	UWS 30%		UWS 25%		UWS 20%	
	(1)	(2)	(3)	(4)	(5)	(6)
CDS Index 5Y	1.163***	1.163***	0.933***	0.933***	0.703***	0.703***
	(0.352)	(0.352)	(0.306)	(0.306)	(0.263)	(0.263)
CDS Index 5Y×CB		-0.307***		-0.251***		-0.196***
		(0.085)		(0.073)		(0.063)
ln(Loan Amount)	-13.246***	-13.246***	-11.287***	-11.287***	-9.328***	-9.328***
	(0.185)	(0.185)	(0.161)	(0.161)	(0.138)	(0.138)
Maturity 1-3Y	8.300***	8.300***	7.875***	7.875***	7.450***	7.450***
	(0.852)	(0.852)	(0.740)	(0.740)	(0.638)	(0.638)
Maturity 3-6Y	10.715***	10.715***	9.777***	9.777***	8.838***	8.838***
	(0.654)	(0.654)	(0.569)	(0.569)	(0.490)	(0.490)
Maturity >6Y	27.136***	27.136***	22.904***	22.904***	18.672***	18.672***
	(1.644)	(1.644)	(1.429)	(1.429)	(1.230)	(1.230)
Secured	19.384***	19.384***	16.919***	16.919***	14.453***	14.453***
	(0.385)	(0.385)	(0.335)	(0.335)	(0.288)	(0.288)
ln(#Lenders)	0.769**	0.769**	1.564***	1.564***	2.359***	2.359***
	(0.335)	(0.335)	(0.291)	(0.291)	(0.251)	(0.251)
Time FE	yes	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes	yes	yes
Purpose FE	yes	yes	yes	yes	yes	yes
Observations	43667	43667	43667	43667	43667	43667
R^2	0.488	0.488	0.471	0.471	0.442	0.442

Table B3. **Cross-Sectional Analysis: Credit Line Fees and Funding Costs (US)**
This table estimates credit line fees on funding costs from a specification in equation OA2.1. The dependent variable is credit line fee measured by all-in-spread-drawn (column (1) and usage-weighted spreads in different drawdown assumptions, including 30% (columns (2)), 25% (columns (3)), and 20% (columns (4)). The independent variables include a dummy equal to one indicating the period after central bank intervention (QE) and funding costs measured by the cross-sectional average of 12 banks' 5-year CDS spreads. Standard errors are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively. Variable definitions can be found in Appendix A.

Sample	Credit Lines			
Specification	ΔAISD	ΔUWS 30%	ΔUWS 25%	ΔUWS 20%
	(1)	(2)	(3)	(4)
ΔCDS Index 5Y	-0.377	-0.069	-0.046	-0.022
	(0.414)	(0.130)	(0.112)	(0.095)
Observations	142	142	142	142
R^2	0.006	0.002	0.001	0.000

Next, we use the European sample to investigate banks' long-term debt overhang cost on firms' comprehensive borrowing cost. Substituting LHS of equation 15 with UWS, a measure combining both drawn and undrawn costs, we run the specification and obtain the results in Table B5. Similar to the US sample (Table B2), columns (1) across (6) show positive and significant coefficients of the CDS index term on UWS. Facing long-term debt overhang costs, European banks pass the pressure to borrowers. Given the interaction between the CDS index and central bank intervention, the coefficients of interaction are negative in columns (2), (4), and (6).

Table B4. **Credit Line Prices and Long-Term Funding Costs (Europe)**

This table estimates corporate borrowing costs on banks' long-term funding costs. The dependent variable is *All In Spread Drawn (AISD)* in columns (1) across (2), and *All In Spread Undrawn (AISU)* in columns (3) across (4). The independent variables include a shock dummy equal to one indicating central bank intervention (QE) and an index averaging 12 representative banks' 5-year CDS spreads. The controls contain a logarithm of facility amount, dummies indicating 1-3 years, 3-6 years, and over 6 years maturities, a dummy indicating whether a facility is secured, and a logarithm of lender numbers. All columns include year-month, two-digit SIC industry, and loan purpose fixed effects. Standard errors are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively. All variables are winsorized at 1% and 99%. Variable definitions can be found in Appendix A.

Sample	Credit Lines			
Dependent Variable	AISD		AISU	
	(1)	(2)	(3)	(4)
CDS Index 5Y	7.782***	7.782***	-5.430***	-5.430***
	(1.738)	(1.738)	(0.760)	(0.760)
CDS Index 5Y×CB		-2.076***		1.055***
		(0.450)		(0.213)
ln(Loan Amount)	-15.047***	-15.047***	-8.753***	-8.753***
	(1.071)	(1.071)	(0.956)	(0.956)
Maturity 1-3Y	51.166***	51.166***	0.815	0.815
	(5.060)	(5.060)	(3.699)	(3.699)
Maturity 3-6Y	43.254***	43.254***	6.472**	6.472**
	(4.629)	(4.629)	(3.071)	(3.071)
Maturity >6Y	73.271***	73.271***	9.061**	9.061**
	(5.697)	(5.697)	(4.519)	(4.519)
Secured	69.379***	69.379***	7.631***	7.631***
	(2.478)	(2.478)	(2.009)	(2.009)
ln(#Lenders)	-27.293***	-27.293***	3.627**	3.627**
	(2.010)	(2.010)	(1.564)	(1.564)
Time FE	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes
Purpose FE	yes	yes	yes	yes
Observations	7064	7064	1995	1995
R^2	0.609	0.609	0.774	0.774

Table B5. **Comprehensive Credit Line Prices on Long-Term Debt Overhang Cost (Europe)**

This table estimates comprehensive corporate borrowing costs on banks' long-term debt overhang costs. The dependent variables are usage-weighted spread in different drawdown assumptions, including 30% (columns (1) and (2)), 25% (columns (3) and (4)), and 20% (columns (5) and (6)). The independent variables include a shock dummy equal to one indicating central bank intervention (QE) and an index averaging 12 representative banks' 5-year CDS spreads. The controls contain a logarithm of facility amount, dummies indicating 1-3 years, 3-6 years, and over 6 years maturities, a dummy indicating whether a facility is secured, and a logarithm of lender numbers. All columns include year-month, two-digit SIC industry, and loan purpose fixed effects. Standard errors are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively. All variables are winsorized at 1% and 99%. Variable definitions can be found in Appendix A.

Sample	Credit Lines					
Dependent Variable	UWS 30%		UWS 25%		UWS 20%	
	(1)	(2)	(3)	(4)	(5)	(6)
CDS Index 5Y	1.666**	1.666**	1.227*	1.227*	0.787	0.787
	(0.757)	(0.757)	(0.717)	(0.717)	(0.686)	(0.686)
CDS Index 5Y×CB		-0.545***		-0.434**		-0.324*
		(0.196)		(0.186)		(0.178)
ln(Loan Amount)	-3.874***	-3.874***	-3.066***	-3.066***	-2.258***	-2.258***
	(0.467)	(0.467)	(0.442)	(0.442)	(0.423)	(0.423)
Maturity 1-3Y	13.083***	13.083***	10.316***	10.316***	7.549***	7.549***
	(2.205)	(2.205)	(2.088)	(2.088)	(1.997)	(1.997)
Maturity 3-6Y	11.436***	11.436***	9.172***	9.172***	6.908***	6.908***
	(2.017)	(2.017)	(1.910)	(1.910)	(1.827)	(1.827)
Maturity >6Y	16.149***	16.149***	12.115***	12.115***	8.080***	8.080***
	(2.483)	(2.483)	(2.351)	(2.351)	(2.249)	(2.249)
Secured	22.204***	22.204***	18.800***	18.800***	15.396***	15.396***
	(1.080)	(1.080)	(1.023)	(1.023)	(0.978)	(0.978)
ln(#Lenders)	-10.370***	-10.370***	-9.118***	-9.118***	-7.865***	-7.865***
	(0.876)	(0.876)	(0.829)	(0.829)	(0.794)	(0.794)
Time FE	yes	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes	yes	yes
Purpose FE	yes	yes	yes	yes	yes	yes
Observations	7064	7064	7064	7064	7064	7064
R^2	0.482	0.482	0.443	0.443	0.395	0.395

C Credit Line Suppliers for US and European Firms

This section shows that US and European banks are the main credit line suppliers for their countries' firms. Only a small fraction of credit comes from foreign suppliers in these two markets.

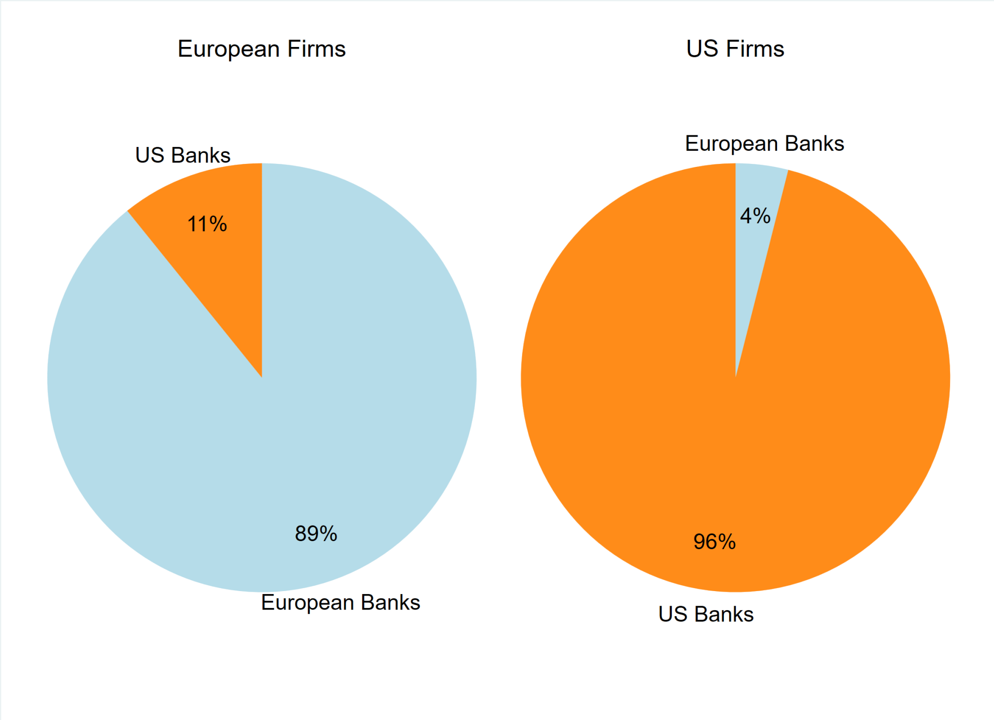

Figure C1. Distribution of Credit Line Suppliers. This figure plots the distribution of credit line suppliers in European and US markets. The left plot shows the proportions of credit line suppliers in European market. The right plot shows the proportions of credit line suppliers in US market.

D Proof

Given equation 13, we at first take the partial derivative of ΔW_E with respect to S, expressing as:

$$\frac{\partial \Delta W_E}{\partial S} = -\frac{F_2^* p_1}{(1+r)^2}. \tag{D1}$$

The negative sign suggests that the higher the credit spread of the bank, the more wealth loss the shareholders suffer, indicating a higher debt overhang cost[20].

We rearrange Equation 13 and express credit spread S as a function of ΔW_E:

$$S = -\frac{(1+r)^2 \Delta W_E}{F_2^* p_1}.$$

Plugging it into the price function in Equation 7, we can obtain a new expression as

$$s = -\frac{(1+r)^2\,\mathbb{E}\left[\delta q \Delta W_E\left((1+C)(1-\varphi)-1\right)\right]}{F_2^*\,\mathbb{E}[\delta p_1 q]}. \tag{D2}$$

Taking the partial derivative of s with respect to ΔW_E yields:

$$\frac{\partial s}{\partial \Delta W_E} = -\frac{(1+r)^2\,\mathbb{E}\left[\delta q\left((1+C)(1-\varphi)-1\right)\right]}{F_2^*\,\mathbb{E}[\delta p_1 q]} \tag{D3}$$

which is negative. It suggests that the more wealth is lost from shareholders (the lower ΔW_E), the higher the credit line price. In other words, the bank seeks compensation from the credit line price to cover the shareholders' loss. Now, combining $\partial \Delta W_E/\partial S$ and $\partial s/\partial \Delta W_E$ and applying for the chain rule, we can obtain the partial differentiation of credit line price s with respect to the credit spread S as shown in equation 14. Since $(1+C)(1-\varphi)-1$ should be positive[21], $\partial s/\partial S > 0$ holds for the rest parameters positive.

We now prove the absolute value of the shareholders' wealth loss is equivalent to the debt

[20] ΔW_E is smaller than or equal to zero in this case. A lower value of it means a greater absolute value, which is more wealth shift.

[21] Otherwise, the credit line price s is always negative.

overhang cost. Given $F_1 = (1+C)(1-\varphi)q$ and $F_2 = (1+r+S)F_1$, we can rewrite equation 10 as

$$\begin{aligned} F_2^* &= \frac{(1+r)F_2}{1+r+S} \\ &= \frac{(1+r)(1+r+S)F_1}{1+r+S} \\ &= \frac{(1+r)(1+r+S)(1+C)(1-\varphi)q}{1+r+S} \\ &= (1+r)(1+C)(1-\varphi)q. \end{aligned} \tag{D4}$$

Substituting the expression for F_2^* into the expression of $|\Delta W_E|$ offers

$$\begin{aligned} |\Delta W_E| &= \frac{F_2^* S p_1}{(1+r)^2} \\ &= \frac{(1+r)(1+C)(1-\varphi)qSp_1}{(1+r)^2} \\ &= \frac{(1+C)(1-\varphi)qSp_1}{1+r}. \end{aligned}$$

Since $\delta = (1+r)^{-1}$, we can rewrite the above expression as

$$|\Delta W_E| = \delta(1+C)(1-\varphi)qSp_1 = \tau, \tag{D5}$$

which is exactly the expression of the debt overhang cost.

Online Appendix

OA1 Empirical Analysis of Central Bank Asset Purchases

In this section, we explore whether central bank total assets serve as a crucial instrument for reducing funding costs—and, consequently, credit line fee pricing—during periods of financial stress. We extract data from the BIS Central Bank Total Assets dataset, which tracks the evolution of central banks' balance sheets globally. Focusing on the US central bank, we construct the variable *Asset Purchases* as the logarithm of its monthly asset amount.

To address potential endogeneity in funding cost, we implement a two-stage least squares (2SLS) procedure. The strong significance of our instrument is confirmed by the first-stage F-statistic, which is 34.882 for drawn credit lines (AISD), well above the conventional threshold of 10, while for undrawn credit lines (AISU) the F-statistic is only 3.159, indicating potential concerns regarding instrument weakness in that specification. In the second stage, we use the fitted values from the first stage to estimate the effect on *Credit Line Fee*, where *Credit Line Fee* is measured in two forms: drawn (*All In Spread Drawn*) and undrawn (*All In Spread Undrawn*) credit lines. Formally, we estimate the following system of equations:

$$\begin{aligned} \textit{CDS Index}_t &= \beta_0 + \beta_1 \cdot \textit{Asset Purchases}_t + \gamma \cdot \textit{Controls}_{i,t} + \epsilon_{i,t} && \text{(OA1.1)} \\ Y_{i,t} &= \alpha_0 + \alpha_1 \cdot \widehat{\textit{CDS Index}}_t + \alpha_2 \cdot \widehat{\textit{CDS Index}}_t \times \textit{CB}_t && \text{(OA1.2)} \\ &\quad + \lambda \cdot \textit{Controls}_{i,t} + \eta_{i,t} \end{aligned}$$

where $Y_{i,t}$ represents the second-stage outcome of interest, *Credit Line Fee*, including the drawn and undrawn prices. We control for the loan sizes, different loan maturities, collateral, and lender numbers. We find fixed effects cause collinearity issues in estimations, so we exclude them in two stages.

Columns (1) and (4) of Table OA1.1 report the OLS estimates of credit line prices on funding costs. Without incorporating central bank total assets, funding costs are positively and significantly related to the prices—as lenders demand higher fees to compensate for increased risk. However, the evidence indicates that central bank intervention, as captured by the interaction term *CDS Index*$\times$ *CB*, substantially mitigates this relationship.

In Table OA1.1 (columns (2) and (5)), the negative second-stage coefficient (-9.763 and -0.191) on instrumented *CDS Index* demonstrates that QE interventions reverse the baseline cost transmission mechanism—a result only identifiable through the 2SLS design. In these specifications, the interaction term between the CDS Index and the QE dummy (denoted by *CB*) captures the baseline effect of funding costs on the prices. Both coefficients are estimated simultaneously within the second-stage regression. Although one might initially expect a positive coefficient on the CDS Index interaction, the negative sign observed here suggests that QE reduces funding costs to such an extent that the sensitivity of credit line prices to these costs is diminished.

Columns (3) and (6) in Table OA1.1 demonstrate that the triple interaction *CDS Index 5Y* $\times$ *Asset Purchases* $\times$ *CB* is negative and significant, confirming that QE interventions stabilize credit markets by decoupling corporate borrowing costs from bank risk. It matches the interaction results in Columns (2) and (5).

Overall, these results underscore the pivotal role of central bank asset purchases in stabilizing credit markets by reducing the sensitivity of credit line prices to fluctuations in funding costs.

Table OA1.1. **Central Bank Asset Purchase (US)**

This table shows the OLS and 2SLS regression results of credit line prices on funding costs. The dependent variables are *All In Spread Drawn (AISD)* in columns (1) through (3) and *All In Spread Undrawn (AISU)* in columns (4) through (6). The independent variables include a shock dummy (*CB*) equal to one during central bank intervention (QE), an index averaging 12 representative banks' 5-year CDS spreads (*CDS Index 5Y*), and the logarithm of the central bank's monthly asset purchase amount (*Asset Purchases*). The controls include the logarithm of the facility amount, dummies for maturities (1–3 years, 3–6 years, and over 6 years), a dummy for whether a facility is secured, and the logarithm of the number of lenders. Columns (1), (3), (4), and (6) report OLS estimates, while columns (2) and (5) report 2SLS estimates using *Asset Purchases* as an instrument for *CDS Index 5Y*. Fixed effects are included where specified. All variables are winsorized at the 1% and 99% levels. Appendix A contains all variable definitions. Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Dependent Variable	AISD			AISU		
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	2SLS	OLS	OLS	2SLS	OLS
CDS Index 5Y	4.287***	-9.763***	-0.825	0.508***	-0.191**	-0.270**
	(1.083)	(0.611)	(0.836)	(0.150)	(0.084)	(0.115)
CDS Index 5Y × CB	-1.016***	-0.515***	0.000	-0.101***	-0.049***	0.000
	(0.261)	(0.085)	(.)	(0.036)	(0.010)	(.)
Asset Purchases			25.082***			-1.524*
			(6.514)			(0.909)
Asset Purchases × CB			0.000			0.000
			(.)			(.)
CDS Index 5Y × Asset Purchases			0.087			0.033**
			(0.097)			(0.013)
CDS Index 5Y × Asset Purchases × CB			-0.036***			-0.004***
			(0.007)			(0.001)
ln(Loan Amount)	-39.628***	-41.430***	-37.621***	-3.945***	-4.347***	-4.266***
	(0.582)	(0.710)	(0.650)	(0.092)	(0.107)	(0.099)
Maturity 1-3Y	6.768**	-10.787***	11.584***	8.357***	7.676***	8.185***
	(2.696)	(3.274)	(2.968)	(0.363)	(0.433)	(0.386)
Maturity 3-6Y	16.206***	38.452***	45.592***	6.816***	7.209***	7.354***
	(2.126)	(2.233)	(2.218)	(0.261)	(0.263)	(0.260)
Maturity >6Y	74.968***	85.855***	113.674***	14.865***	15.820***	16.386***
	(5.104)	(6.012)	(5.753)	(0.978)	(1.110)	(1.077)
Secured	52.900***	62.037***	84.690***	10.676***	13.209***	13.691***
	(1.189)	(1.807)	(1.278)	(0.182)	(0.260)	(0.185)
ln(#Lenders)	-10.687***	-7.043***	-23.512***	-0.360**	-0.190	-0.536***
	(1.045)	(1.567)	(1.171)	(0.171)	(0.237)	(0.184)
Time FE	yes	no	no	yes	no	no
Industry FE	yes	no	no	yes	no	no
Purpose FE	yes	no	no	yes	no	no
Observations	42880	42880	42880	27314	27314	27314
R^2	0.502	0.324	0.324	0.500	0.353	0.353
First-Stage Results						
Asset Purchases		-3.153***			-3.153***	
		(0.270)			(0.270)	

OA2 Cross-Sectional Analysis

In this section, we complement the results in the main context using an alternative econometric strategy. We estimate a cross-sectional regression with a specification as follows:

$$\Delta Credit\ Line\ Fee_i \quad = \quad \beta_0 + \beta_1 \Delta Funding\ Cost_i + \epsilon_i \tag{OA2.1}$$

where $\Delta Credit\ Line\ Fee_i$ is the daily change in credit line prices of lender i, measured by all-in-spread-drawn (AISD) and comprehensive fees based on different assumptions of drawn rates (30%, 25%, and 20%). $\Delta Funding\ Cost_i$ is the change in funding costs, measured by the 6-month (12-month) LIBOR-OIS spreads. The sampling period contains only one week before and after the first Federal Reserve announcement on March 15, 2020.

Table OA2.1 reports the estimation and confirms our previous results. Central banks' QE is strongly associated with reducing banks' funding costs and credit line prices.

Table OA2.1. **Cross-Sectional Analysis: Credit Line Fees and Funding Costs (US)**
This table estimates credit line fees on funding costs from a specification in equation OA2.1. The dependent variable is credit line fee measured by all-in-spread-drawn (column (1) and usage-weighted spreads in different drawdown assumptions, including 30% (columns (2)), 25% (columns (3)), and 20% (columns (4)). The independent variables include a dummy equal to one indicating the period after central bank intervention (QE) and funding costs measured by 6-month and 12-month LIBOR-OIS spreads. Standard errors are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively. Variable definitions can be found in Appendix A.

Sample	Credit Lines			
Specification	ΔAISD	ΔUWS 30%	ΔUWS 25%	ΔUWS 20%
Panel A: LIBOR-OIS 6M as Proxy				
	(1)	(2)	(3)	(4)
ΔLIBOR-OIS 6M	-1.612**	-0.518**	-0.439**	-0.359*
	(0.800)	(0.257)	(0.220)	(0.186)
Observations	136	136	136	136
R^2	0.029	0.030	0.029	0.027
Panel B: LIBOR-OIS 12M as Proxy				
	(1)	(2)	(3)	(4)
ΔLIBOR-OIS 12M	-1.862*	-0.484	-0.390	-0.296
	(1.085)	(0.349)	(0.300)	(0.253)
Observations	136	136	136	136
R^2	0.021	0.014	0.012	0.010

OA3 Alternative Test of the QE Impact

We focus on the US sample, including six months before and after March 2020, and estimate cross-sectional specifications as follows:

$$Y_{i,t} = \beta_0 + \beta_1 QE_t + \beta_2 Funding\ Cost_t + \beta_3 Funding\ Cost_t \times QE_t + \gamma_i + \eta_t + \epsilon_{i,t} \quad \text{(OA3.1)}$$

where $Y_{i,t}$ is all-in-spread-drawn (AISD) and comprehensive fees based on different assumptions of drawn rates (30%, 25%, and 20%). QE_t is a dummy that takes the value one indicating March 2020 and onward. $Funding\ Cost_t$ is the 6-month (12-month) LIBOR-OIS spreads. γ_i is a set of bank (i.e. lender) fixed effects, and η_t is a set of time fixed effects. Table OA3.1 reports the results. We also find similar results in the European sample reported in Table OA3.2.

Table OA3.1. **Cross-Sectional Analysis: Credit Line Prices and Funding Costs (US)** This table estimates credit line fees on funding costs from a specification in equation OA3.1. The dependent variable is credit line fee measured by all-in-spread-drawn (column (1) and usage-weighted spreads in different drawdown assumptions, including 30% (columns (2)), 25% (columns (3)), and 20% (columns (4)). The independent variables include a dummy equal to one indicating the period after central bank intervention (QE) and funding costs measured by 6-month and 12-month LIBOR-OIS spreads. All columns include bank and time fixed effects. Standard errors are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively. All variables are winsorized at 1% and 99%. Variable definitions can be found in Appendix A.

Sample	Credit Lines			
Specification	AISD	UWS 30%	UWS 25%	UWS 20%
Panel A: LIBOR-OIS 6M as Proxy				
	(1)	(2)	(3)	(4)
QE	378.036***	112.410***	96.432***	80.454***
	(62.771)	(21.557)	(18.846)	(16.273)
LIBOR-OIS 6M	5.096***	0.989***	0.800***	0.611***
	(0.914)	(0.310)	(0.271)	(0.234)
LIBOR-OIS 6M×QE	-13.235***	-4.106***	-3.537***	-2.968***
	(2.576)	(0.886)	(0.775)	(0.669)
Bank FE	yes	yes	yes	yes
Time FE	yes	yes	yes	yes
Observations	4772	4930	4930	4930
R^2	0.507	0.436	0.411	0.373
Panel B: LIBOR-OIS 12M as Proxy				
	(1)	(2)	(3)	(4)
QE	650.505***	160.397***	134.564***	108.731***
	(98.258)	(33.460)	(29.252)	(25.258)
LIBOR-OIS 12M	9.662***	1.876***	1.518***	1.159***
	(1.733)	(0.587)	(0.513)	(0.443)
LIBOR-OIS 12M×QE	-14.085***	-3.570***	-3.005***	-2.440***
	(2.173)	(0.741)	(0.648)	(0.560)
Bank FE	yes	yes	yes	yes
Time FE	yes	yes	yes	yes
Observations	4772	4930	4930	4930
R^2	0.507	0.436	0.411	0.373

Table OA3.2. **Cross-Sectional Analysis: Credit Line Prices and Funding Costs (Europe)**
This table estimates credit line fees on funding costs from a specification in equation OA3.1. The dependent variable is credit line fee measured by all-in-spread-drawn (column (1) and usage-weighted spreads in different drawdown assumptions, including 30% (columns (2)), 25% (columns (3)), and 20% (columns (4)). The independent variables include a dummy equal to one indicating the period after central bank intervention (QE) and funding costs measured by 6-month and 12-month LIBOR-OIS spreads. All columns include bank and time fixed effects. Standard errors are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively. All variables are winsorized at 1% and 99%. Variable definitions can be found in Appendix A.

Sample	Credit Lines			
Specification	AISD	UWS 30%	UWS 25%	UWS 20%
Panel A: LIBOR-OIS 6M as Proxy				
	(1)	(2)	(3)	(4)
QE	331.899	306.786***	304.992***	303.198***
	(201.437)	(79.554)	(72.772)	(66.716)
LIBOR-OIS 6M	4.606**	2.196**	2.024**	1.851**
	(2.203)	(0.870)	(0.796)	(0.730)
LIBOR-OIS 6M×QE	-13.987	-12.644***	-12.548***	-12.452***
	(8.906)	(3.517)	(3.217)	(2.950)
Bank FE	yes	yes	yes	yes
Time FE	yes	yes	yes	yes
Observations	594	594	594	594
R^2	0.464	0.491	0.499	0.509
Panel B: LIBOR-OIS 12M as Proxy				
	(1)	(2)	(3)	(4)
QE	571.734**	401.967***	389.841***	377.715***
	(264.462)	(104.444)	(95.540)	(87.590)
LIBOR-OIS 12M	8.735**	4.164**	3.837**	3.510**
	(4.178)	(1.650)	(1.509)	(1.384)
LIBOR-OIS 12M×QE	-13.832**	-9.841***	-9.556***	-9.271***
	(6.375)	(2.518)	(2.303)	(2.111)
Bank FE	yes	yes	yes	yes
Time FE	yes	yes	yes	yes
Observations	594	594	594	594
R^2	0.464	0.491	0.499	0.509

OA4 Alternative Test of Funding Cost: 12 Banks CDS Spreads

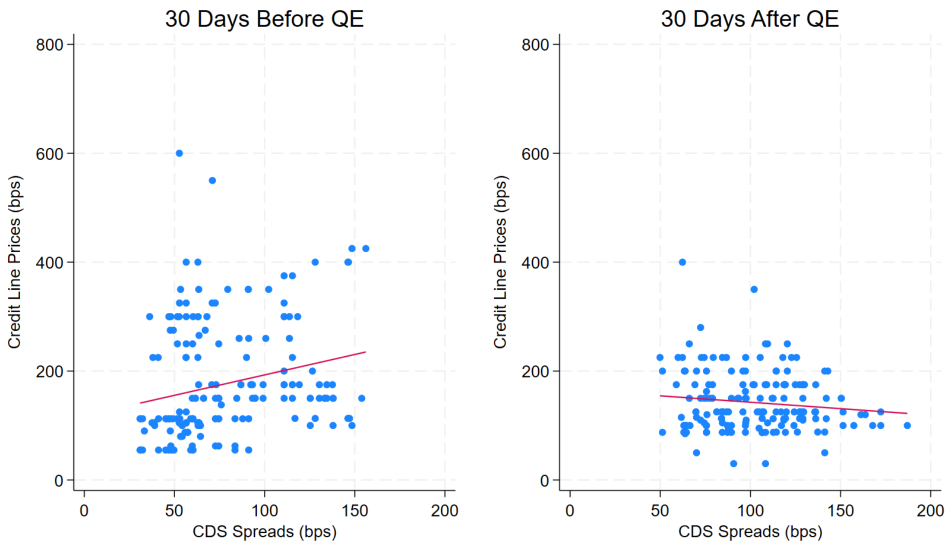

Figure OA4.1. Event Study: 12 Banks. This figure plots the credit line prices against 5-year CDS spreads within the 12 selected banks. The left plot shows 30 days before the QE. The right plot shows 30 days after the QE.

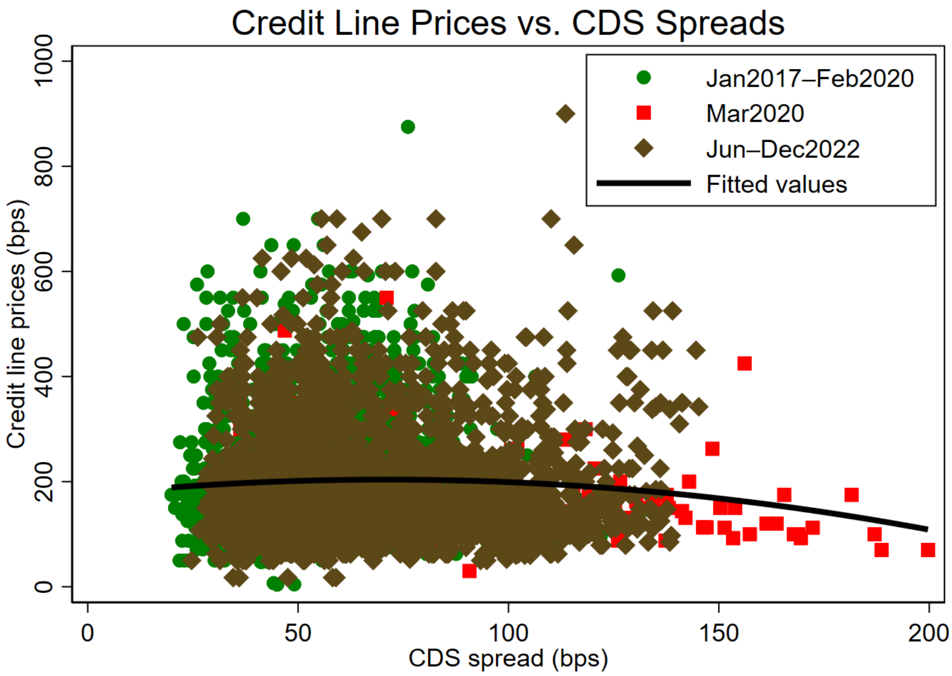

Figure OA4.2. Credit Line Prices versus CDS Spreads. This figure plots the credit line prices against the CDS spreads within the 12 selected banks. The green cycles indicate the period before the QE happening in March 2020. The red squares indicate the shock of QE in March 2020. The brown diamonds indicate the period after the shock.

Table OA4.1. **Comprehensive Credit Line Prices on Debt Overhang Cost (12 Banks)**
This table estimates corporate borrowing costs on banks' funding costs. The dependent variable is *All In Spread Drawn (AISD)* in columns (1) across (2), and *All In Spread Undrawn (AISU)* in columns (3) across (4). The independent variables include 5-year CDS spreads of the 12 banks and a shock dummy equal to one indicating central bank intervention (QE). The controls contain a logarithm of facility amount, dummies indicating 1-3 years, 3-6 years, and over 6 years maturities, a dummy indicating whether a facility is secured, and a logarithm of lender numbers. All columns include year-month, two-digit SIC industry, and loan purpose fixed effects. Standard errors are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively. All variables are winsorized at 1% and 99%. Variable definitions can be found in Appendix A.

	(1)	(2)	(3)	(4)
	AISD	AISU	AISD	AISU
CDS Spread 5Y	0.295***	0.331***	0.033***	0.035***
	(0.050)	(0.053)	(0.011)	(0.012)
CDS Spread 5Y×CB		-0.402**		-0.015
		(0.176)		(0.035)
ln(Loan Amount)	-15.675***	-15.655***	-4.375***	-4.375***
	(0.793)	(0.792)	(0.193)	(0.193)
Maturity 1-3Y	34.700***	34.638***	12.470***	12.464***
	(3.146)	(3.146)	(0.722)	(0.722)
Maturity 3-6Y	24.735***	24.734***	8.417***	8.418***
	(2.454)	(2.454)	(0.510)	(0.510)
Maturity >6Y	69.817***	69.737***	26.261***	26.257***
	(4.950)	(4.949)	(1.646)	(1.646)
Secured	56.935***	56.925***	11.660***	11.661***
	(1.623)	(1.623)	(0.393)	(0.393)
ln(#Lenders)	-19.929***	-20.016***	0.840**	0.836**
	(1.358)	(1.359)	(0.345)	(0.345)
Time FE	yes	yes	yes	yes
Purpose FE	yes	yes	yes	yes
Observations	17366	17366	10660	10660
R^2	0.372	0.372	0.362	0.362