Internet Appendix

"Portfolio Dynamics and the Supply of Safe Securities"

This Internet Appendix consists of four sections. Section IA.1 describes the data and sample. Section IA.2 presents additional facts on nonbank institutions in the leveraged loan market. Section IA.3 discusses empirical patterns of CLOs' collateral constraints. Finally, Section IA.4 shows patterns of transitory loan price changes at the onset of COVID-19 crisis.

IA.1. Data and Sample Construction

IA.1.1. Data and Sample

The main data used in this study come from Acuris Creditflux CLO-i, a database compiled from CLO trustee reports. This database provides information on CLO tranches, portfolio holdings, loan trades, and collateral test results. To examine CLOs' balance sheets, I construct a quarterly panel sample using the most recent reports of a CLO by the end of each quarter. I include a CLO–quarter pair if information on the CLO's liabilities is available and its portfolio includes at least 50 loans and has at least $50 million total par value. This filter leads to 13,825 quarterly observations for US CLOs between 2010–2019.

To investigate loan trades upon the arrival of a negative systemic shock, I construct a cross-sectional sample that tracks the changes in CLO loan portfolios between February 15 and June 30 of 2020. This sample includes all US CLOs that are issued before year 2020. For each CLO, I use the last portfolio snapshot available between January 1 and February 14, 2020 as the observation for a "pre" period and the first snapshot available between July 1 and August 15, 2020 for a "post" period.[1] To measure secondary market prices at the trough,

[1]CLO trustee reports do not have any uniform report dates, and the time windows are used to select snapshots that are informative about CLO portfolios before and after the shock. My findings are insensitive to different choices of time windows.

I use the last snapshot between March 15 and April 15, 2020 as the observation for the "mid" period. To alleviate measurement errors, I winsorize prices at the 1% and 99% percentiles.

Other databases used in this paper include CRSP mutual fund portfolio holdings, Mergent Fixed Income Securities Database (FISD), Morningstar, and the SEC's Form ADV.

IA.1.2. Cleaning CLO datasets

Creditflux CLO-i database collects information about individual CLOs from trustee reports. In this database, each CLO is identified by a unique deal ID, and each of the CLO's liability tranches is uniquely identified by a tranche ID. Unlike regulated institutions (e.g., banks and mutual funds), CLOs do not have regular disclosure dates, and their balance sheets are rarely reported exactly at the end of a certain calendar period. In the database, 75% of CLO–month pairs have at least one reported snapshot available.

Liabilities. I begin with all US CLO deals that are issued in US dollars and have a nonmissing closing date (i.e., the date when a CLO comes into legal existence) between 2000 and 2020. There are 2,306 unique CLOs, 21,970 unique tranches, and 82,447 deal-level reports, and 612,689 tranche-level reports in total. These reports provide information on the original and current sizes of individual tranches and the legal identity of the asset manager. To determine the seniority of a tranche, I use the variable Seniority Name and rely on original credit rating whenever this variable is missing. I hand match CLO manager company names to the filing number in the SEC's Form ADV database and use this number as a unique manager identifier.

Portfolio Holdings. The holdings dataset provides information on the borrower, loan facility type, interest rate, balance amount, credit rating, maturity date, and Moody's industry classification for each loan in a CLO's portfolio snapshot. For years after 2017, a trustee-reported market price for each holding is also available. An important data limitation is the absence of a loan-level identifier. While the dataset provides issuer names and issuer

IDs, a substantial fraction of these two variables are incorrectly assigned. Moreover, as different CLO managers prepare reports independently and most borrowers are private companies, a borrower might appear with different names in different reports. To mitigate the impact of data inaccuracy on inferences based on the COVID-19 cross-sectional sample, I carefully compare the name of every leverage loan borrower between 2016—2019 with the issuer names in CLO holdings data and manually correct 1,297 issuers that have mismatched names and/or IDs.[2] I also replace a loan's interest rate to be missing if the reported value is zero. After correcting these data errors, I eliminate duplicate records at the deal ID–report date–borrower–maturity date–balance amount level and aggregate balance amount to the deal ID–report date–borrower–maturity date level.[3] After this cleaning procedure, the dataset includes 22.3 million holding records.

Loan Trades. For each loan trade, the raw transactions dataset provides information on the direction (buy or sell), loan par amount, transaction price, and the date of the trade. After removing duplicate records, I map loan trade records to CLOs using deal report ID.

Collateral Tests. The raw dataset for collateral tests provides information on the name, current score, threshold score, and the date of a test. I determine a test record as an over-collateralization test if the test name includes keywords "OC", "O/C", or "overcollateral". Among OC tests, I further determine a record as a test for a senior tranche if the test name contains keywords "Class A", "Senior", "A ", "A/B OC", or "AB OC". This procedure selects all senior OC thresholds and test scores, but cannot accurately identify the thresholds for the most senior (AAA) tranches. Any zero-valued threshold or test score is treated as missing. If the current threshold is missing or zero, I use original threshold score instead. For a few cases where a deal has multiple test scores for senior tranches, I use the lowest nonmissing score to mitigate the impact of data errors.

[2]When different names of the same firm are reported, I check each borrower's historical names, business names, nicknames, acquisition target names, and wholly-owned financing subsidiary names, and ensure that the same issuer ID is applied.

[3]These duplicates were generated when the database scraped data from original trustee reports.

Currency Conversion. CLO tranches and portfolio loan holdings denominated in Euro are converted into US dollar based on the current USD-EUR exchange rate.

IA.1.3. Counterfactual portfolios

I construct counterfactual static CLO portfolios by tracking loan holdings before the COVID-19 shock hits the US market. The static portfolio is based on the last portfolio snapshot reported between January 1 and February 15, 2020 ("pre period"). To track the quality changes for each loan, I begin with a large set of portfolio holdings that consist of every CLO's first portfolio snapshot reported between July 1 and August 15, 2020 ("post period"). Since there is no unique loan identifier, I identify individual loans by a pair of issuer ID and maturity date.[4] I then determine ex-post credit rating (or coupon rate) of a loan as the value-weighted average rating (or coupon rate) of that particular loan across all CLOs' ex-post holdings.[5] Merging ex-post observations with ex-ante snapshots allows me to track changes in credit ratings and coupon rates for more than 94% of ex-ante loan holdings. To mitigate data errors introduced in this procedure, I use only portfolios for which at least 90% of pre-period holdings are tracked in counterfactual static portfolios (97% of the sample).

IA.2. Market Structure of Nonbanks: Additional Facts

Figure IA.1 summarizes annual CLO issuance. The pre-crisis issuance volume fell almost zero in 2009 and rebounded in 2012. In each of recent years, roughly 100 unique managers issued a total of 200–300 new CLOs, whose aggregate size is around $150 billion.

Figure IA.2 presents detailed information on loan funds. Based on data from regulatory reports, Panel (a) reports leveraged loan holdings by mutual funds and hedge funds, the two

[4]Occasionally, for the same loan, there is moderate variation in reported maturity dates across different CLOs. To address this, I use the quarter of reported maturity date.

[5]A limitation of this approach is that two loans issued by the same borrower and have the same maturity date would not be distinguished.

largest groups of loan funds in this market. Whereas the holdings of mutual funds fluctuate between \$100–200 billion in recent years, the amount of loans held by hedge funds has grown substantially. As of 2021, these two groups hold similar amounts of leveraged loans.

Panel (b) decomposes the size and number of public loan funds into three groups: open-end mutual funds, close-end mutual funds, and exchange-traded funds (ETFs). Open-end funds clearly dominate in terms of assets under management, despite a comparable number of close-end funds and the entry of ETFs in the last decade.

IA.3. The Slackness of CLOs' Collateral Constraints

Collateral constraints imposed by CLOs' contracts play a critical role in governing the dynamics of the CLO balance sheet. Figure IA.3 shows quarterly cross-sectional distribution of the slackness of senior OC constraints between 2010 and 2019. Among CLOs in reinvestment period, the average senior OC score is slightly (8%) above the threshold and stable over time.[6] In the cross section of CLOs, the slackness is tightly distributed around the average. These persistently binding constraints suggest that managers fully use safe debt capacity provided by their loan portfolios. By contrast, in amortization period, as CLO leverage decreases with principal repayment, the slackness becomes larger and much more dispersed.

IA.4. CLO Loan Trades and Secondary Market Prices

When more than a thousand CLOs are forced to trade in the same direction, their trades are likely to exert pressure on secondary market loan prices. This subsection examines the cross section of leveraged loan price drops in late March of 2020 ("mid" period), the epicenter of

[6] In my data, the senior OC thresholds can be that of AAA and AA tranches, so my calculation may overstate the actual slackness of AAA OC constraints.

the COVID-19 shock. For each loan, I measure its transitory price drop as

$$Drop_j = \frac{Price_j^{mid}}{\frac{1}{2} \times (Price_j^{pre} + Price_j^{post})} - 1, \tag{IA.1}$$

where the prices in each of the three periods are calculated as weighted average market values reported in CLO portfolio snapshots.[7] This measure captures the magnitude of a loan's price drop relative to a hypothetically linearly-extrapolated price level. My goal is to detect price pressures of CLO trades by comparing price drops across loans of different quality. To do so, I categorize individual loans based on post-period credit rating and calculate an average drop magnitude for each category.

Empirically isolating loan price changes caused by CLO trades is challenging. To alleviate the concern that observed price changes might be merely driven by changes in perceived fundamentals, I apply the same exercise above to high-yield bonds, which are not traded by CLOs, using similar data from mutual fund portfolio snapshots.

Figure IA.4 presents the results. Although these corporate debt generally experienced sizable transitory price drops, leveraged loans and high-yield bonds exhibited different cross-sectional patterns. In Panel (a), the magnitude of loan price drops is monotonic in credit rating, ranging from nearly 15% for the "B-" group to only 5% for the "BB+" group. By contrast, in Panel (b), the magnitudes of bond price drops are mostly around 15% across rating groups. These price patterns suggest that CLOs' purchases of high-quality loans increase, while sales of low-quality loans decrease, secondary market loan prices. Such asymmetric price pressures make it more costly for CLOs to maintain collateral quality through portfolio rebalancing.

[7] I use market values reported in portfolio holdings because these prices are based on current dealer quotes or trustee bank estimates, which helps mitigate the concern of price staleness for infrequently traded loans.

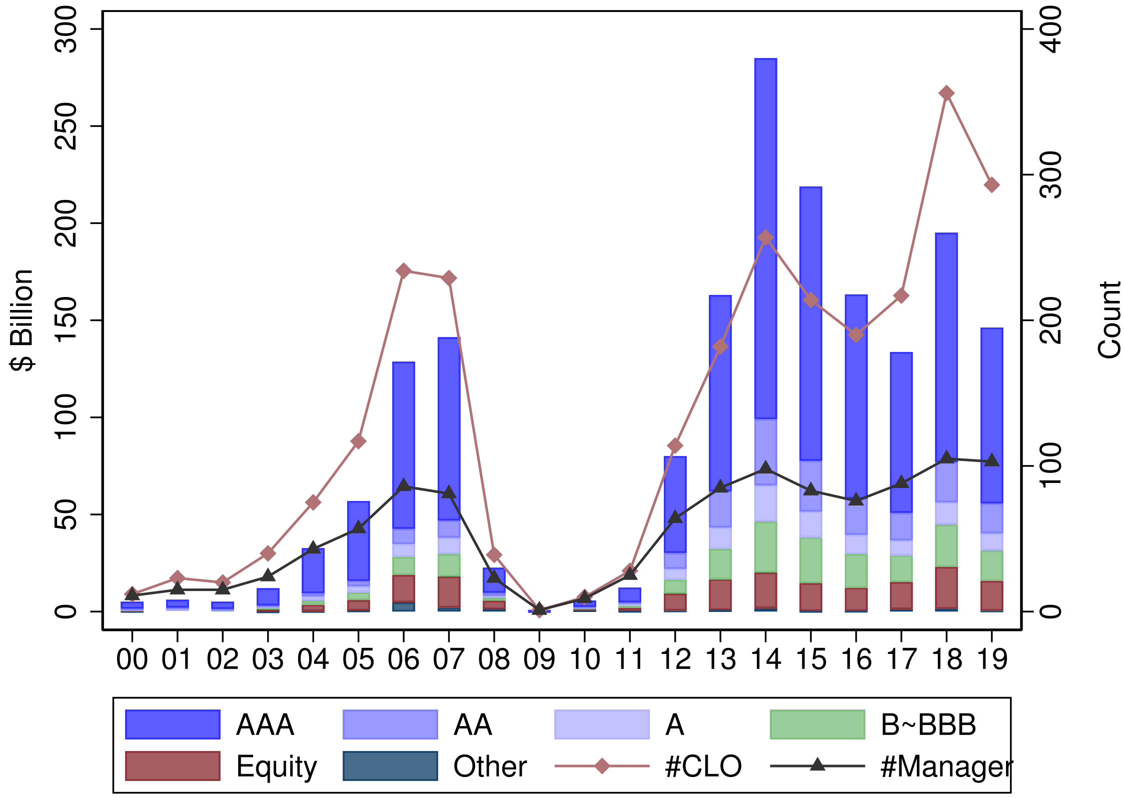
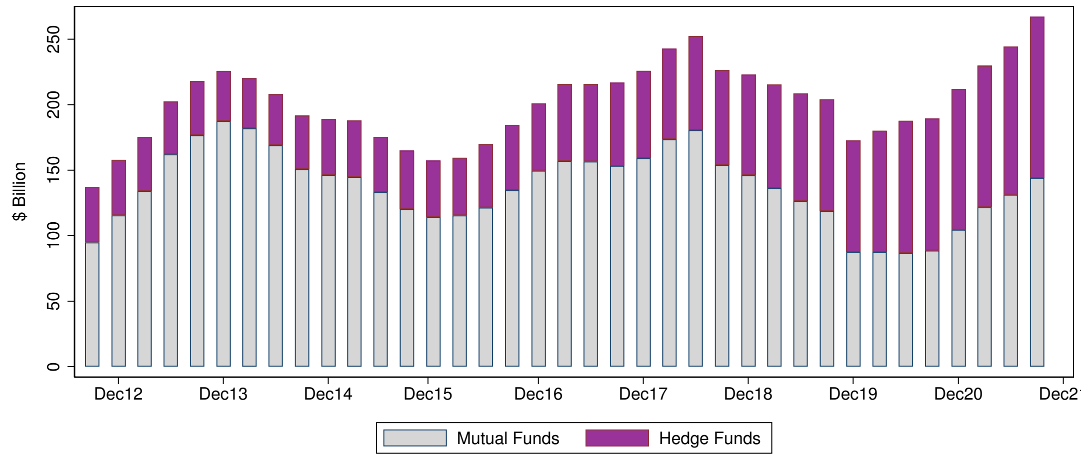
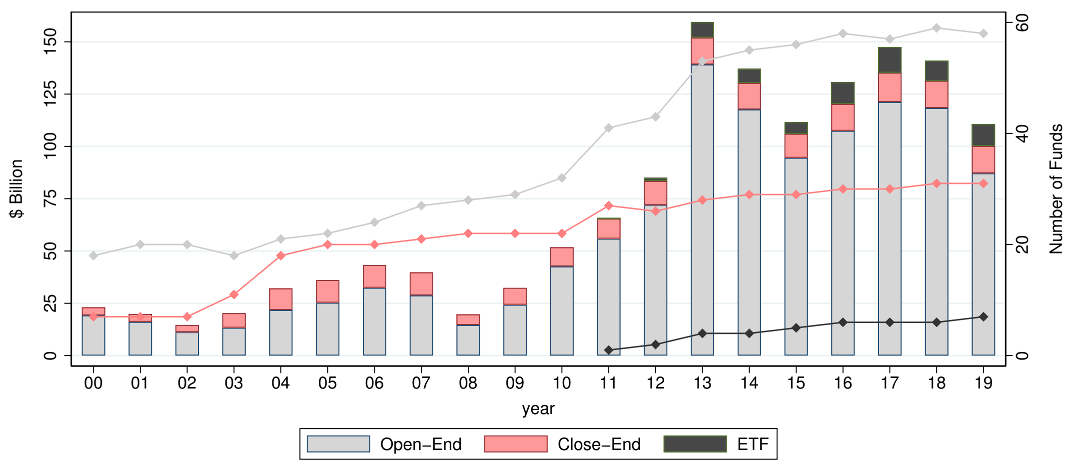


Figure IA.1: **CLO Issuance.**
This figure plots annual issuance of open-market CLOs in the US and Europe between 2000–2019. The issuance amount is by CLO tranche, identified based on initial credit ratings. Tranche size denominated in Euros are converted to USD using the exchange rate at issuance date. The connected lines indicate the numbers of deals and asset managers in each year. “Others” include mixed tranches and other non-rated tranches. Data come from Creditflux CLO-i database.



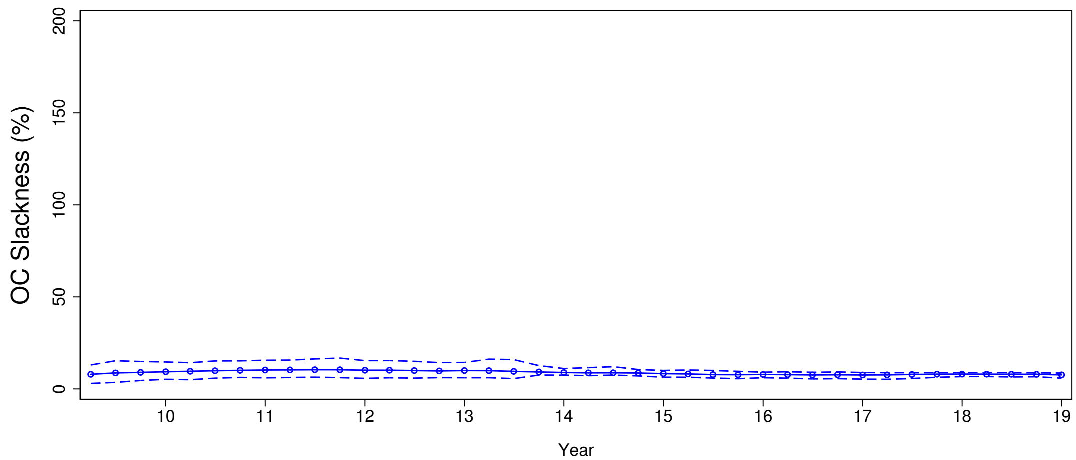
(a) Leveraged Loans Held by Mutual Funds and Hedge Funds



(b) Composition of Public Loan Funds

Figure IA.2: **Composition of Loan Funds.**
Panel (a) of this figure shows the amount of leveraged loans held by mutual funds (reported in the Shared National Credit Program) and hedge funds (reported in SEC Form PF) between 2012–2021. Data are from FRED, Federal Reserve Bank of St. Louis. Panel (b) decomposes public loan funds into open-end mutual funds, close-end mutual funds, and exchange-traded funds between 2000–2019. The stacked bars plot total assets under management, and the connected lines show the number of funds. Data for public loan funds are from Morningstar.

(a) CLOs in Reinvestment Period



(b) CLOs in Amortization Period

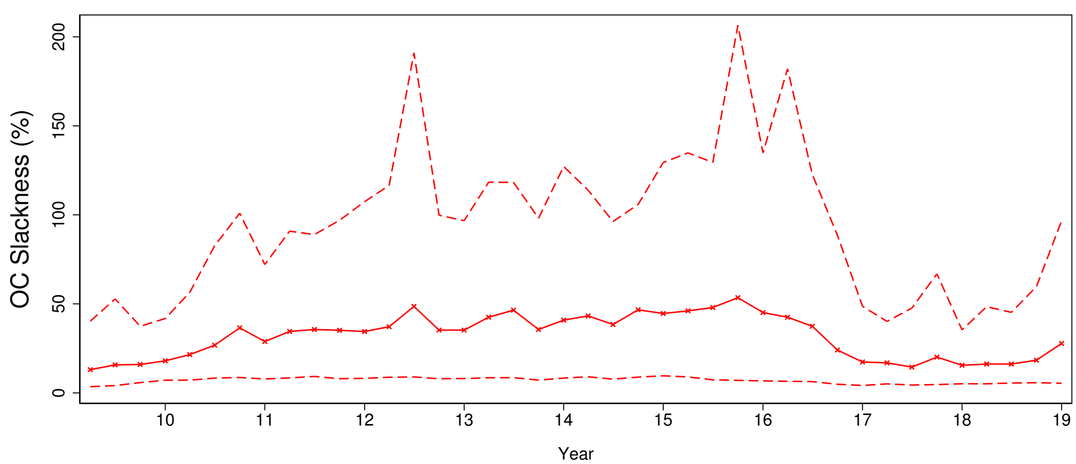
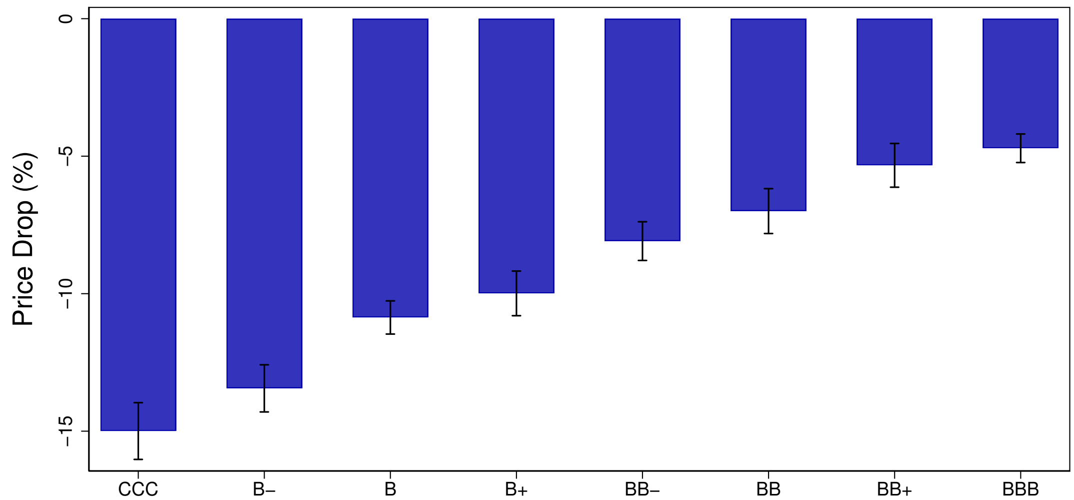
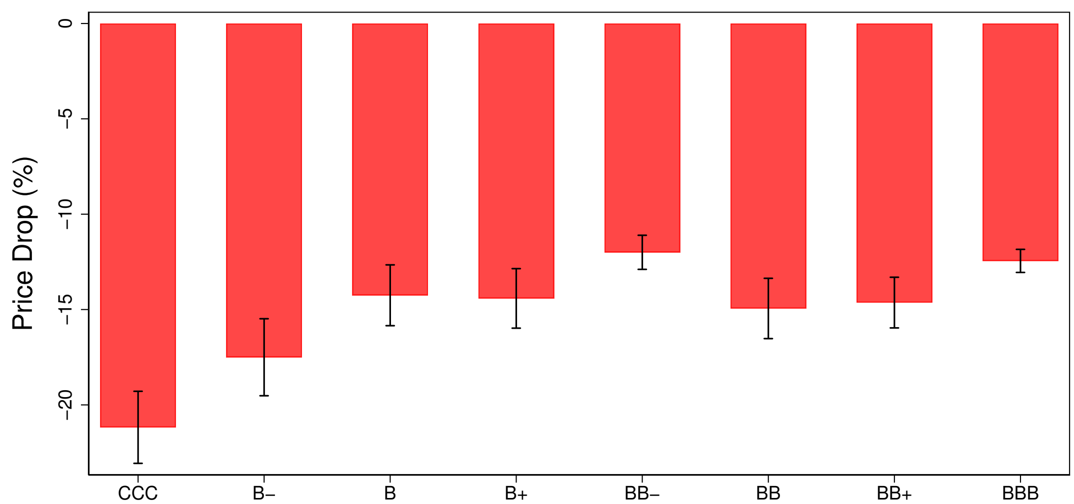


Figure IA.3: **CLOs' Binding Collateral Constraints.**
This Figure presents quarterly time series of cross-sectional dispersion in the slackness of CLO senior tranche over-collateralization (OC) constraints between 2010–2019. The slackness is defined as extra OC score scaled by the OC test's predetermined threshold level. Dashed lines indicate 5th and 95th percentiles in each cross section. Panel (a) reports CLOs in reinvestment period, and panel (b) reports CLOs in amortization period.



(a) Leveraged Loans



(b) High-Yield Bonds

Figure IA.4: **Secondary Market Prices in the COVID-19 Crisis.**
This figure plots average transitory secondary market price drop in March 2020 for corporate debts within each credit rating group. In Panel (a), leveraged loan prices are based on reported market values in CLO portfolio holdings. In Panel (b), high yield corporate bond prices are based on reported market values in corporate bond mutual fund portfolio holdings. Price drop is measured as the decrease in secondary market price in March 2020 relative to the average price before and after the COVID-19 shock. The vertical lines indicate 95% confidence intervals for group means.

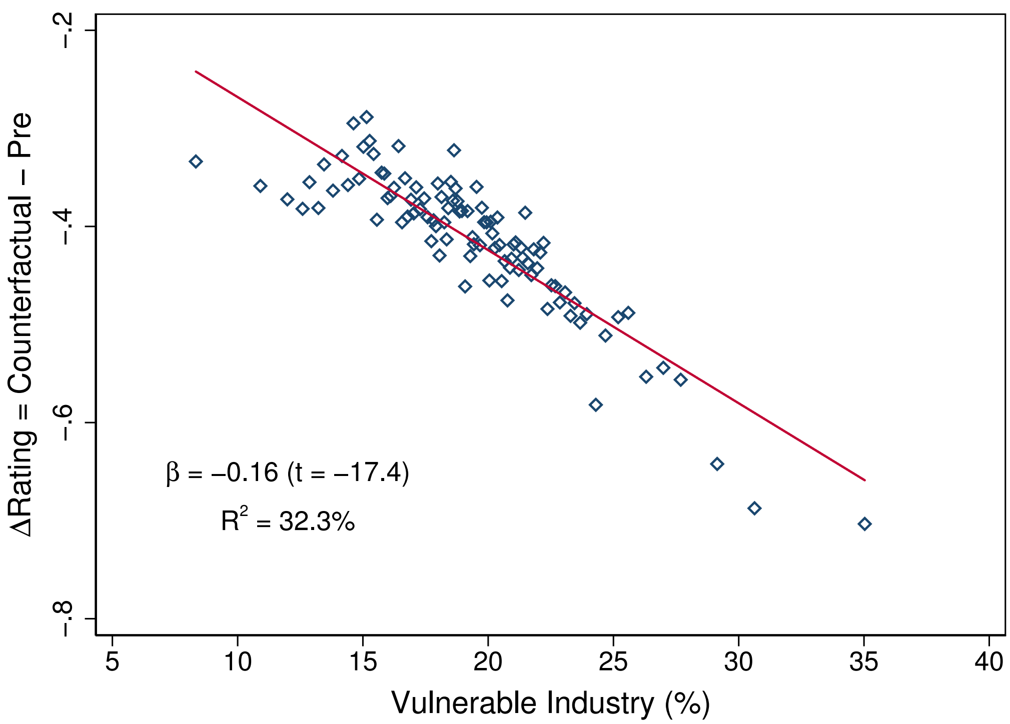


Figure IA.5: **Exposure to Vulnerable Industries and Counterfactual Quality Deterioration.**

This figure is a scatter plot that groups CLOs into 100 bins by portfolio weight in industries vulnerable to the COVID-19 pandemic before February 15, 2020 and depict the average counterfactual portfolio value-weighted average credit rating change between February 15 and June 30, 2020 within each bin.

Table IA.1: **CLO Debt Maturity**

This table presents empirical distributions of CLO debt tranche maturity, measured in number of years. The sample includes US CLOs issued between 2010 and 2020.

Seniority	Mean	SD	p10	p25	p50	p75	p90	N
AAA	9.1	2.6	6	8	9	11	12	2,928
AA	9.8	2.4	7	9	10	12	13	2,238
A	10.2	2.5	7	9	10	12	13	2,194
BBB	11.1	2.7	8	10	12	12	14	2,051
BB	11.8	2.9	9	11	12	13	15	1,917
B	11.9	3.2	8	11	12	13	16	676
Total	10.4	2.9	7	9	11	12	13	12,004

Table IA.2: **Conversion from Letter Rating and Numerical Rating**

This table presents the conversion from letter ratings to numerical ratings, for credit ratings by Moody's and S&P. If only one rating agency's letter rating is available for a debt, the numerical rating is based on the available rating. If the two rating agencies' letter ratings convert to different numbers, the numerical rating is calculated as the average of the two converted numbers.

Letter Rating		Numeric Rating
Moody's	S&P	
Aaa–A3	AAA–A-	14
Baa1	BBB+	13
Baa2	BBB	12
Baa3	BBB-	11
Ba1	BB+	10
Ba2	BB	9
Ba3	BB-	8
B1	B+	7
B2	B	6
B3	B-	5
Caa1	CCC+	4
Caa2	CCC	3
Caa3	CCC-	2
Ca	CC, C	1
C	SD, D	0