# Internet Appendix

## Financial Market Structure and the Supply of Safe Assets: An Analysis of the Leveraged Loan Market

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This online appendix contains the following five parts. First, Section IA.1 describes the data and sample. Second, Section IA.2 provides detailed evidence for the empirical facts discussed in Section 1 of this paper. Third, in Section IA.3, I extend the model to generalized settings to explore the boundaries of long-term safe debt contracts. Finally, Section IA.4 and Section IA.5 respectively present supplementary theoretical and empirical analyses.

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# 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 bank 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 based on 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 secondary market interactions in response to the arrival of a negative macroeconomic shock, I construct a cross-sectional sample that tracks the changes in CLO loan portfolios between February 15 – 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 – February 14, 2020 as the observation for a "pre" period, and I use the first snapshot available between July 1 – August 15, 2020 for a "post" period.[1] To measure secondary market prices at the trough, I also use the last snapshot between March 15–April 15, 2020 as the observation for the "mid" period. To alleviate measurement errors, I winsorize prices at the 1% and 99% percentiles.

Complementary databases include CRSP mutual fund portfolio holdings, Mergent Fixed Income Securities Database (FISD), Morningstar, and the SEC's Form ADV. Panel A of Table IA.3 provides summary statistics of the panel sample. On average, a CLO has $435 million principal outstanding and a portfolio consisting of 222 loans. CLOs in the sample are overall young with an average age of 4.2 years. For most CLOs, 60% to 75% of liabilities are AAA-rated tranches.

### 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 usually not reported at the end of a certain period. In the database, 75% of CLO–month pairs have at least one report 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 2000–2020. There are 2,306 unique CLOs, 21,970 unique tranches, and 82,447 deal-level

[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.

reports, and 612,689 tranche-level reports in total. These reports provide information on original and current amount of liability outstanding at the tranche level, and the asset manager company. To determine the seniority of a tranche, I first use the seniority name variable, and use 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 held in the portfolio, 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 that there is no loan-level unique identifier. While the holdings 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 inaccurate data on inferences for tests using the COVID-19 cross sectional sample, I carefully compare the name of every leverage loan borrower during 2016—2019 with the issuer names in CLO holdings data and manually correct 1,297 issuers that have mismatched names or (and) 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 holding dataset includes 22.3 million holding records.

*Loan Trades.* For each loan trade, the transactions raw dataset provides information on the direction (buy or sell), face amount of the loan, transaction price, and date of the trade.

[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 are generated when the data vendor scrape data from original trustee reports.

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 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.

*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. Consistent with the natural-experiment sample, the static portfolio is based on the last portfolio snapshot reported between January 1 and February 15, 2020 ("pre period"). To generate a counterfactual observation 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 loan-level unique identifier available, I identify individual loans by a pair of issuer ID and maturity date.[4] I then calculate ex-post credit rating (coupon rate) for an ex-ante loan holding as the value-weighted

[4] To address that reported maturity dates for the same loan sometimes varies moderately across different CLOs' portfolio reports, I use the quarter of reported maturity.

average rating (coupon rate) across all CLOs' ex-post matched holdings.[5] Merging ex-post information to the pre 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 Empirical Evidence

### IA.2.1 CLO Issuance and Other Intermediaries

Figure IA.1 shows annual CLO issuance. The pre-crisis issuance volume dropped to almost zero in 2009 and bounced back in 2012. In each of recent years, roughly 100 unique asset managers issued 200–300 new CLO deals in total, whose aggregate size is around $150 billion.

Figure IA.2 provides information on the size of different intermediaries based on alternative data sources. Consistent with Figure 1, the market share of CLOs has been persistently around 50%. A noticeable recent trend is that the size of hedge funds has grown and replaced a fraction of public funds in this market.

### IA.2.2 Covenants and Collateral Constraints

In each period, a CLO's collateral test scores are calculated based on current loan holdings and debt outstanding and then compared with predetermined threshold levels. For example, the OC test score for AAA tranches is calculated as

$$\text{AAA OC score} = \frac{\text{quality-adjusted total face value of loan holdings}}{\text{face value of AAA tranche outstanding}}, \qquad \text{(IA.1)}$$

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

where the quality adjustment is based on portfolio loans' current ratings and prices. When the OC test fails, the covenants typically require the manager to accelerate debt repayment, which reduces the score's denominator. To do so, the manager has to divert cash flows generated by loan holdings away from paying junior tranches (or buying more loans) to paying the senior tranche. However, an alternative action that also improves the OC score is increasing the numerator via secondary market trades. Which action will managers choose is an empirical question, and the answer is in the next subsection.

Collateral tests impose constraints that dynamically govern the relationship between a CLO's loan portfolio and safe debt. Figure IA.3 presents quarterly cross-sectional distribution for the slackness of senior OC constraints between 2010–2019. Among CLOs in reinvestment period, the average OC score is only slightly (8%) above the minimum required level and is fairly stable over time.[6] In every quarter, the slackness of collateral constraints is tightly distributed around this average. These binding constraints can be interpreted in two ways: First, managers fully use safe debt capacity allowed by their portfolios, and second, they carefully maintain just enough quality-adjusted loan holdings given safe debt outstanding. For CLOs in amortization period, in contrast, constraint slackness is much larger on average and more dispersed. This is because CLO leverage decreases along with debt principal repayment, and their managers no longer actively trade loans.

### IA.2.3 Balance Sheet Dynamics around the Onset of COVID-19

Safe debt issued by CLOs are long-term bonds. This is different from traditional banking, where safe debt have very short maturities, and depositors can force intermediaries to pay back before asset losses fully materialize. Without short maturities to enforce repayment, do asset managers respond to negative macro shocks? Figure IA.4 depicts CLO balance sheet

[6] The observed senior OC thresholds are not necessarily that of the most senior (AAA) tranche, so my calculation over-states the actual slackness. See Appendix IA.1.2 for details on this data limitation.

dynamics before and around the onset of COVID-19 crisis in 2020.

Panel (a) shows quarterly average total loan holdings, by CLO issuance year cohort. For all cohorts, portfolio size remained stable over time. This suggests that CLOs did not liquidate loans when the pandemic hit the economy. By contrast, Panel (b) shows that the pattern of early senior debt repayment dropped. While earlier cohorts on average repaid some of senior tranches after typically 2–3 years of non-call periods, such early repayment largely discontinued due to the difficulty of refinancing in 2020.

The absence of portfolio liquidation and early debt repayment does not imply that CLO managers did respond to the shock. In Panel (c), the average numbers of loan purchases and sales both nearly doubled upon the arrival of the COVID-19, which indicates that managers were actively buying and selling loans in the secondary market. To understand the nature of these trades, Panel (d) examines loan trades within individual CLOs during the first two quarters of 2020. As the bin scatter plot shows, there is a strong positive (and nearly one-to-one) relationship between a CLO's loan purchases and sales. Therefore, secondary market trades achieved portfolio substitution at the individual CLO level.

### IA.2.4 Portfolio Substitution Improves Collateral Quality

COVID-19 caused unanticipated and systematic deterioration of leveraged loan quality, which threatened CLOs' binding collateral constraints. The previous subsection documents that managers responded to this threat by changing portfolio composition instead of repaying debt. This subsection uses granular CLO portfolio holdings data to examine how secondary market trades affect collateral quality.

Figure IA.5 presents portfolio changes from February 15 ("pre") to June 30 ("post") of year 2020, for all CLOs in reinvestment period (87% of the sample). Panel (a) shows

OC constraint slackness before and after the shock.[7] As the pandemic caused a massive downgrading wave, the distribution of slackness shifts to the left, and the dispersion among CLOs increases. However, when the crisis settled in July, only 1.2% of CLOs failed senior OC tests.

The reason behind limited test failure, as the previous subsection suggests, could be portfolio substitution during the shock. To quantify its causal effect, for each CLO, I track individual loan quality changes and measure the portfolio's counterfactual ex-post quality in the absence of loan trades.[8] Panel (b) shows the distribution of value-weighted portfolio average ratings. A larger numeric rating corresponds to a better letter rating (see Table IA.2 for details). Clearly, the pandemic lowered overall ratings, but managers' trading mitigated deterioration, improving the realized ex-post distribution relative to the counterfactual.

Although CLOs faced similarly binding constraints, their portfolios had different exposures to COVID-19. CLOs experiencing more severe deterioration would be forced to respond more intensively. I measure a CLO's exposure with the difference in average rating between the pre and counterfactual-post portfolios.[9] Panel (c) shows that almost all CLOs replaced deteriorated loans, and that the effect on quality linearly increases in exposure. The slope estimate indicates that on average, portfolio substitution offsets 60% of quality deterioration caused by COVID-19. Panel (d) replaces the outcome variable with value-weighted average coupon rate, which measures portfolio quality based on primary market loan pricing. In response to a 1-notch decrease in average rating, the manager's trades reduced portfolio average coupon by 30 basis points, or roughly one standard deviation.

Panels (e) and (f) examine the direction of loan trades by comparing ratings and coupons between the loans bought and sold by a CLO, respectively. Clearly, CLOs more threatened

[7] I calculate constraint slackness using test scores reported by trustee banks. However, I am not able to calculate a counterfactual test score due to data limitations, such as unobservable cash holdings.

[8] See Subsection IA.1.3 in the Appendix for details on the construction of counterfactual portfolios.

[9] Figure IA.7 shows a strong correlation between this counterfactual quality deterioration and ex-ante portfolio weight in pandemic-vulnerable industries.

by the shock responded more aggressively in replacing low-quality loans. The results further support that binding collateral constraints triggered portfolio substitution trades that substantially improved collateral quality.

### IA.2.5 CLO Loan Trades and Secondary Market Prices

More than a thousand CLOs' portfolio substitution trades in the same direction are likely to affect 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 the COVID-19 shock. For each loan, I measure its transitory price drop as

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

where the prices are calculated using market values reported in CLO portfolio snapshots in the three periods.[10] This measure captures the magnitude of a loan's price drop relative to a hypothetical 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 group individual loans based on rating and calculate an average drop magnitude for each group.

Empirically isolating loan price changes caused by CLO trades is challenging. To alleviate the concern that observed price changes could 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.6 presents the results. Although all risky corporate debt 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

[10] I use market values reported in portfolio holdings because these prices are based on dealer quotes and trustee banks' estimates, which help mitigate the concern of price staleness for infrequently traded debt. See Appendix IA.1.1 for details on price measurement.

Panel (b), the magnitudes of bond price drops are mostly around 15% across rating groups. These price patterns provide suggestive evidence that CLOs' purchases (sales) of high-quality (low-quality) loans increase (decrease) secondary market loan prices. Such asymmetric price pressures makes it costly to improve collateral quality through trading.

## IA.3 Model Extensions

The banking literature has studied a short-maturity channel whereby safe debt investors (i.e., depositors) receive repayment from the proceeds of asset liquidation (e.g., Diamond and Dybvig, 1983; Stein, 2012; Hanson et al., 2015). The model in previous sections deliberately abstracts from this channel. In this section, I explore two extensions to understand conditions under which long-term contracts with dynamic collateral management arise as the preferred safe debt contracts.

### IA.3.1 Safe Debt Maturity

The loan payoff distributions in Section 2 of the paper, as will be clear shortly, discourage asset managers from using short-term safe debt. Moreover, the absence of net cash trades in the secondary market makes early repayment impossible in equilibrium. In this subsection, I relax these assumptions and analyze asset managers' choices of debt maturity. To do so, I extend the model in two aspects. First, I allow risky loans to have more general payoff distributions, and second, I introduce additional loan buyers into the secondary market.

The payoff distributions are generalized as follows. For convenience, I denote a loan's fundamental value conditional on news $s$ at $t = 1$ by $F_j^s := \mathbb{E}[R_j^\omega | s]$, $j \in \{h, l\}$ and let $f_j^s$ be the lower bound of the support of the conditional distribution.[11] The support of the

[11] Accordingly, Assumption 2 is generalized to $c'(\bar{x}_l) < pF_h^+ + (1-p)F_h^-$.

conditional distribution can be any compact subset of $\mathbb{R}_+$ such that $f_h^+, f_h^- > 0$. To simplify the analysis while preserving the intuition, I assume $f_j^+ > F_j^-$ for $j \in \{h, l\}$ and $f_l^- = 0$.[12]

There is a costly technology that allows investors to store consumption goods from $t = 0$ to $t = 1$. I interpret this storage technology as the formation of specialized capital for buying liquidated assets during market downturns, such as distressed debt strategy funds. Storing every unit of consumption goods incurs a constant cost $\kappa > 0$. Let outsider buyers' demand for loan $j$ after news $s$ be $z_j^s$. The market clearing condition in period $t = 1$ thus becomes

$$\int_i \Delta x_{i,j}^s \, \mathrm{d}i + \frac{z_j^s}{q_j^s} = 0 \quad \text{for } j \in \{h, l\}, s \in \{+, -\}. \tag{IA.3}$$

#### IA.3.1.1 Manager Choices

Under these assumptions, an asset manager can flexibly choose between short-term and long-term safe debt contracts. The manager's $t = 0$ initial collateral constraint becomes

$$x_{i,h} q_h + x_{i,l} q_l \geq \min\left\{a_i \frac{q_h}{f_h^-}, a_i\right\}. \tag{ICC'}$$

This constraint requires the intermediary's portfolio value to be enough to ensure debt safety in the negative-news stage, either through portfolio substitution or early repayment. Which of these two types of balance sheet adjustment allows for a larger safe debt capacity depends on the level of price $q_h$ relative to the loan's worst-possible payoff $f_h^-$. When $q_h \leq f_h^-$, long-term contract maximizes safe debt capacity, and short-term contract maximizes debt capacity when $q_h > f_h^-$. After an intermediary issues short-term safe debt, the debt can be rolled over at $t = 1$ if the manager is both able and willing to hold enough collateral; otherwise, she has to repay. The rollover can be interpreted as equivalent to long-term safe debt.

I first analyze the manager's secondary market problem, taking choices at $t = 0$ and loan prices as given. In the positive-news stage, debt rolls over, and trades are trivial. So similar

[12] As long as $f_l^-$ is sufficiently lower than $f_h^-$, replacing bad loans with good loans improves the worst-possible portfolio payoff, and dynamic collateral management can increase long-term safe debt capacity.

to earlier sections, I suppress superscripts in net trades, repayment, and loan prices. When negative news arrives at $t = 1$, the manager takes prices as given and solves

$$v(x_{i,h}, x_{i,l}, a_i) = \max_{\Delta x_{i,h}, \Delta x_{i,l}, \Delta a_i} \sum_j (x_{i,j} + \Delta x_{i,j}) F_j^- - (a + \Delta a_i), \tag{IA.4}$$

where $\Delta a_i$ is the net change in safe debt outstanding (i.e., $\Delta a_i < 0$ is a repayment). She faces budget constraint

$$\sum_j x_{i,j} q_j + \Delta a_i \geq \sum_j (x_{i,j} + \Delta x_{i,j}) q_j, \tag{BC'}$$

maintenance collateral constraint

$$(x_{i,h} + \Delta x_{i,h}) f_h^- \geq a_i + \Delta a_i, \tag{MCC'}$$

and short-sale constraints $\Delta x_{i,h} \geq -x_{i,h}, \Delta x_{i,l} \geq -x_{i,l}, -a_i \leq \Delta a_i \leq 0$. Similar to the baseline model, this problem can be simplified to

$$\max_{\Delta x_{i,l}, \Delta a_i} \quad \Delta x_{i,l} \Big( F_l^- - F_h^- \frac{q_l}{q_h} \Big) + \Big( \frac{F_h^-}{q_h} - 1 \Big) \Delta a_i, \tag{P1'}$$

subject to constraints

$$\Delta x_{i,l} f_h^- \frac{q_l}{q_h} + \Delta a_i \Big( 1 - \frac{f_h^-}{q_h} \Big) \leq x_{i,h} f_h^- - a_i, \tag{IA.5}$$

and $\Delta x_{i,l} \geq -x_{i,l}, -a_i \leq \Delta a_i \leq 0$.

The manager's optimal choices that solve problem (P1') depend on both balance sheet at $t = 0$ and loan prices at $t = 1$, which jointly determine what choices are ex-post desirable and feasible. In the proof, I show that early repayment ($\Delta a_i = -a_i$) is desirable if and only if $q_h > f_h^\star := f_h^- + \frac{q_l}{F_l^-}(F_h^- - f_h^-)$. That is, the manager wants to repay debt early if and only if $q_h$ is sufficiently high. In this case, after the repayment, the manager can hold only low-quality loans and expect a high equity return. By contrast, if $q_h \leq f_h^\star$, delaying repayment by holding enough collateral is desirable. Moreover, the feasibility of these actions is predetermined by inequality (ICC'). If a desirable action is ex-post infeasible, the manager has to choose an undesirable action to satisfy the collateral constraint. For instance, if $q_h > f_h^-$, a manager having short-term safe debt $a_i > (x_{i,h}q_h + x_{i,l}q_l)\frac{q_h}{f_h^-}$ has to repay in the negative-news stage even if her ex-post desired action is to rollover debt.

#### IA.3.1.2 Outsider Purchase

Given the linear cost structure of the storage technology, outside buyers' demand for loan $j$ in the secondary market is

$$z_j(q_j) = \begin{cases} +\infty, & (1-p)\left(\frac{F_j^-}{q_j} - 1\right) > \kappa \\ \forall z \in \mathbb{R}_+, & (1-p)\left(\frac{F_j^-}{q_j} - 1\right) = \kappa \\ 0, & (1-p)\left(\frac{F_j^-}{q_j} - 1\right) < \kappa \end{cases}. \tag{IA.6}$$

Intuitively, the quantity of loan purchase is determined by a tradeoff between the profit from the price's deviation from fundamentals and the cost of storing consumption goods.

#### IA.3.1.3 Equilibrium

The manager's safe debt maturity choice at $t = 0$ is based on a tradeoff between ex-ante safe debt capacity and ex-post liquidation costs, both of which depend on secondary market loan prices. Since outside buyers are the only traders who can absorb liquidated loans, the *levels* of loan prices are associated with their funding costs. The following proposition summarizes the set of competitive equilibria that can arise in this generalized economy.

**Proposition IA.1** (Equilibrium with Safe Debt Maturity Choice)**.** *Depending on parameter values, there are four types of competitive equilibrium, each has a different combination of intermediary liabilities:*

*(i) Long-term safe debt and equity financing. There exists a unique* $\lambda^{lt} \in (0,1)$ *such that managers* $[0, \lambda^{lt}]$ *issue long-term safe debt, and the rest issue only equity. No risky loan is sold to outside buyers.*

*(ii) Short-term safe debt, long-term safe debt, and equity financing. There exist a unique pair of $\lambda^{st}, \lambda^{lt}$, where $0 < \lambda^{st} < \lambda^{lt} < 1$, such that managers $[0, \lambda^{st}]$ issue short-term safe debt, $(\lambda^{st}, \lambda^{lt}]$ issue long-term safe debt, and the rest issue only equity. A subset of low-quality loans are sold to outside buyers after negative news.*

*(iii) Short-term safe debt and long-term safe debt. There exists a unique $\lambda^{st} \in (0, 1)$ such that managers $[0, \lambda^{st}]$ issue short-term safe debt, and the rest issue long-term safe debt. All low-quality loans are sold to outside buyers after negative news.*

*(iv) Only short-term safe debt. All managers issue short-term safe debt, and all high-quality and low-quality loans are sold to outside buyers after negative news.*

Type-i equilibrium arises when outsiders' cost of buying loans is high relative to the safety premium. In this case, either the short-term contract fails to maximize safe debt capacity, or the benefit of its debt capacity is smaller than the cost of early liquidation. Hence all safe debt-financed intermediaries use long-term contracts and substitute collateral in the secondary market. This result suggests that CLOs issue long-term safe debt because the leveraged loan market is segmented from public securities markets, and it is costly for outsiders to trade loans. The model in earlier sections is a special case of this equilibrium, so it is without loss of generality to restrict attention to long-term safe debt contract.[13]

Type-ii and type-iii equilibria feature a "pecking order" in maturity choices. While short-term contracts maximize safe debt capacity, it is more costly to liquidate loans than to substitute collateral ex post. A greater safe debt capacity is more valuable for managers with better securitization technology. In equilibrium, only managers with sufficiently low issuance costs use short-term contracts, and others issue long-term safe debt or only equity. In the negative-news stage, the first group of intermediaries liquidate all risky loans, whereas the

[13] The payoff distribution in Section 2.1 dictates that $F_h^- = f_h^- = 1$, so $q_h \leq f_h^-$. This implies that short-term contract not only fails to maximize safe debt capacity, but also leads to lower ex-post payoff to a manager given the quantity of safe debt issued.

second and third groups substitute collateral. Outside buyers absorb low-quality loans, which provide a higher return. High-quality loans change hands among intermediaries.

Type-iv equilibrium arises when outsiders' funding cost is sufficiently low. In this equilibrium, the cost of early liquidation is smaller than the benefit of greater safe debt capacity. Hence, all intermediaries optimally issue short-term safe debt to exploit cheap financing and liquidate their entire portfolios when negative news arrives. Unlike equilibrium types i–iii, no intermediary's debt relies on loans originated by others, and the constrained inefficiency associated with collateral substitution does not exist in this equilibrium.

### IA.3.2 Contractual Frictions

My model assumes that asset managers can fully commit to future loan trades that maintain collateral quality. This simplifies the analysis but is unrealistic. Although there exist publicly verifiable proxies associated with a loan's quality (e.g., credit ratings), contracting based on these proxies as if they perfectly measure loan quality is unlikely to ensure debt safety. In this subsection, I briefly discuss whether and how the debt contract can be modified to accommodate such contractual frictions.

I introduce the following generalization that allows loan types to be imperfectly contractible: A contract that requires a quantity $m_i \in \mathbb{R}_+$ of high-quality loans can only enforce

$$\hat{x}_{i,h} + \Delta x_{i,h} + \rho(x_{i,l} + \Delta x_{i,l}) \geq m_i. \tag{IA.7}$$

The left hand side of (IA.7) can be interpreted as the quantity of pre-trade qualified loans that will continue to satisfy the contract's requirement after secondary market trades. From the manager's perspective, every unit of high-quality loans will continue to be qualified with certainty, whereas each unit of low-quality loans that is pre-trade qualified has only a $\rho \in (0, 1)$ chance of being qualified post trade. Parameter $\rho$ thus captures the manager's limited commitment due to noises in loan quality proxies. The larger $\rho$ is, the more low-quality loans the manager can mix into the required quantity $m_i$ of qualified holdings. As $\rho$ approaches zero (one), managers approach full (zero) commitment. Moreover, managers' information may be imperfect. Specifically, a manager's perceived quantity of high-quality loans, $\hat{x}_{i,h}$, includes an unobservable low-quality component: $\hat{x}_{i,h} = x_{i,h} + \hat{\epsilon}_i$, where $\hat{\epsilon}_i$ is independent and identically distributed over $(0, \bar{\epsilon}] \subset \mathbb{R}_+$ and $\bar{\epsilon} < c'^{-1}(pR + 1 - p) - \bar{x}_l$.

When negative news arrives, asset managers privately prefer low-quality loans to high-quality loans. This risk-shifting incentive and the contractual frictions imply that the contract in Section 2 inevitably fails to ensure debt safety. In particular, if the contract specifies $m_i = a_i$, the manager would "reach for yield" by choosing a post-trade portfolio with $x_{i,h} + \Delta x_{i,h} < \hat{x}_{i,h} + \Delta x_{i,h} \leq a_i$, which provides a higher payoff to equity. This choice implies that the portfolio's payoff in state $s = d$ is insufficient to repay debt, and from an ex-ante perspective, the debt defaults with a positive probability.[14]

The debt contract can still rely on verifiable loan quality proxies to address the contractual frictions. A provision that potentially restores debt safety is over-collateralization, which requires the quantity of qualified loans to be no less than the sum of safe debt face value and an additional quantity $a_i^{oc} > 0$:

$$\hat{x}_{i,h} + \Delta x_{i,h} + \rho(x_{i,l} + \Delta x_{i,l}) \geq m_i = a_i + a_i^{oc}. \tag{OC}$$

The manager's secondary market budget constraint suggests that she can mix one unit of low-quality loans into qualified holdings at the cost of $\frac{q_l}{q_h}$ units of actual high-quality loans. This unit of low-quality loans only fulfills $\rho$ units towards the requirement. When $\rho$ is relatively small, mixing in low-quality loans reduces the quantity of qualified holdings in the portfolio. In this case, the manager's risk shifting upon the arrival of negative news is constrained by the quantity of low-quality loans that she can possibly hold without violating the over-collateralization requirement. Hence, the contract can set a sufficiently large $a_i^{oc}$

[14]Note that paying the manager an incentive fee conditional on that debt does not default cannot prevent the risk shifting as long as the bonus comes as a part of portfolio payoff.

to force the manager to include enough high-quality loans in the post-trade portfolio. By contrast, when $\rho$ is large, the left hand side of (OC) would be increasing in $\Delta x_{i,l}$, relaxing this constraint as the manager increases portfolio risk. Based on this intuition, the following proposition characterizes the conditions for debt safety to be achievable.

**Proposition IA.2** (Over-Collateralization)**.** *The debt contract can be revised to ensure safety if $\rho, \bar{\epsilon}$ are relatively small such that there exists an over-collateralization requirement $a_i^{oc}$ that satisfies*

$$\rho\Big((x_{i,h} - a_i)\frac{q_h}{q_l} + x_{i,l}\Big) + \bar{\epsilon} \leq a_i^{oc} \leq \Big((x_{i,h} - a_i)\frac{q_h}{q_l} + x_{i,l}\Big)\frac{q_l}{q_h}. \tag{IA.8}$$

Proposition IA.2 indicates that full commitment is not a necessary condition for dynamic trading to increase safe debt capacity. As long as the proxies for loan quality allow the contract to sufficiently discipline the manager's portfolio choices, promised trades can be implemented with over-collateralization. The secondary market price ratio $\frac{q_l}{q_h}$ plays an important role in this contract: First, a deeply depressed price ratio compromises the constraint on the manager's risk shifting, and second, the ratio also has to be sufficiently greater than $\rho$ for condition (IA.8) to be feasibly satisfied.

**Proof of Proposition IA.1**. The proof begins with the observation that $\Delta a_i = -a_i$ is ex-post desirable if and only if $q_h > f_h^\star := f_h^- + \frac{q_l}{F_l^-}(F_h^- - f_h^-)$. To see that $q_h > f_h^\star$ is sufficient, note that it implies $\frac{q_h}{F_h^-} > \frac{q_l}{F_l^-} + \frac{f_h^-}{F_h^-}\Big(1 - \frac{q_l}{F_l^-}\Big) \geq \frac{q_l}{F_l^-}$, so constraint (IA.5) binds: the objective in problem (P1') then reduces to $\Delta a_i \frac{F_l^-(f_h^\star - q_h)}{f_h^- q_l}$, which strictly decreases in $\Delta a_i$. From above, it is also clear that $q_h > f_h^\star$ is necessary when $\frac{q_l}{F_l^-} < \frac{q_h}{F_h^-}$; When $\frac{q_l}{F_l^-} \geq \frac{q_h}{F_h^-}$, $\Delta a_i = -a_i$ is not desirable because optimal $\Delta x_{i,l} = -x_{i,l}$, and the objective reduces to $\Delta a_i\Big(\frac{F_h^-}{q_h} - 1\Big)$, which strictly increases in $\Delta a_i$.

I characterize competitive equilibria by searching over three mutually exclusive cases.

*Case 1*: $q_h \in (0, f_h^-]$. In this case, short-term contract is strictly dominated because long-term contract maximizes ex-ante safe debt capacity ($a_i\frac{q_h}{q_l} \leq a_i$), and $\Delta a_i = 0$ is ex-post desirable. All safe debt-financed intermediaries use long-term contract. The equilibrium has an interior cutoff and is unique with respective to price ratio $\frac{q_l}{q_h} < \frac{F_l^-}{F_h^-}$. Secondary market clearing condition implies that no loan can be sold to outsider buyers. So in this equilibrium, $q_l \geq \frac{(1-p)F_l^-}{1-p+\kappa}$. The equilibrium exists when $\kappa$ is relatively large with respect to $\gamma$.

*Case 2*: $q_h \in (f_h^-, f_h^\star]$. In this case, short-term contract maximizes safe debt capacity ($a_i \frac{q_h}{q_l} > a_i$), but $\Delta a_i = 0$ is ex-post desirable. Inequality $\frac{q_l}{q_h} \leq \frac{F_l^-}{F_h^-}$ holds, otherwise there is either zero demand for low-quality loans or infinite demand for high-quality loans.[15] Hence, constraint (IA.5) binds, and optimal secondary market trades can be derived accordingly. There are generally three liability types for asset managers to choose from.

(i) If an intermediary issues only equity, optimal secondary market trades are $\Delta x_{i,h} = -x_{i,h}, \Delta x_{i,l} = x_{i,h}\frac{q_h}{q_l}$, and continuation value $v^e = (x_{i,h}\frac{q_h}{q_l} + x_{i,l})F_l^-$. The manager's marginal payoff from lending is $y_i^e := pF_h^+ + (1-p)F_l^- \frac{q_h}{q_l}$, and her payoff is

$$V_i^e = y_i^e c'^{-1}(y_i^e) - c(c'^{-1}(y_i^e)) - x_{i,l}\Big(p(F_h^+ - F_l^+) + (y_i^e - pF_h^+)\Big(1 - \frac{q_l}{q_h}\Big)\Big). \quad \text{(IA.9)}$$

(ii) If an intermediary issues long-term safe debt, optimal secondary market trades are $\Delta x_{i,h} = \frac{a_i}{f_h^-} - x_{i,h}, \Delta x_{i,l} = (x_{i,h} - \frac{a_i}{f_h^-})\frac{q_h}{q_l}$, and continuation value $v^{lt} = (x_{i,h}\frac{q_h}{q_l} + x_{i,l})F_l^- - a_i(1 + \frac{q_h F_l^-}{q_l f_h^-} - \frac{F_h^-}{f_h^-})$. At $t = 0$, the manager faces constraint $a_i \leq (x_{i,h} + x_{i,l}\frac{q_l}{q_h})f_h^-$, with shadow price $\eta_i^{lt} = \max\{\gamma - \xi_i - (1-p)(\frac{q_h F_l^-}{q_l f_h} - \frac{F_h^-}{f_h^-}), 0\}$. When $\eta_i^{lt} > 0$, the marginal payoff from lending is $y_i^{lt} = pF_h^+ + (1-p)F_h^- + (\gamma - \xi_i)f_h^-$, and her payoff is

$$V_i^{lt} = y_i^{lt} c'^{-1}(y_i^{lt}) - c(c'^{-1}(y_i^{lt})) - x_{i,l}\Big(p(F_h^+ - F_l^+) + (y_i^{lt} - pF_h^+)\Big(1 - \frac{q_l}{q_h}\Big)\Big). \quad \text{(IA.10)}$$

(iii) If an intermediary issues short-term safe debt, in negative-news stage it optimally repays $\Delta a_i = -\frac{a_i q_h - (x_{i,h}q_h + x_{i,l}q_l)f_h^-}{q_h - f_h^-}$ and trades $\Delta x_{i,h} = \frac{x_{i,h}f_h^- + x_{i,l}q_l - a_i}{q_h - f_h^-}, \Delta x_{i,l} = -x_l$. These actions lead to continuation value $v^{st} = \frac{F_h^- - f_h^-}{q_h - f_h^-}(x_{i,h}q_h + x_{i,l}q_l - a_i)$. At $t = 0$, the manager faces constraints $a_i \leq x_{i,h}q_h + x_{i,l}q_l, (x_{i,h} + x_{i,l}\frac{q_l}{q_h})f_h^- \leq a_i$, with shadow prices $\eta_i^{st} =$

[15] For different intermediary liability types, see below for the corresponding optimal secondary market trades, which are derived from problem (P1').

$\max\{\gamma - \xi_i - (1-p)\frac{F_h^- - f_h^-}{q_h - f_h^-}, 0\}$ and $\varphi_i^{st} = \max\{(1-p)\frac{F_h^- - f_h^-}{q_h - f_h^-} - (\gamma - \xi_i), 0\}$, respectively. When $\eta_i^{st} > 0$, the marginal payoff from lending is $y_i^{st} = pF_h^+ + (1 - p + \gamma - \xi_i)q_h$, and her payoff is

$$V_i^{st} = y_i^{st} c'^{-1}(y_i^{st}) - c(c'^{-1}(y_i^{st})) - x_{i,l}\Big(p(F_h^+ - F_l^+) + (y_i^{st} - pF_h^+)\Big(1 - \frac{q_l}{q_h}\Big)\Big). \quad \text{(IA.11)}$$

The following observations suggest a pecking order among these liability choices. First, $q_h \in (f_h^-, f_h^\star]$ implies $\frac{F_h^- - f_h^-}{q_h - f_h^-} - (\frac{q_h F_l^-}{q_l f_h^-} - \frac{F_h^-}{f_h^-}) = -\frac{q_h(q_h - f_h^\star)}{(q_h - f_h^-)q_l f_h^-} \geq 0$, which further implies $\eta_i^{lt} \geq \eta_i^{st}$. Second, $y_i^{lt} = y_i^e + \eta_i^{lt} f_h$ when $\eta_i^{lt} > 0$, and $y_i^{st} = y_i^{lt} + \eta_i^{st}(q_h - f_h^-)$ when $\eta_i^{st} > 0$, so $y_i^e < y_i^{lt} < y_i^{st}$. Third, manager payoff strictly increases in $y_i$: $\frac{\partial V_i}{\partial y_i} = c'^{-1}(y_i) - x_{i,l}(1 - \frac{q_l}{q_h}) > c'^{-1}(pF_h^+ + (1-p)F_h^-) - x_{i,l} > 0$. Hence others equal, a manager issues short-term safe debt if $\eta_i^{st} > 0$, issues long-term safe debt if $\eta_i^{lt} > \eta_i^{st} = 0$, and issues only equity if $\eta_i^{lt} = 0$.

By monotonicity of $\eta_i^{lt}$ and $\eta_i^{st}$ in $i$, liability choices in equilibrium are characterized by cutoffs. The uniqueness of these cutoffs are guaranteed by secondary market aggregate excess demand's monotonicity. Clearly, $\eta_i^{lt}$ cannot be zero for all $i$, otherwise $\Delta x_{i,l} > 0$ for all $i$ and market does not clear unless $\frac{q_l}{F_l^-} = \frac{q_h}{F_h^-}$, but this equation contradicts $\eta_i^{lt} = 0$. Market-clearing condition (IA.3) indicates that in equilibrium, outsiders only buy loans that have a (weakly) higher expected return. Equilibrium outcomes depend parameter values:

1. $\eta_i^{st} = 0$ for all $i$, and there exists $\lambda^{lt} \in (0,1)$ such that $\eta_i^{lt} > 0$ if and only if $i \in [0, \lambda^{lt}]$. Equilibrium loan prices satisfy $q_h \leq f_h^- + \frac{1}{\gamma}(1-p)(F_h^- - f_h^-)$, $q_l \geq \frac{(1-p)F_l^-}{1-p+\kappa}$, and $\frac{q_l}{q_h} = \frac{(1-p)F_l^-}{(1-p)F_h^- + (\gamma - \xi_{\lambda^{lt}})f_h^-}$. No risky loan is sold to outsiders.
2. There exist $\lambda^{st}, \lambda^{lt}$ such that $0 < \lambda^{st} < \lambda^{lt} < 1$, $\eta_i^{st} > 0$ if and only if $i \in [0, \lambda^{st}]$, and $\eta_i^{lt} > \eta_i^{st} = 0$ if and only if $i \in (\lambda^{st}, \lambda^{lt}]$. Equilibrium loan prices satisfy $q_h = f_h^- + \frac{(1-p)(F_h^- - f_h^-)}{\gamma - \xi_{\lambda^{st}}}$, $q_l = \frac{(1-p)F_l^-}{1-p+\kappa}$, and $\frac{q_l}{q_h} = \frac{(1-p)F_l^-}{(1-p)F_h^- + (\gamma - \xi_{\lambda^{lt}})f_h^-}$. In the secondary market, long-term safe debt-financed intermediaries buy all high-quality loans sold by short-term safe debt-financed and equity-financed intermediaries. Low-quality loans are bought by equity-financed intermediaries and outsiders.

3. $\eta_i^{lt} > 0$ for all $i$, and there exists $\lambda^{st} \in (0,1)$ such that $\eta_i^{st} > 0$ if and only if $i \in [0, \lambda^{st}]$. Equilibrium loan prices satisfy $q_h = f_h^- + \frac{(1-p)(F_h^- - f_h^-)}{\gamma - \xi_{\lambda^{st}}}$, $q_l = \frac{(1-p)F_l^-}{1-p+\kappa}$, and $\frac{q_l}{q_h} > \frac{(1-p)F_l^-}{(1-p)F_h^- + (\gamma - 2\xi) f_h^-}$. In the secondary market, long-term safe debt-financed intermediaries buy all high-quality loans sold by short-term safe debt-financed intermediaries. All low-quality loans are bought by outsiders.

4. $\eta_i^{st} > 0$ for all $i$. Equilibrium loan prices are $q_j = \frac{(1-p)F_j^-}{1-p+\kappa}$, $j = h, l$. In the secondary market, all risky loans are sold to outsiders.

*Case 3*: $q_h \in (f_h^\star, F_h^-]$. In this case, long-term contract is strictly dominated because short-term contract maximizes ex-ante safe debt capacity ($a_i \frac{q_h}{q_l} > a_i$), and $\Delta a_i = -a_i$ is ex-post desirable. Since all safe debt-financed intermediaries will use short-term contract and that $q_h > f_h^\star$ implies $\frac{q_l}{F_l^-} < \frac{q_h}{F_h^-}$, optimal trades $\Delta x_{i,h} = -x_{i,h}$ for all $i \in \mathcal{I}$. If outsiders buy loan $h$, their demand for loan $l$, which has a higher return, will be infinity. This contradicts with market clearing condition (IA.3). So this case cannot exist in equilibrium.

**Proof of Proposition IA.2**. Suppose constraint (OC) is binding for some intermediaries, similar to Lemma 2, the manager's objective in trading problem (P1a) is increasing in $\Delta x_{i,l}$. If $\rho < \frac{q_l}{q_h - q_l}$, the manager's desired trade of loan $l$ given constraint (OC) is $\Delta x_{i,l} = (\frac{q_l}{q_h} - \rho)^{-1}(\hat{x}_{i,h} + \rho x_{i,l} - a_i - a_i^{oc})$. If this desired trade is feasible, the binding budget constraint implies that $\Delta x_{i,h} = -\Delta x_{i,l} \frac{q_l}{q_h}$ and hence $x_{i,h} + \Delta x_{i,h} = (1 - \rho \frac{q_h}{q_l})^{-1}(a_i + a_i^{oc} - \rho(x_{i,h} \frac{q_h}{q_l} + x_{i,l}) - \hat{\epsilon}_i)$. So $x_{i,h} + \Delta x_{i,h} \geq a_i$ holds with probability one if and only if $a_i^{oc} \geq \rho((x_{i,h} - a_i)\frac{q_h}{q_l} + x_{i,l}) + \bar{\epsilon}$. This lower bound of $a_i^{oc}$ ensures that short-sale constraint of loan $h$ is always satisfied: $\Delta x_{i,h} = (1 - \rho \frac{q_h}{q_l})^{-1}(a_i + a_i^{oc} - \hat{x}_{i,h} - \rho x_{i,l}) \geq a_i - x_{i,h} + (1 - \rho \frac{q_h}{q_l})^{-1}(\bar{\epsilon} - \hat{\epsilon}_i) \geq -x_{i,h}$. Moreover, for the desired trade to be feasible, another short-sale constraint $\Delta x_{i,l} \geq -x_{i,l}$ must be also satisfied, which is equivalent to $a_i^{oc} \leq ((x_{i,h} - a_i)\frac{q_h}{q_l} + x_{i,l})\frac{q_l}{q_h} + \hat{\epsilon}_i$. This inequality always holds if and only if $a_i^{oc} \leq ((x_{i,h} - a_i)\frac{q_h}{q_l} + x_{i,l})\frac{q_l}{q_h}$.

Note that this modified contract implements debt safety only if $\rho < \frac{q_l}{q_h}$; if $\rho \geq \frac{q_l}{q_h}$ instead, the manager would be able to substitute all high-quality loans to low-quality loans without violating constraint (OC).

## IA.4 Supplementary Theoretical Analysis

### IA.4.1 Equilibrium with Discrete Manager Types

Consider the simplest case with heterogeneity: managers have two types $\xi_i \in \{\underline{\xi}, \bar{\xi}\}$, where $0 \leq \underline{\xi} < \bar{\xi} < \gamma$. The two types have exogenous population mass $\alpha \in (0,1)$ and $1-\alpha$, respectively. In this case, initial collateral constraints must bind for at least one type. This is because the two types face the same cost (or profit) of portfolio substitution but enjoy different private benefits from safe debt issuance. Market-clearing prices, and hence allocations, depend on fraction $\alpha$. To illustrate the inefficiency in this two-type case, the proposition below focuses on a subset of $\alpha$ values, and the complete analysis can be found in the proof. For notational convenience, I use $(\underline{x}^{CE}, \bar{x}^{CE}, \underline{a}_i^{CE}, \bar{a}_i^{CE})$ and $(\underline{x}^{SP}, \bar{x}^{SP}, \underline{a}_i^{SP}, \bar{a}_i^{SP})$ to denote respectively the competitive and planned allocations for the two types.[16]

**Proposition IA.3.** *Suppose $\xi_i \in \{\underline{\xi}, \bar{\xi}\}$, then $\underline{x}^{CE} = \underline{x}^{SP}$ for any $\alpha \in (0,1)$. When $\alpha \in (\underline{\alpha}^{CE}, \bar{\alpha}^{SP})$ for endogenous cutoffs $0 < \underline{\alpha}^{CE} < \bar{\alpha}^{SP} < 1$, the equilibrium is constrained inefficient. In particular, high-cost managers underinvest, and the market underproduces safe assets: $\bar{x}^{CE} < \bar{x}^{SP}$, $\underline{a}^{CE} < \underline{a}^{SP} = x_{i,h} + x_{i,l}\pi$, $\bar{a}^{CE} = \bar{a}^{SP} = 0$, and $A^{CE} < A^{SP}$.*

When $\alpha$ is in a medium region, the equilibrium price ratio tightens the low-cost type's binding collateral constraints, preventing these managers from issuing socially optimal quantities of safe debt. While the low-cost type's lending is socially efficient, high-cost managers underinvest as they do not fully internalize the social benefits of collateral. Consequently, the market underproduces safe assets because of a deficiency of aggregate collateral.

[16] I include subscript $i$ for choices of $a_i$ because these choices depend on idiosyncratic quality shocks $\tilde{x}_{i,l}$.

The intuition of this underproduction result is the same as that in Proposition 2. Note that in this case, there is no excessive entry into safe asset production because there are only two manager types. If there are three or more types, there can be managers who have mediocre securitization technology and inefficiently choose to issue safe debt in equilibrium.

**Proof of Proposition IA.3.** In both the competitive and planner's allocations, the exogenous fraction $\alpha \in (0,1)$ determines which type(s) faces a binding constraint on the choice of $a_i$. There are three possibilities. For each possibility, allocation results follow respectively from Kuhn-Tucker conditions (4)–(6) and (12)–(14) and the market clearing condition. Figure IA.9 summarizes these results. There are four endogenous cutoffs, $0 < \underline{\alpha}^{SP} < \underline{\alpha}^{CE} < \bar{\alpha}^{SP} < \bar{\alpha}^{CE} < 1$, that divide $(0,1)$ into five mutually exclusive regions. Prices and allocations are different across regions. For convenience, I define $(\underline{x}, \bar{x}) := \Big(c'^{-1}(pR + 1 - p + \gamma - \underline{\xi}), c'^{-1}(pR + 1 - p + \gamma - \bar{\xi})\Big)$.

*Both types bind*: For the competitive market, this implies $\frac{(1-p)\pi}{1-p+\gamma-\underline{\xi}} < \frac{q_l}{q_h} < \frac{(1-p)\pi}{1-p+\gamma-\bar{\xi}}$, $(\underline{x}^{CE}, \bar{x}^{CE}) = \Big(\underline{x}, c'^{-1}(pR + (1-p)\pi\frac{q_h}{q_l})\Big)$, and $(\underline{a}_i^{CE}, \bar{a}_i^{CE}) = (x_{i,h} + x_{i,l}\frac{q_l}{q_h}, 0)$. Secondary market demand and supply for $h$ are $\alpha x_L \frac{q_l}{q_h}$ and $(1-\alpha)(\bar{x} - x_L)$. Market clearing requires $\alpha \in (\underline{\alpha}^{CE}, \bar{\alpha}^{CE})$, where $\underline{\alpha}^{CE} := (\bar{x} - x_L)\Big(\bar{x} - (1 - \frac{(1-p)\pi}{1-p+\gamma-\bar{\xi}}x_L)\Big)^{-1}$ and $\bar{\alpha}^{CE} := (\underline{x} - x_L)\Big(\underline{x} - (1 - \frac{(1-p)\pi}{1-p+\gamma-\underline{\xi}}x_L)\Big)^{-1}$. For the planner, both types facing binding collateral constraints implies $(\underline{x}^{SP}, \bar{x}^{SP}) = \Big(\underline{x}, c'^{-1}(pR + 1 - p + \psi^{SP})\Big)$ and $(\underline{a}_i^{SP}, \bar{a}_i^{SP}) = (x_{i,h} + x_{i,l}\pi, 0)$. Note that $\gamma - \bar{\xi} < \psi^{SP} < \gamma - \underline{\xi}$, so market clearing requires $\alpha \in (\underline{\alpha}^{SP}, \bar{\alpha}^{SP})$, where $\underline{\alpha}^{SP} := (\bar{x} - x_L)(\bar{x} - (1-\pi)x_L)^{-1}$ and $\bar{\alpha}^{SP} := (\underline{x} - x_L)(\underline{x} - (1-\pi)x_L)^{-1}$.

*Type $\underline{\xi}$ slack*: For the competitive market, this implies $\frac{q_l}{q_h} = \frac{(1-p)\pi}{1-p+\gamma-\bar{\xi}}$, $(\underline{x}^{CE}, \bar{x}^{CE}) = (\underline{x}, \bar{x})$, and $\underline{a}_i^{CE} = x_{i,h} + x_{i,l}\frac{q_l}{q_h}, \bar{a}_i^{CE} \in [0, x_{i,h} + x_{i,l}\frac{q_l}{q_h}]$. Secondary market demand and supply for $h$ are $\alpha x_L \frac{q_l}{q_h}$ and $(1-\alpha)(\bar{x} - x_L) - \int_\alpha^1 \bar{a}_i^{CE}\,\mathrm{d}i$. Market clearing requires the demand to be no less than the supply when $\bar{a}_i^{CE} = 0, \forall i \in [\alpha, 1]$, which is equivalent to $\alpha \leq \underline{\alpha}^{CE}$. For the planner, type $\underline{\xi}$ facing slack collateral constraints implies $(\underline{x}^{SP}, \bar{x}^{SP}) = (\underline{x}, \bar{x})$, and $\underline{a}_i^{SP} = x_{i,h} + x_{i,l}\pi, \bar{a}_i^{SP} \in [0, x_{i,h} + x_{i,l}\pi]$. Similarly, market clearing requires $\alpha \leq \underline{\alpha}^{SP}$.

*Type $\bar{\xi}$ slack*: For the competitive market, this implies $\frac{q_l}{q_h} = \frac{(1-p)\pi}{1-p+\gamma-\underline{\xi}}$, $(\underline{x}^{CE}, \bar{x}^{CE}) = (\underline{x}, \underline{x})$, and $\underline{a}_i^{CE} \in [0, x_{i,h} + x_{i,l}\frac{q_l}{q_h}], \bar{a}_i^{CE} = 0$. Secondary market demand and supply for $h$ are $\int_0^\alpha \underline{a}_i^{CE}\,\mathrm{d}i - \alpha(\underline{x} - x_L)$ and $(1-\alpha)(\underline{x} - x_L)$. Market clearing requires the demand to be no less than the supply when $\underline{a}_i^{CE} = x_{i,h} + x_{i,l}\frac{q_l}{q_h}, \forall i \in [\alpha, 1]$, which is equivalent to $\alpha \geq \bar{\alpha}^{CE}$. For the planner, type $\bar{\xi}$ facing slack collateral constraints implies $(\underline{x}^{SP}, \bar{x}^{SP}) = (\underline{x}, \underline{x})$, and $\underline{a}_i^{SP} \in [0, x_{i,h} + x_{i,l}\pi], \bar{a}_i^{SP} = 0$. Similarly, market clearing requires $\alpha \geq \bar{\alpha}^{SP}$.

Clearly, $\underline{x}^{CE} = \underline{x}^{SP} = \underline{x}$ for any $\alpha$. When $\alpha \leq \underline{\alpha}^{SP}$ or $\alpha \geq \bar{\alpha}^{CE}$, lending choices are identical in the competitive and planner's allocations, so $A^{CE} = A^{SP}$ by Equation (7).[17] The result that $\bar{x}^{CE} < \bar{x}^{SP}$ and $A^{CE} < A^{SP}$ when $\alpha \in (\underline{\alpha}^{SP}, \underline{\alpha}^{CE})$ follows from the following observations. When $\underline{\alpha}^{SP} < \alpha \leq \underline{\alpha}^{CE}$, $\psi^{SP} > \gamma - \bar{\xi}$ implies $\bar{x}^{CE} < \bar{x}^{SP}$; When $\underline{\alpha}^{CE} < \alpha \leq \bar{\alpha}^{SP}$, $\underline{a}_i^{CE} < \underline{a}_i^{SP}$ and $\bar{a}_i^{CE} = \bar{a}_i^{SP}$; When $\bar{\alpha}^{SP} < \alpha \leq \bar{\alpha}^{SP}$, $(1-p)\pi\frac{q_h}{q_l} < 1 - p + \gamma - \underline{\xi}$ implies $\bar{x}^{CE} < \bar{x}^{SP}$. This completes the proof.

### IA.4.2 Ideal Policy Intervention

Section 4 of the paper shows that the equilibrium's inefficiency is reflected on both sides of the intermediary balance sheet and that policies correcting the over-entry into safe debt issuance exacerbates the underproduction of safe assets. Similarly, a policy forcing equity-financed intermediaries to invest at the socially optimal level can also worsen the equilibrium. This is because lending beyond individually optimal levels reduces the managers' payoff, and they will issue safe debt to escape the scope of this policy.

To move the equilibrium towards constrained efficiency, an ideal policy should correct both sides of intermediary balance sheets. Specifically, the policymaker should both reduce entry into safe asset production and increase equity-financed intermediaries' lending.

If the policymaker's information set includes all model parameters, the implementation of

[17] The intuition for this result is similar to that of Lemma 3: when constraints are slack for both individual managers and the planner, the pecuniary externality does not affect the efficiency of allocation.

an entry policy is straightforward. It can be carried out as, for instance, a lump sum tax on any intermediary that issues safe debt, or a targeted quantity of tradable permits for safe debt issuance. In contrast, subsidizing lending could raise concerns over actions not explicitly considered in the model. For instance, a subsidy based on the quantity of lending might have a perverse effect if it incentivizes asset managers to lower screening standard and originate large quantities of low-quality loans.[18]

# IA.5 Supplementary Empirical Analysis

## IA.5.1 Capital Structure and Portfolio Quality

In my model, asset managers' financing choices lead to a positive cross-sectional relationship between an intermediary's capital structure and the quality of its loan portfolio. It is trivial that loans of better quality secure more debt; However, as CLO managers optimally exhaust safe debt capacity, the model predicts a strong positive correlation between portfolio quality and safe debt outstanding. This endogenous relationship arises from optimal joint choices of portfolio and safe debt financing, which are commonly driven by unobserved securitization costs. I estimate this relationship in the cross section of CLOs by estimating panel regression

$$Quality_{it} = \beta AAA\%_i + \Gamma' Control_{it} + \delta_t + \epsilon_{it}, \tag{IA.12}$$

where the dependent variable is collateral quality measured using either portfolio value-weighted average loan rating or coupon rate. The variable of interest, $AAA\%_i$, is a CLO's AAA-rated tranche size as a fraction of total size of the deal. All specifications include year-quarter fixed effects $\delta_t$, thereby estimating $\beta$ using only cross-sectional variation. This accounts for the impact of time-varying market conditions on overall leveraged loan quality.

[18] See the Financial Stability Board report (Financial Stability Board, 2019) for potential concerns about the vulnerabilities associated with leveraged loans and CLOs.

Panel B of Table IA.3 presents summary statistics, and Table IA.4 reports the estimation results. Across specifications, the point estimates $\hat{\beta}$ are both statistically and economically significant. Column (1) indicates that a CLO with a 10% larger AAA tranche on average holds a loan portfolio with 0.17 notch higher credit rating. Controlling for CLO size and age, as in column (2), the estimate becomes moderately larger. In column (3), I also include CLO cohort fixed effects that absorb any persistent balance sheet heterogeneity induced by different timings of CLO issuance.[19] The point estimate remains similar, suggesting that the result is not driven by unobserved shocks during the quarter of CLO issuance.

Columns (4)–(6) replace the dependent variable with portfolio value-weighted average coupon rate, which measures loan quality based on market risk pricing rather than rating agencies' models. Since leveraged loan coupons are quarterly updated based on a floating benchmark rate (typically 3-month LIBOR), in the cross section, a higher coupon implies a riskier portfolio. For both measures, an interquartile variation in $AAA\%$ is associated with roughly 0.5 standard deviation higher collateral quality, suggesting a strong positive relationship between portfolio quality and safe debt outstanding.[20]

### IA.5.2 Estimating the Effect of Risk Retention

The Credit Risk Retention Rule's inclusion of CLOs received considerable resistance from practitioners. Panel (a) of Figure IA.8 shows that the LSTA more than doubled its lobbying spending in 2014, the year when the rule was finalized. Panel (b) presents the results of LSTA's 2013 survey on CLO managers' expectation of the rule's impact on their business, which appears devastating. This subsection investigates the policy's realized impact.

Identifying and estimating the US Credit Risk Retention Rule's effect on CLO entry is challenging. First, the policy was imposed on the entirety of CLOs issued during its effective

[19]CLO age is absorbed by the two groups of fixed effects in columns (3) and (6).
[20]After partialling out time fixed effects, the standard deviation of coupon rate is 0.48%.

period, making it difficult to find a control group. Second, the policy was introduced soon after the crisis and then revoked shortly, leaving us with very limited time-series variations for statistical inference. As an attempt to quantify the effect, I exploit the fact that virtually the same policy was imposed on the European CLO market before the US market and estimate panel regression

$$Entry_{imt} = \beta_0 + \beta_1 USmkt_{im} \times CRR_t + \beta_2 USmkt_{im} + \beta_3 CRR_t + \Gamma' Control_{m,t-1} + \epsilon_{imt}, \quad \text{(IA.13)}$$

where every observation is a manager–market–year during 2013—2019. $USmkt_{im}$ is an indicator variable that equals one (zero) for any manager $i$ if market $m$ is US (Europe). $CRR_t$ is an indicator variable that equals one for 2015–2017, during which the Credit Risk Retention Rule affects the US market. I control for lagged growth rates of government debt and total bank deposits in either market as proxies for the supply of major safe assets. The identification of parameter $\beta_1$ is based on an assumption that the entry rate in the US market would have evolved similarly as in the European market in the absence of the policy.

Panel B of Table IA.3 presents summary statistics for this sample, and Table IA.5 reports the estimation results. Columns (1) and (4) indicate that the policy reduces the number and size of CLO entry by 0.3 and \$130 million, respectively. In column (2), the magnitude is similar for entry count after controlling for safe asset supply, and the magnitude becomes greater for the size of entry in column (5). In columns (3) and (6), I further include interaction terms with an indicator variable that equals one if the asset manager's CLO AUM in year 2014 is above median. The triple-interacted term's coefficient is statistically indistinguishable from zero, suggesting that the absolute effect of regulation has similar magnitudes on smaller and larger managers. As smaller managers' pre-treatment levels of outcome variables are substantially smaller larger managers', this indicates a greater relative impact on smaller managers' business. Overall, the regulation causes an economically large reduction in CLO entry: the magnitudes are roughly 40% of unconditional averages.

# References


Diamond, D. W. and P. H. Dybvig (1983). Bank runs, deposit insurance, and liquidity. *Journal of political economy 91*(3), 401–419.

Financial Stability Board (2019). Vulnerabilities associated with leveraged loans and collateralised loan obligations. Technical report.

Foley-Fisher, N., G. B. Gorton, and S. Verani (2020). Adverse selection dynamics in privately-produced safe debt markets. Technical report, National Bureau of Economic Research.

Hanson, S. G., A. Shleifer, J. C. Stein, and R. W. Vishny (2015). Banks as patient fixed-income investors. *Journal of Financial Economics 117*(3), 449–469.

Stein, J. C. (2012). Monetary policy as financial stability regulation. *The Quarterly Journal of Economics 127*(1), 57–95.

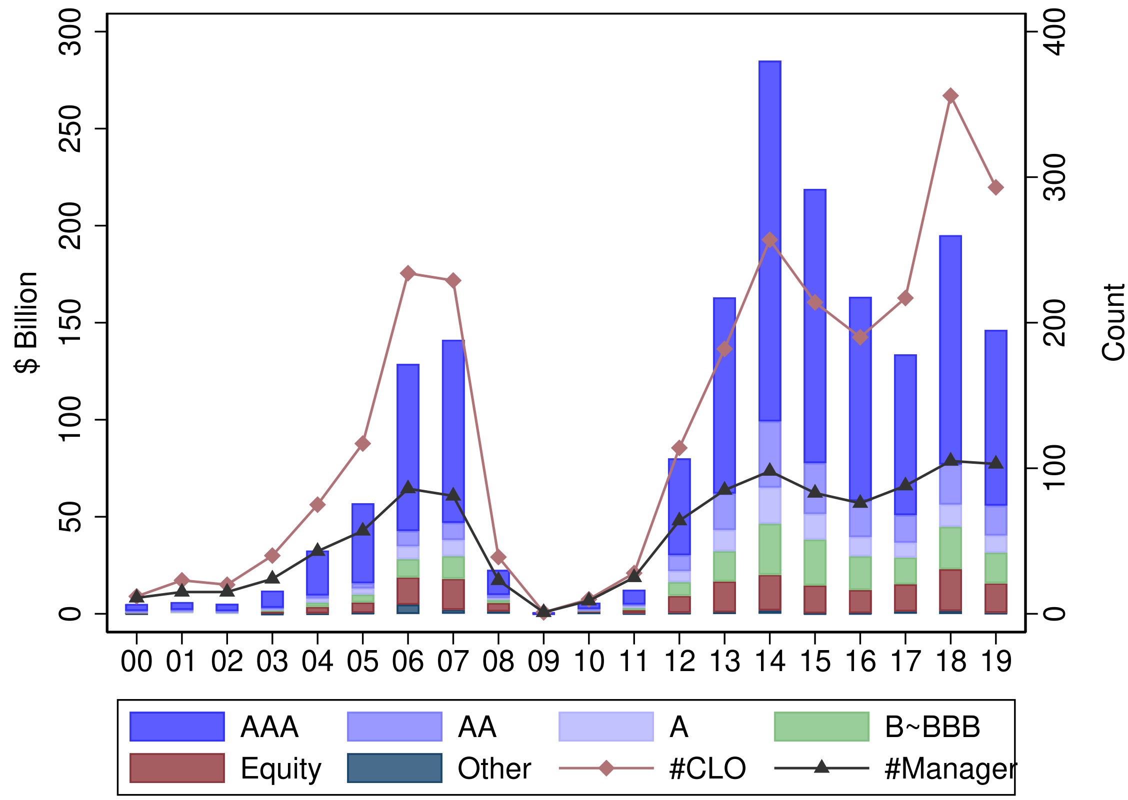



Figure IA.1: **Annual CLO issuance, 2000–2019.**
This Figure plots annual issuance amount and the numbers of deals and asset managers of open-market CLOs issued in the US and Europe. The issuance amount is decomposed by CLO liability tranches based on initial credit ratings, and tranche size denominated in Euros are converted to USD using exchange rate at issuance date. "Others" include mixed tranches and other non-rated tranches. Data come from Creditflux CLO-i databse.

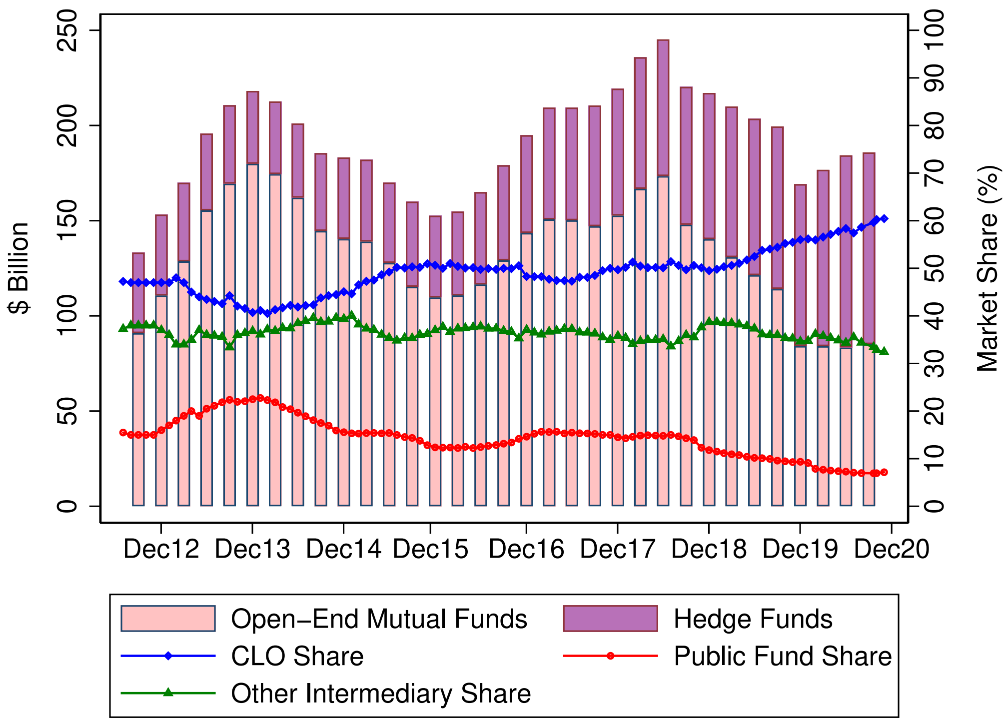
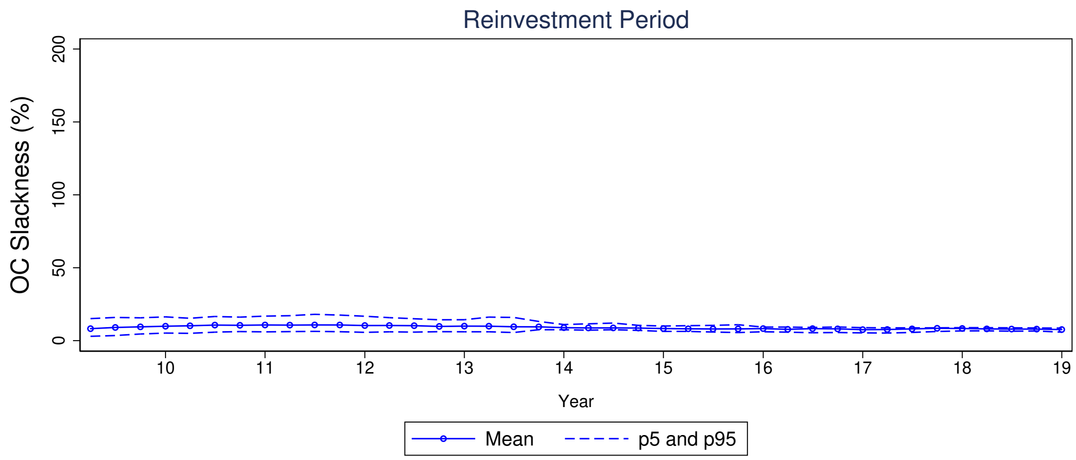
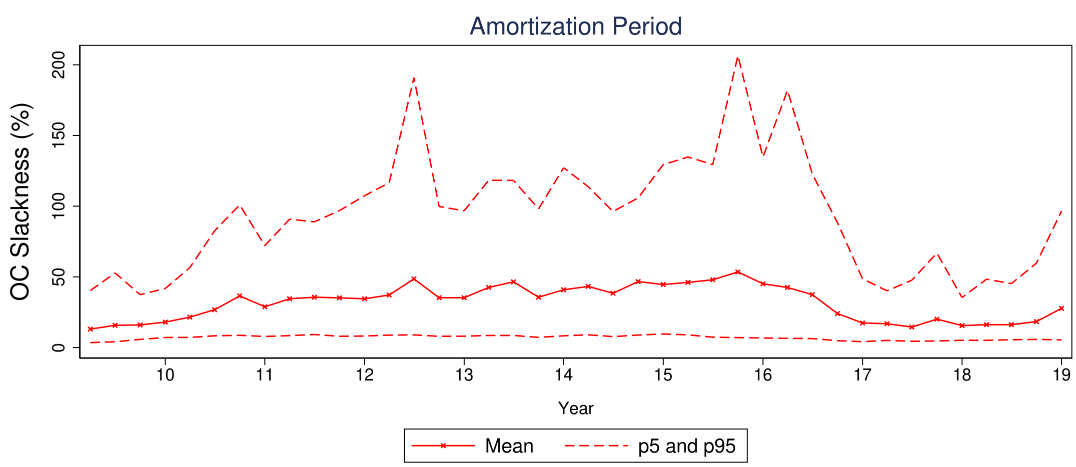



Figure IA.2: **Intermediaries in the leveraged loan market, 2012–2020.**
This Figure provides more detailed information on the composition of intermediaries in the leveraged loan market. The stacked bars plot total values of leveraged loans held by open-end mutual funds and hedge funds (left axis). The connected lines show market shares of leveraged loans outstanding (right axis), decomposed into collateralized loan obligations, public funds (open-end and close-end mutual funds and ETFs), and other intermediaries. Data come from Financial Accounts of the United States and Refinitiv LPC.

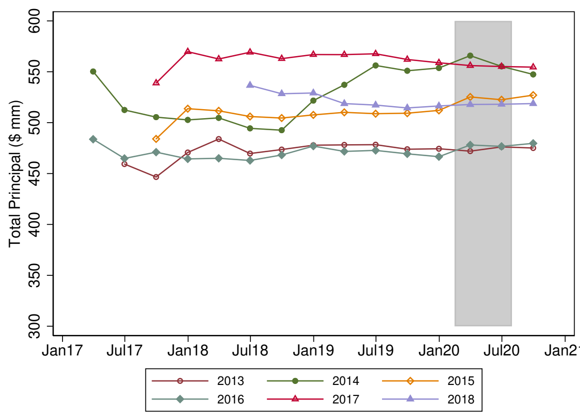



(a) CLOs in Reinvestment Period

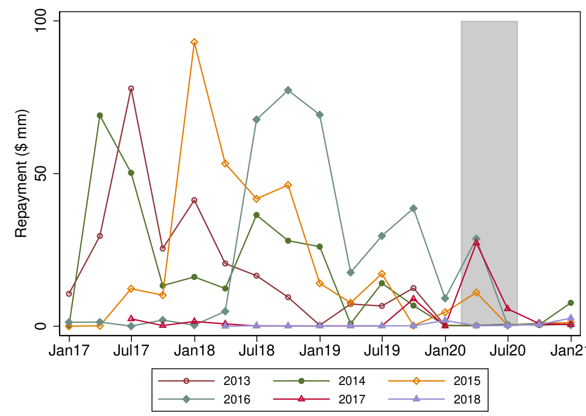



(b) CLOs in Amortization Period

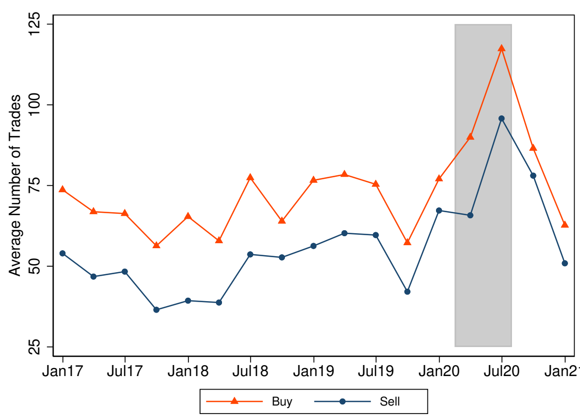
Figure IA.3: **Slackness of senior tranche over-collateralization constraint.**
This Figure presents quarterly time series of cross-sectional dispersion in the slackness of CLO senior tranche over-collateralization (OC) constraints between 2010–2019. The slackness is defined as extra OC score scaled 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.



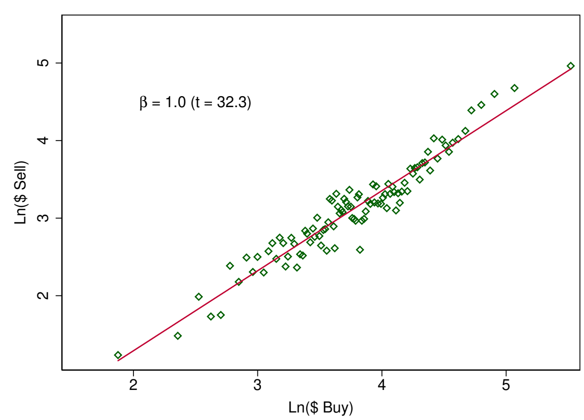

(a) Portfolio Total Loan Holdings




(b) Accelerated Debt Repayment

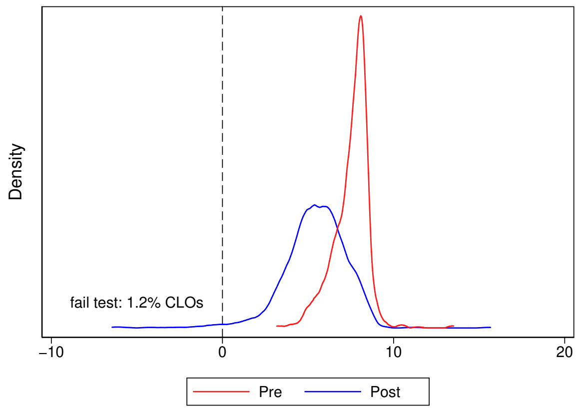



(c) Quarterly Loan Trades

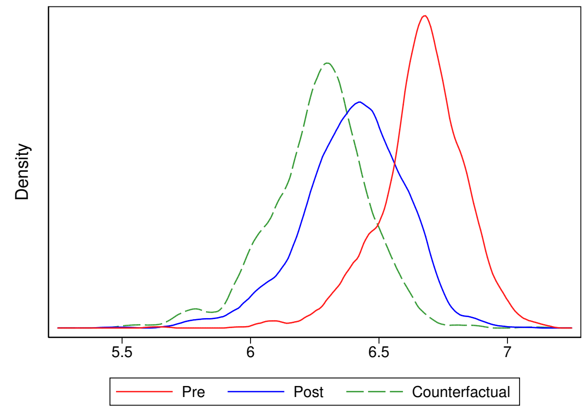



(d) Individual CLOs' Purchases and Sales

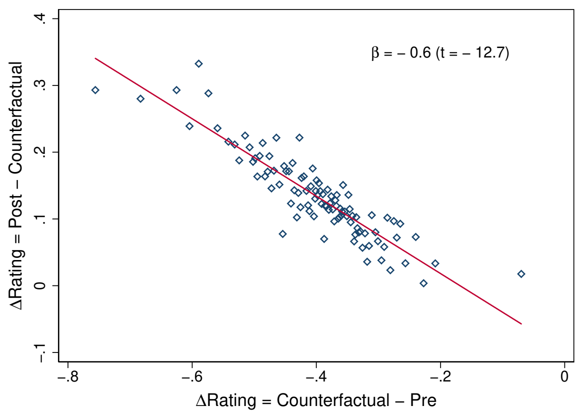
Figure IA.4: **Balance sheet dynamics around the onset of COVID-19 pandemic.** This Figure shows quarterly changes in CLOs' assets and liabilities before and during the COVID-19 shock in 2020. Panel (a) plots average CLO total loan holdings by issuance year cohort. Panel (b) plots average CLO accelerated principal repayment of AAA tranches by issuance year cohort. Panel (c) plots average numbers of loan purchases and sales during a quarter. Panel (d) is a scatter plot that groups CLOs into 100 bins based on natural logarithms of individual CLOs' loan buy and sell dollar volumes during the first two quarters of 2020. Only CLOs in reinvestment period are included.



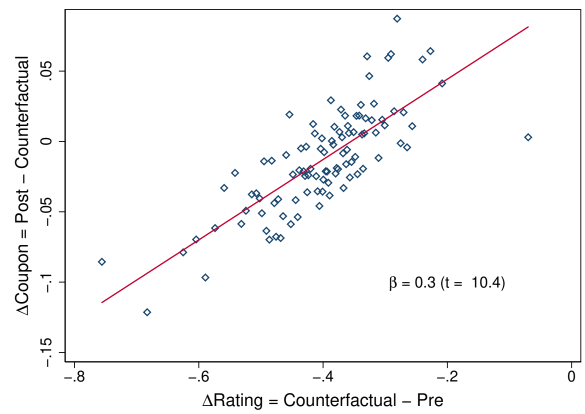

(a) Slackness of OC Constraint (%)



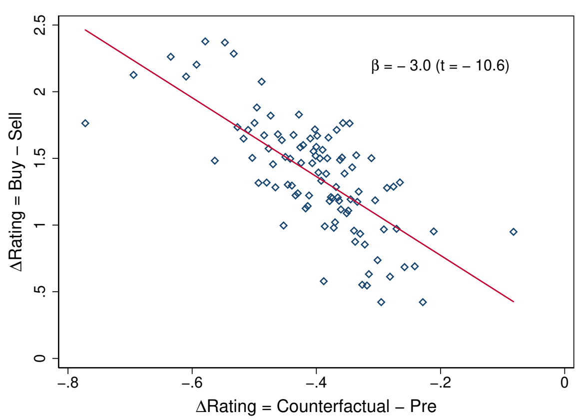

(b) Portfolio Value-Weighted Average Rating



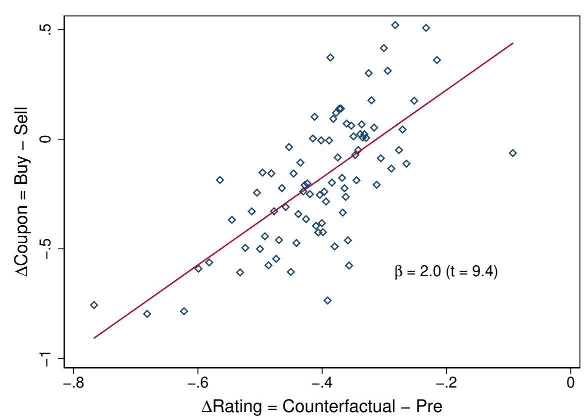

(c) Quality Improvement: Rating




(d) Quality Improvement: Coupon

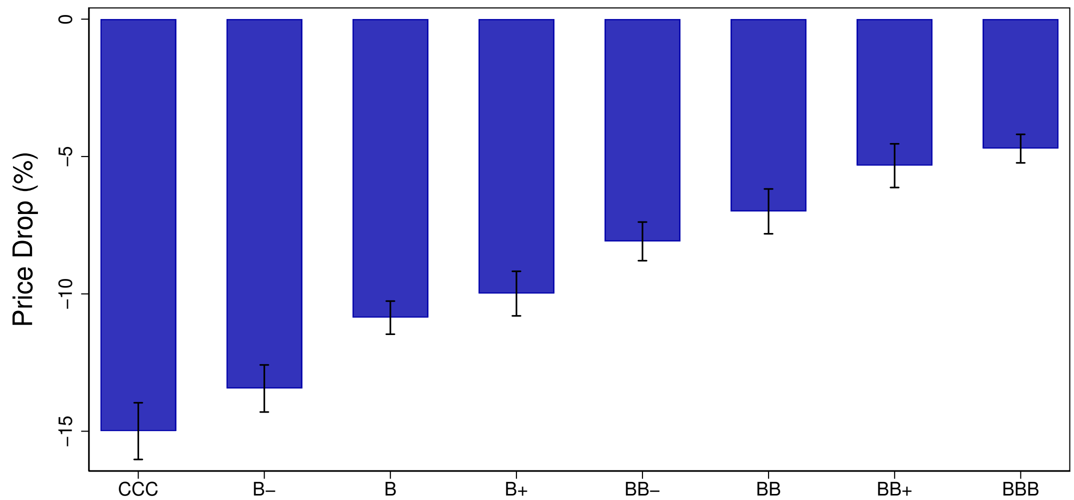



(e) Trading Direction: Rating

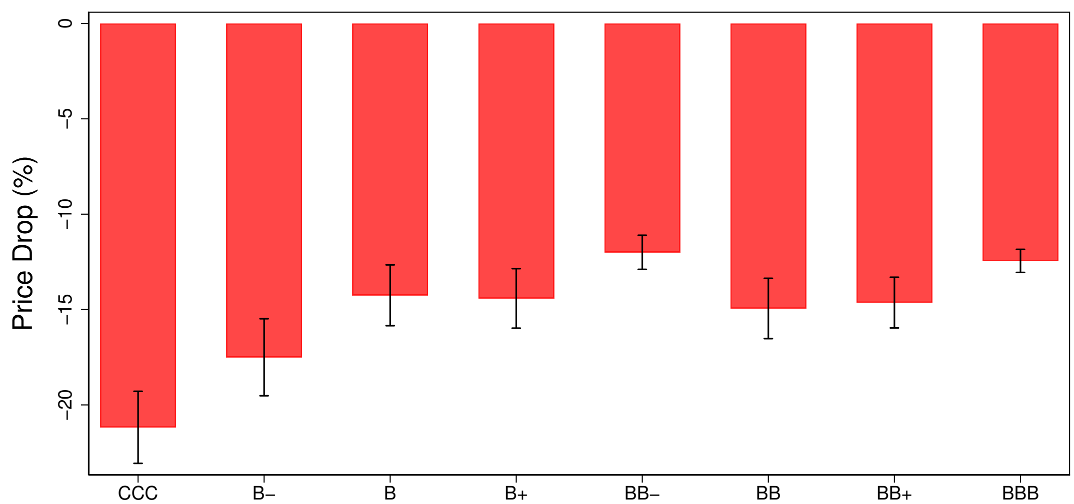



(f) Trading Direction: Coupon

Figure IA.5: **Portfolio substitution improves collateral quality.**
This Figure shows the effect of portfolio substitution on CLOs' collateral quality between February 15 and June 30 of 2020. Panel (a) plots kernel density estimates for the distribution of senior OC constraint slackness before and after the onset of COVID-19 pandemic. Panel (b) plots kernel density estimates for the distribution of value-weighted average credit rating for portfolios before and after the shock as well as counterfactual static portfolios. Panels (c)-(f) are scatter plots that group CLOs into 100 bins by counterfactual collateral deterioration and depict the average effect of loan trading within each bin. The fitted lines represent OLS estimates, and t-statistics are based on heteroskedasticity-robust standard errors. Only CLOs in reinvestment period (87%) are included.




(a) Leveraged Loans




(b) High-Yield Bonds

Figure IA.6: **Secondary market price drops during 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 loans 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.

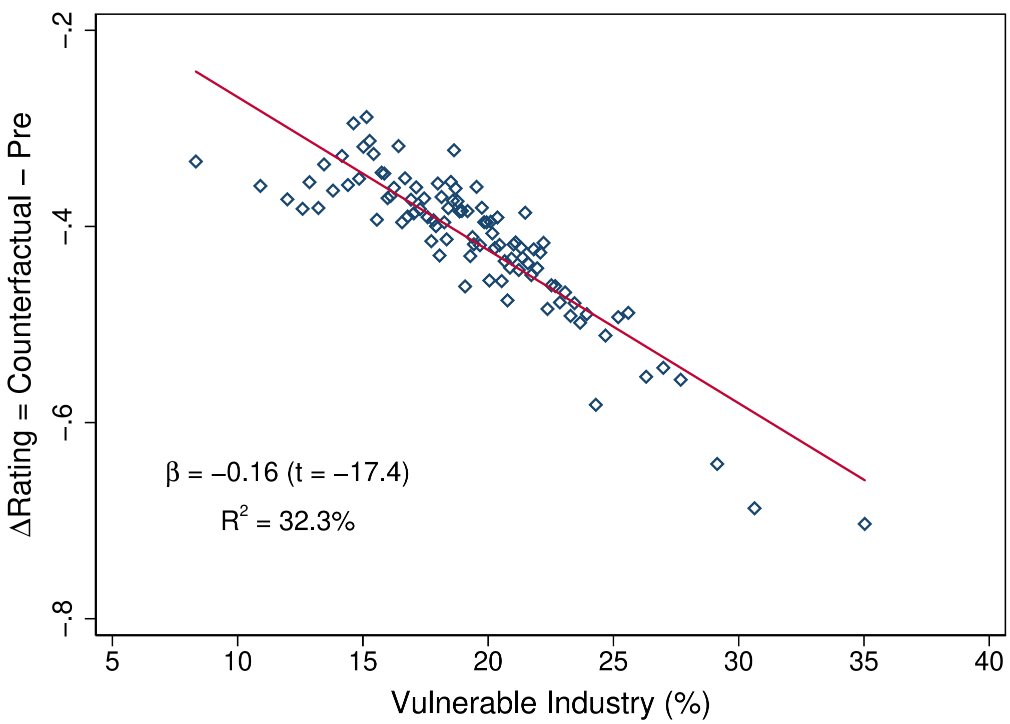
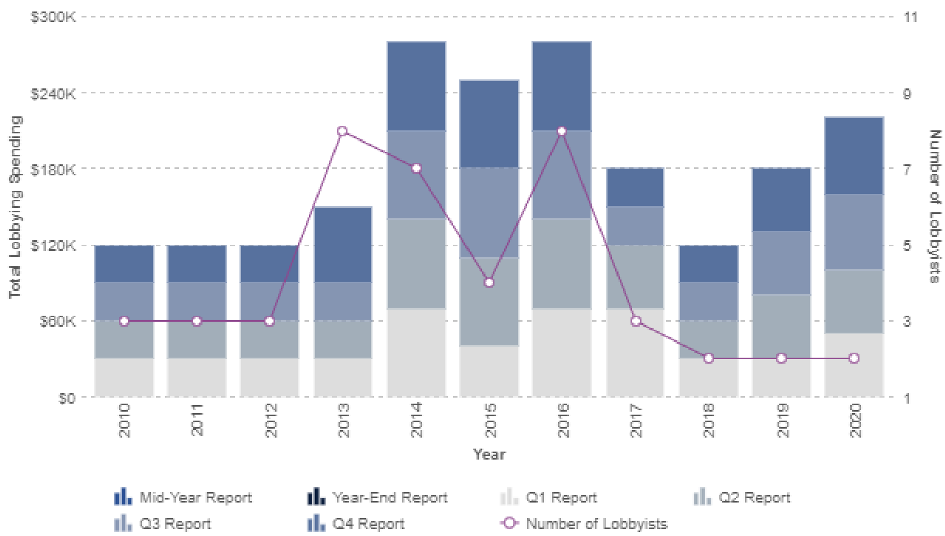
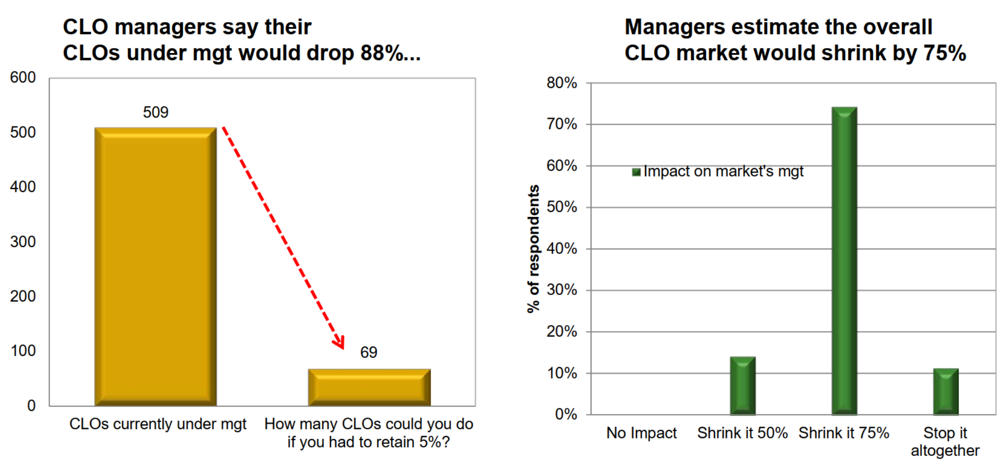



Figure IA.7: **Vulnerable industry exposure and counterfactual collateral quality deterioration.**
This Figure is a scatter plot that groups CLOs into 100 bins by portfolio weight in industries vulnerable to the COVID-19 pandemic before February 15, 2020 and depict the average counterfactual portfolio value-weighted average credit rating change between February 15 and June 30, 2020 within each bin. The definition of vulnerable industries follows Foley-Fisher, Gorton, and Verani (2020): Automotive, Consumer goods: Durable, Energy: Oil & Gas, Hotel, Gaming & Leisure, Retail, Transportation: Cargo, and Transportation: Consumer.




(a) LSTA Lobbying by Year




(b) Asset Manager Survey, 2013

Figure IA.8: **Industry response to CLO Risk Retention.**
Panel IA.8a of this Figure shows the Loan Syndication and Trading Association's (LSTA) annual lobbying spending (Source: Center for Responsive Politics). Panel IA.8b shows the result of LSTA 2013 survey on asset managers' expected impact of US CLO Credit Risk Retention on the market.

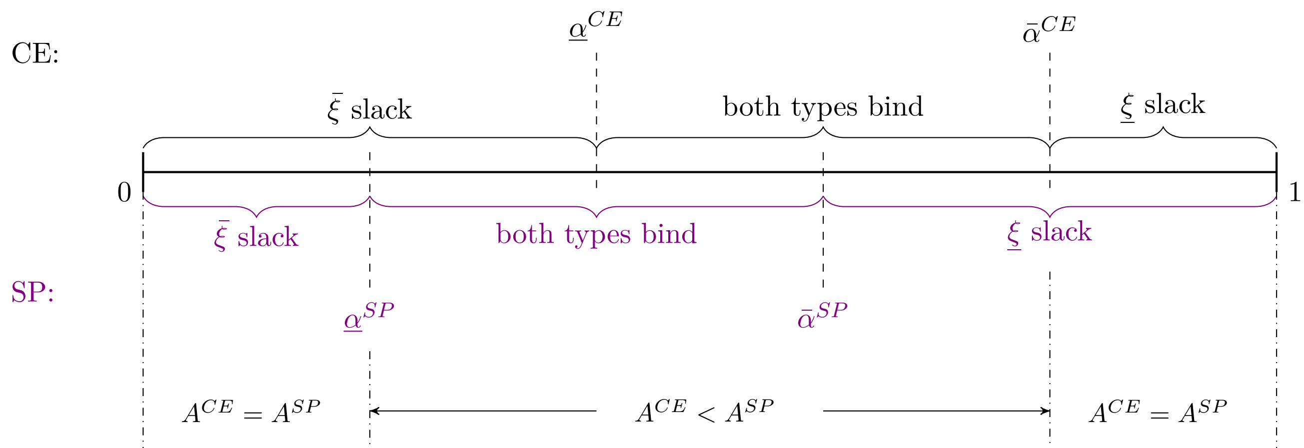



Figure IA.9: **Two-type case: competitive and planner's allocations.**
This figure illustrates how the competitive and planned allocations in the two-type case depend on $\alpha \in (0, 1)$, the fraction of low-cost manager type.

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 |

Table IA.3: **Summary Statistics**

Panel A of this table presents summary statistics of the quarterly panel dataset for 2010–2019, where every observation is a US CLO's most recent information reported by the end of a quarter. The size of a CLO is measured with the total par value of loan holdings (in USD million). *AAA%* is a CLO's most senior debt tranche size divided by total liabilities as observed at its issuance. *Rating* and *Coupon* are par value-weighted averages of a CLO's portfolio loan holdings' current credit ratings and coupon rates (i.e., the sum of a floating benchmark rate and a fixed spread). Panel B presents summary statistics for an annual panel dataset that includes CLOs in both the US and European markets, where every observation is an asset manager–market–year between 2013–2019. *GovDebtGrwoth* and *DepositGrowth* are respectively the growth rates of total government debt and bank deposits in either market. Details on sample construction and the conversion of letter ratings are provided in Appendix IA.1.

| | mean | sd | min | p10 | p25 | p50 | p75 | p90 | max |
|---|---|---|---|---|---|---|---|---|---|
| **Panel A: CLO–quarter panel, 2010-2019** | | | | | | | | | |
| Observations: 13,825 | | | | | | | | | |
| Size ($mm) | 435.4 | 194.2 | 50.1 | 213.4 | 334.1 | 417.7 | 508.3 | 623.8 | 3,067.4 |
| Loans (count) | 222.3 | 103.2 | 51 | 94 | 147 | 217 | 282 | 344 | 815 |
| Age (year) | 4.23 | 2.56 | 0.00 | 0.75 | 2.00 | 4.00 | 6.25 | 8.00 | 15.50 |
| AAA% | 0.68 | 0.07 | 0.44 | 0.61 | 0.64 | 0.67 | 0.74 | 0.76 | 0.83 |
| Rating | 6.77 | 0.38 | 2.51 | 6.37 | 6.61 | 6.79 | 6.97 | 7.17 | 8.39 |
| Coupon (%) | 4.91 | 0.84 | 0.04 | 3.80 | 4.23 | 4.92 | 5.60 | 5.92 | 8.91 |
| **Panel B: asset manager–market–year panel, 2013–2019** | | | | | | | | | |
| Observations: 2,044 | | | | | | | | | |
| Entry (count) | 0.75 | 1.3 | 0 | 0 | 0 | 0 | 1 | 3 | 9 |
| Entry ($ mm) | 586.7 | 1146.8 | 0.0 | 0.0 | 0.0 | 0.0 | 787.3 | 2,006.1 | 9,544.8 |
| GovDebtGrowth (%) | 3.9 | 2.0 | 1.4 | 1.9 | 2.1 | 3.6 | 5.6 | 7.2 | 8.0 |
| DepositGrowth (%) | 5.1 | 2.5 | 1.2 | 3.0 | 3.7 | 4.1 | 6.2 | 8.5 | 11.1 |

Table IA.4: **Safe Debt Financing and Portfolio Quality**

This table reports results from estimating panel regression

$$Quality_{it} = \beta AAA\%_i + \Gamma' Control_{it} + \delta_t + \epsilon_{it},$$

where every observation is a CLO-quarter pair measured based on the last portfolio snapshot available by the end of a quarter during 2010-2019. The dependent variable is a collateral quality measure. Regressor $AAA\%_i$ is original size of CLO $i$'s AAA-rated debt tranche size divided by total size of the deal. In columns (1)–(3), collateral quality is measured with portfolio value-weighted average loan rating. The measure in columns (4)-(6) is value-weighted average loan interest rate (the sum of a fixed spread and a floating benchmark rate). Control variables, including natural logarithm of total par value of loan holdings and CLO age (in year), are measured at the date when portfolios are reported. Standard errors are clustered at the CLO deal level, and the t-statistics are reported in parentheses. *, **, *** represent 10%, 5%, and 1% levels of statistical significance.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Dep. Var. | | *Rating* | | | *Coupon* | |
| *AAA%* | 1.68*** | 1.88*** | 1.76*** | −2.94*** | −2.25*** | −2.25*** |
| | (6.39) | (6.66) | (6.43) | (-8.06) | (-6.21) | (-6.10) |
| ln(Size) | | 0.07** | 0.06** | | 0.14*** | 0.01 |
| | | (2.62) | (2.85) | | (2.37) | (0.28) |
| Age | | -0.01 | | | −0.03*** | |
| | | (-1.25) | | | (-4.74) | |
| Year-Quarter FEs | Y | Y | Y | Y | Y | Y |
| CLO Cohort FEs | N | N | Y | N | N | Y |
| Observations | 13,825 | 13,825 | 13,823 | 13,825 | 13,825 | 13,823 |
| R-squared | 0.11 | 0.12 | 0.17 | 0.70 | 0.71 | 0.74 |

Table IA.5: **Credit Risk Retention and CLO Entry**

This table reports results from estimating panel regression

$$Entry_{imt} = \beta_0 + \beta_1 USmkt_{im} \times CRR_t + \beta_2 USmkt_{im} + \beta_3 CRR_t + \Gamma' Control_{m,t-1} + \epsilon_{imt},$$

where every observation is an asset manager–market–year between 2013–2019. $USmkt_{im}$ is an indicator variable that equals one (zero) if market $m$ is the US (Europe). $CRR_t$ is an indicator variable that equals one for years that Credit Risk Retention Rule affects the US market. Control variables are lagged growth rates of total government debt and total deposit in market $m$. The dependent variable in columns (1)–(3) is manager $i$'s number of CLO issuance in market $m$ and year $t$. In columns (4)–(6), the dependent variable is the total size (in $ million) of manager $i$'s CLO issuance in market $m$ and year $t$. In columns (3) and (6), $LargeMgr$ is an indicator variable that equals one if the manager's total size of CLOs measured in year 2014 is above median. Standard errors are clustered at the manager-by-market level, and the t-statistics are reported in parentheses. *, **, *** represent 10%, 5%, and 1% levels of statistical significance.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Dep. Var. | Entry Count | | | Entry Size ($ mm) | | |
| USmkt×CRR | −0.28*** | −0.31*** | −0.23*** | −130.58*** | −218.29*** | −184.19*** |
| | (-5.01) | (-4.42) | (-3.53) | (-2.58) | (-3.28) | (-3.84) |
| USmkt×CRR×LargeMgr | | | -0.16 | | | -68.20 |
| | | | (-1.40) | | | (-0.68) |
| USmkt | 1.07*** | 1.37*** | 0.77*** | 829.96*** | 952.91*** | 414.14*** |
| | (8.32) | (8.54) | (6.70) | (7.55) | (7.30) | (5.73) |
| CRR | −0.06*** | -0.03 | -0.01 | -14.27 | -2.25 | 3.10 |
| | (-2.61) | (-1.56) | (-0.29) | (-1.16) | (-0.18) | (0.26) |
| LargeMgr | | | 0.49*** | | | 353.61*** |
| | | | (5.40) | | | (4.83) |
| USmkt×LargeMgr | | | 1.19*** | | | 1,077.55*** |
| | | | (5.63) | | | (6.00) |
| CRR×LargeMgr | | | -0.06 | | | -18.11 |
| | | | (-1.28) | | | (-0.52) |
| Controls | N | Y | Y | N | Y | Y |
| Observations | 2,044 | 2,044 | 2,044 | 2,044 | 2,044 | 2,044 |
| R-squared | 0.14 | 0.15 | 0.35 | 0.12 | 0.12 | 0.32 |