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

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Abstract

Collateralized loan obligations (CLOs) create AAA-rated securities backed by dynamic portfolios of leveraged loans and maintain collateral quality by trading with other intermediaries. To understand safe asset production by CLOs, I study an equilibrium model in which intermediaries flexibly choose liabilities and can commit to future loan trades. Secondary market trading increases the supply of safe assets beyond static securitization but generates a pecuniary externality that is not internalized in private lending and financing decisions. As a result, there is excessive entry into operating CLOs, and the market underproduces safe assets overall. The model sheds light on recent regulatory changes.

JEL classifications: G11, G23, G28

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Introduction

Recent literature provides evidence that safe assets, namely debt instruments with very low probabilities of default, are priced at a premium (Krishnamurthy and Vissing-Jorgensen, 2012; Nagel, 2016; Van Binsbergen, Diamond, and Grotteria, 2021). The existence of this premium incentivizes the private sector to repackage risky loans into securities, with the intention of creating safe senior tranches (Gorton and Metrick, 2013; Gorton, 2017). Securitization, which started with mortgage loans in the 1970s, gradually extended to other asset classes. In the late 1990s, collateralized loan obligations (CLOs) were introduced to create AAA-rated securities backed by speculative-grade corporate loans ("leveraged loans"). Since 2008, CLOs have financed more than $2 trillion of leveraged loans, and the regulation of CLOs has led to lawsuits against regulators that resulted in policy changes.

The key innovation of CLOs is that the underlying loans are actively managed, which allows for a larger safe senior tranche given the same initial collateral. With a dynamic portfolio, the manager can sell loans whose quality deteriorates and buy less risky loans to maintain collateral quality. These trades prevent the portfolio's subsequent cash flows from being too low, which protects the senior tranche *ex post* and provides greater safe debt capacity *ex ante*, so that the CLO can raise cheaper funding to finance risky lending.

The leveraged loan market meets two necessary conditions for the use of dynamic trading to increase safe debt capacity. First, CLO managers can credibly commit to their promised trades[1], and second, enough counterparties are willing and able to trade with CLOs. Unlike other private debt, the vast majority of leveraged loans are individually rated by third parties, and long-term contracts enforced based on the ratings allow managers to commit to future portfolio choices. The market also has a unique market structure whereby two distinct groups of intermediaries coexist. In addition to the CLOs, other intermediaries, including mutual

[1] Otherwise, the risk-shifting incentives of a leveraged intermediary may lead to even less safe debt capacity than allowed by static collateral.

funds and hedge funds, do not use their loan holdings as collateral to create safe securities and serve as natural secondary market counterparties.

This paper provides the first theoretical analysis of safe asset production by CLOs. Specifically, I develop an equilibrium model of the leveraged loan market to study the supply of safe assets and the dynamic trading of underlying loans. The model's main insight is that when managers can promise to maintain collateral quality in downturns, intermediaries with two distinct types of liabilities endogenously coexist, and the market produces more safe assets beyond static securitization. I then show, however, that the competitive equilibrium may not be socially optimal and that a recent policy can exacerbate the inefficiency.

I consider a three-period model in which investors get utility from holding safe assets. The challenge faced by intermediaries trying to issue more safe debt is that risky loans are scarce (due to diminishing returns) and may deteriorate after origination (due to aggregate shocks). Deteriorated loans have a positive probability of paying off poorly, but which loans will deteriorate is unknown ex ante. In bad times, a mismatch between assets and liabilities arises: Good loans are more useful as collateral, but they may be held by intermediaries with no safe debt outstanding. Hence the secondary market allows intermediaries with different liabilities to trade and facilitates a contingent reallocation of risky loans. In equilibrium, intermediaries' ex-ante lending and financing choices affect their ex-post trades, which feed back to the balance sheet choices through loan prices.

My analytical framework rationalizes the observed market structure as a stable equilibrium outcome. It is natural to ask why intermediaries investing in the same market have distinct liabilities, and particularly, why a subset of them persistently choose not to issue any safe debt. I show that these financing choices are endogenously driven by loan prices. Given a positive safety premium, every intermediary could profitably issue extra safe debt by promising to replace deteriorated loans. Unless trading in the opposite direction is sufficiently profitable, the secondary market demand for collateral will overwhelm the supply. So to clear the market, the price of bad loans decreases relative to the price of good loans until enough intermediaries want to provide collateral to others and give up issuing safe debt. Therefore, in equilibrium two groups of intermediaries with distinct liabilities, like CLOs and mutual funds, coexist and trade as counterparties in the secondary market.

The benefits of this market structure arise from specialization. A key observation from my model is that the total supply of safe assets cannot exceed the worst-possible aggregate payoff of all risky loans. Given that there is only aggregate uncertainty, reallocating loans before their payoffs realize improves welfare only if intermediaries are heterogeneous in securitization technology. Anticipating profitable trades, collateral providers, who lack superior technology to securitize loans, lend more than in static securitization, and their lending is more productive at the margin; Meanwhile, the increased collateral allows safe debt issuers, who face lower costs of securitization, to produce a greater supply of safe assets.

Despite the benefits, I show that this market structure suffers from an inherent inefficiency precisely when secondary market trading improves welfare. The source of inefficiency is a pecuniary externality: intermediaries ignore the equilibrium effects of their lending and financing choices on loan prices, which tighten safe debt issuers' binding collateral constraints. On the asset side, collateral providers underinvest because the private profits of selling good loans are lower than the social benefits of collateral. On the liability side, issuing safe debt is privately optimal for intermediaries with mediocre securitization technology, but doing so is socially inefficient as it reduces collateral available to others. These two forces jointly depress the marginal rate of collateral substitution commonly faced by all safe debt issuers. As a result, the equilibrium has too large a fraction of intermediaries issuing safe debt, but they underproduce safe assets relative to a constrained planner's allocation.

This constrained inefficiency creates the rationale for regulatory intervention, but the market structure presents unique policy challenges. In particular, simple policies correcting only one side of the intermediary balance sheet cannot move the market towards constrained efficiency and may exacerbate the welfare loss through equilibrium effects. For example, given the equilibrium's welfare properties, one might conjecture that a policy that reduces the fraction of safe debt issuers could improve welfare. By introducing an entry cost into the model, I show that correcting this over-entry problem exacerbates the underproduction of safe assets. This is because the reduction in safe debt issuers makes providing collateral in the secondary market less profitable, which discourages collateral providers' lending and thereby worsens the shortage of aggregate collateral.

Through the lens of the model, I shed light on a controversial regulation. This regulation, called Credit Risk Retention Rule and finalized in the US in 2014, requires asset managers to contribute 5% of capital to the CLOs they operate. Because the rule imposes substantial operational and capital costs on issuing safe securities, it has led to both a decrease in the number of new CLOs and fierce resistance from practitioners. After winning a lawsuit against regulators in 2018, CLO managers were exempted from the rule, but whether to reapply it is still an ongoing debate. My analysis explains, from an equilibrium perspective, why this policy can cause unintended consequences that regulators should take into consideration.

Finally, I analyze two extensions to explore the boundaries of the CLO contract. My model's focus on long-term debt leaves the question open as to why CLOs do not issue short-term debt, which can be made safe by liquidating loans and repaying debtholders in bad times. First, I allow debt maturity choices and loan trades to be jointly determined with secondary market purchases by outside investors.[2] Intuitively, long-term contracts help CLOs maximize and maintain cheap leverage when it is costly for outsiders to participate and buy liquidated loans. Second, I discuss contractual frictions, under which managers strategically respond to collateral constraints. I show that requiring over-collateralization can constrain managers from reaching for yield. However, the informativeness of verifiable proxies for loan quality is crucial to the safety of long-term debt backed by dynamic portfolios.

[2] Outsiders (e.g., distressed debt funds) differ from intermediaries in that they only invest in liquidated assets in the secondary market, especially during market downturns.

This paper proceeds as follows. Section 1 presents motivating empirical facts. Section 2 introduces the model, and Section 3 characterizes the equilibrium. Section 4 analyzes the equilibrium's welfare properties and the effects of policy interventions. Section 5 extends the model to more general settings. Section 6 concludes.

Related Literature

The framework presented in this paper helps organize and interpret a fast-growing body of literature on leveraged loans and CLOs. A number of empirical studies provide complementary evidence for the key ingredients of my model. Cordell, Roberts, and Schwert (2021) show that on a risk-adjusted basis, CLO equity earns positive abnormal returns because debt tranches are overpriced relative to leveraged loans, which is consistent with the view that CLOs arise in response to regulated institutions' demand for safe assets (Benmelech and Dlugosz, 2009). Tracking the dynamics of loan ownership, Giannetti and Meisenzahl (2021) document that mutual funds and hedge funds buy deteriorated loans sold by CLOs, supporting that the coexistence of other intermediaries is essential to CLOs' dynamic collateral management.[3] Consistent with the purpose of collateral substitution, Fabozzi et al. (2021) show that CLOs' simultaneous purchases and sales of loans are associated with lower portfolio quality deterioration. Elkamhi and Nozawa (2022) find that binding collateral constraints force CLOs to sell downgraded loans and that overlapped holdings across CLOs cause pressures on loan prices. Such price pressures affect the marginal rate of collateral substitution, which in my model critically determines CLOs' safe debt capacity. Moreover, existing evidence does not support the importance of adverse selection in this particular market.[4] So different from

[3] My analysis also suggests that in equilibrium, part of the rents earned by CLOs pass through secondary market trades to these counterparties.

[4] Shivdasani and Wang (2011) and Benmelech, Dlugosz, and Ivashina (2012) find that loans financed by CLOs do not perform worse than loans retained by banks, and Blickle et al. (2020) show that loans sold by lead arrangers are less likely to become non-performing subsequently. See Cordell, Roberts, and Schwert (2021) for a more detailed discussion on this issue.

traditional theories of banking (e.g., Rajan 1992; Parlour and Plantin, 2008) and securitization (e.g., DeMarzo and Duffie, 1999; DeMarzo, 2005), my model abstracts from informational frictions and focuses on safe asset production in incomplete markets.

So far, this literature generally takes the observed CLO contracts as given. Several papers recognize that because the contracting is based on imperfect proxies for a loan's quality and value, CLO managers may strategically respond by selectively selling loans that are marked-to-market (Elkamhi and Nozawa, 2022; Kundu, 2021) or traded at higher prices (Loumioti and Vasvari, 2019; Nicolai, 2020). Focusing on the liability side of the balance sheet, Foley-Fisher, Gorton, and Verani (2020) study investor reactions to the changes in information sensitivity of CLO securities, and Griffin and Nickerson (2020) assess the staleness of ratings of these securities. My paper contributes to this literature by explaining how the CLO contract arises under financial frictions, governs the joint dynamics of intermediary assets and liabilities, and shapes the structure of the leveraged loan market.

More broadly, this paper's analysis of nonbank intermediaries provides a new perspective on modern financial intermediation. Seminal work by Diamond and Dybvig (1983) and Gorton and Pennacchi (1990) find that by creating safe and liquid claims, intermediaries facilitate efficient allocation under information frictions. Subsequent research further develops the insight that safety creation drives intermediary asset choices (Hanson et al., 2015; DeAngelo and Stulz, 2015; Dang et al., 2017; Diamond, 2020; Drechsler, Savov, and Schnabl, 2021).[5] In the existing literature, there is no role for dynamic asset portfolios in the production of safe liabilities. The key innovation of my paper is to analyze how dynamic collateral management allows intermediaries to increase the supply of safe assets beyond the level produced by static pooling and tranching. The idea of collateral reallocation is shared by Holmström and Tirole

[5]Empirical studies on the pricing of and the interactions among different safe assets include Krishnamurthy and Vissing-Jorgensen (2012), Sunderam (2015), Nagel (2016), Gissler and Narajabad (2018), and Infante (2020). Another strand of literature posits that an excessive production of private safe assets can lead to financial fragility due to fire sales (Stein, 2012; Greenwood, Hanson, and Stein, 2015) or neglected risks (Gennaioli, Shleifer, and Vishny, 2012, 2013).

(1998, 2001), where trading mitigates the impact of liquidity shocks on firms' real investment.

The normative analysis in this paper builds on insights from the theoretical literature on pecuniary externalities when agents face price-dependent borrowing constraints à la Shleifer and Vishny (1992) and Kiyotaki and Moore (1997). Under this financial friction, trades between heterogeneous agents may fail to achieve an efficient allocation because, through their influence on the binding constraints, competitive prices divert resources away from productive uses (e.g., Caballero and Krishnamurthy, 2001; Gromb and Vayanos, 2002; Bianchi, 2011; Bianchi and Mendoza, 2010; Jeanne and Korinek, 2019). Dávila and Korinek (2018) refer to this type of pecuniary externalities as "collateral externalities".

One strand of this literature focuses on financial intermediaries' loan sales. In Stein (2012), banks overborrow safe debt and liquidate loans at an interim date without internalizing that lower prices crowd out buyers' real investments. Neuhann (2019) analyzes a setting where higher buyer wealth not only relaxes banks' collateral constraints, but also compromises their incentives to screen loans, generating inefficiently low asset quality. To capture institutional features, my model substantially differs from this literature in two ways. First, safe debt is secured by substituting rather than liquidating risky loans, so collateral constraints are sensitive to the ratio, instead of the level, of loan prices. Second, intermediaries in my model have zero endowment and identical lending technology, and the direction of trades is flexibly determined by an intermediary's financing choices. As a result, aggregate collateral depends on ex-ante lending by the two sides of the market, and equilibrium in this economy generally features underborrowing. This new form of inefficiency has important policy implications because traditional policies, if used in isolation, cannot restore constrained efficiency.

1 Motivating Evidence

Before presenting the theoretical framework, this section provides motivating evidence on the dynamic approach of safe asset production. Details on data and sample are in Appendix C.

1.1 Institutional Background

Leveraged loans are private debt extended to corporations that have a high existing leverage.[6] These loans are originated through syndication deals, where underwriters organize select groups of lenders to privately contract with the borrowers. Following Federal Reserve Board (2021), this paper focuses on "institutional leveraged loans", which are term loans and mostly held by nonbanks.[7] Collateralized loan obligations (CLOs) are the largest group of nonbank intermediaries that hold leveraged loans. As Figure 1 shows, US leveraged loans quickly grew from \$130 billion to \$1.2 trillion between 2001—2020, and CLOs consistently held roughly half of these loans. The vast majority of CLOs are "open-market CLOs", which are operated by asset managers that are independent from the underwriter banks.

The key innovation of CLOs is active management. Unlike other asset-backed securities that are backed by static collateral, CLOs allow their managers to buy and sell loans during a predetermined reinvestment period.[8] A CLO lasts around 10 years, and the reinvestment period is usually the first 5 years. After this period, the CLO enters its amortization period and repays debt principals over time.[9] The manager's compensation consists of fixed fees (based on tranche size) and incentive fees (based on equity performance).

[6] S&P Global Market Intelligence defines a loan as leveraged if it is rated below Baa3/BBB-, or if it is secured and has a spread of at least 125 basis points.

[7] Regulatory data (Shared National Credit Program) show that 84% of non-investment grade term loans are held by nonbanks in 2020.

[8] Recently, this contract design became popular in the commercial mortgage market, where 20% of securitization deals are structured as "CRE CLOs" in 2019.

[9] During the amortization period, CLO managers can only buy loans using the cash generated by existing loans' prepayments. See Fitch's report for more details: Reinvestment in Amortization Period of U.S. CLOs.

Safe Asset Production. Since no asset is literally risk free, the definitions of safe assets are diverse and sometimes vague. Existing definitions often involve the convenience services provided by low-risk debt instruments. In the context of this paper, such services are mainly reflected in that highly-rated CLO securities help regulated financial institutions satisfy risk-based capital requirements. While leveraged loans have speculative-grade ratings, CLOs' senior debt tranches (about 65% of liabilities) are rated AAA and have zero default record in history.[10] The safety of senior tranches relies on several factors. First, the underlying portfolios are diversified, typically consisting of 100–300 loan shares. Second, the default recovery rates of leveraged loans have been moderately high.[11] Third, CLO contracts include covenants that protect debtholders, which I will introduce in detail later.

Other Intermediaries. In addition to CLOs, other nonbank intermediaries also hold a significant proportion of leveraged loans.[12] These intermediaries, including mutual funds and hedge funds, do not collateralize their loan holdings to issue any safe securities. Since there is no regulatory barrier, asset managers participating in the same market should be able to choose which type(s) of intermediaries to operate. Consistent with this conjecture, Figure 2 shows that managers in the leveraged loan market selectively operate CLOs and/or mutual funds. For example, CVC Credit Partners only offers CLOs, whereas Fidelity Investments predominantly manages leveraged loan mutual funds. Such financing choices lead to a coexistence of two distinct types of intermediaries.

[10] See SEC report (Kothari et al., 2020, p.41–p.49) for a discussion on why CLOs' "AAA-rated senior tranches will not incur losses unless economic conditions worsen dramatically" following the COVID-19 crisis.

[11] Corporate loans are senior to bonds and usually explicitly secured by collateral. See S&P report for more details on recovery rates: LossStats.

[12] Figure A.3 provides information on the size of different intermediaries based on alternative data sources.

1.2 Contracts and Collateral Constraints

Leveraged loans and the borrowers are large: the average loan size is around \$700 million in my sample. This size creates an economy of scale in information production, and almost every single loan is rated by third parties. The availability of continually updated loan ratings allows CLO managers to commit to long-term contracts that discipline their future portfolio choices and collateral quality. CLO contracts implement this commitment with regular (e.g., monthly) collateral tests. In each period, test scores are calculated based on current loan holdings and compared with predetermined threshold levels. A test failure prevents the manager from receiving compensation until test scores recover.

The most important collateral test is the over-collateralization (OC) test.[13] The OC score for AAA tranches is calculated as

$$\text{AAA OC score} = \frac{\text{quality-adjusted total face value of loan holdings}}{\text{face value of AAA tranche outstanding}}, \tag{1}$$

where the quality adjustment is based on portfolio loans' current ratings and prices. When the OC test fails, covenants typically require the manager to accelerate debt repayment, which reduces the score's denominator.[14] 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 capacity. Figure 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

[13]Other collateral tests include the interest coverage (IC) test and interest diversion (ID) test, which also induce the manager to hold enough collateral for debt tranches.

[14]The repayment is achieved by diverting cash flows generated by loan holdings away from paying junior tranches (or buying more loans) to paying the senior tranche.

required level and is fairly stable over time.[15] In every quarter, the slackness of collateral constraints is tightly distributed around this average. These binding constraints have two interpretations: First, managers fully exploit safe debt capacity allowed by portfolios, and second, they carefully maintain just enough quality-adjusted loan holdings given safe debt outstanding. By contrast, constraint slackness is much larger on average and more dispersed for CLOs in amortization period. This is because CLO leverage decreases along with debt principal repayment, and their managers no longer actively trade loans.

1.3 Balance Sheet Dynamics around the Onset of COVID-19

Safe debt produced 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 4 depicts CLO balance sheet 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

[15] 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 C.2 for details on this data limitation.

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.

1.4 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 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.[16] 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.[17] Panel (b) shows the distribution of value-weighted portfolio average ratings. A larger numeric rating corresponds to a better letter rating (see Table A.2 for details). Clearly, the pandemic lowered overall ratings, but managers' trading mitigated deterioration, improving the realized ex-post distribution relative to the counterfactual.

[16] 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.

[17] See Subsection C.3 in the Appendix for details on the construction of counterfactual portfolios.

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.[18] 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 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. Similar effects of reverse risk shifting trades were observed during the 2008–2009 financial crisis (Standard & Poor's, 2016), suggesting that the contractual design consistently protects senior tranches in bad times.

1.5 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.

[18] Figure A.6 in the Appendix shows a strong correlation between this counterfactual quality deterioration and ex-ante portfolio weight in pandemic-vulnerable industries.

For each loan, I measure its transitory price drop as

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

where the prices are calculated using market values reported in CLO portfolio snapshots in the three periods.[19] 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 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 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.

[19] 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 C.1 for details on price measurement.

2 A Model of Long-Term Securitized Debt

This section presents a model of securitized lending in which asset managers can credibly promise to maintain collateral quality through secondary market trading. The setup focuses on long-term contracts under full commitment and relegates the analysis of maturity choice and contractual frictions to Section 5. All proofs and derivations are in Appendix A.

2.1 Environment

The economy has three time periods $t \in \{0, 1, 2\}$ and two types of agents: investors and asset managers.

Investors. There is a unit mass of investors who receive an endowment e of perishable consumption goods in the beginning of period $t = 0$ and maximize additively separable utility

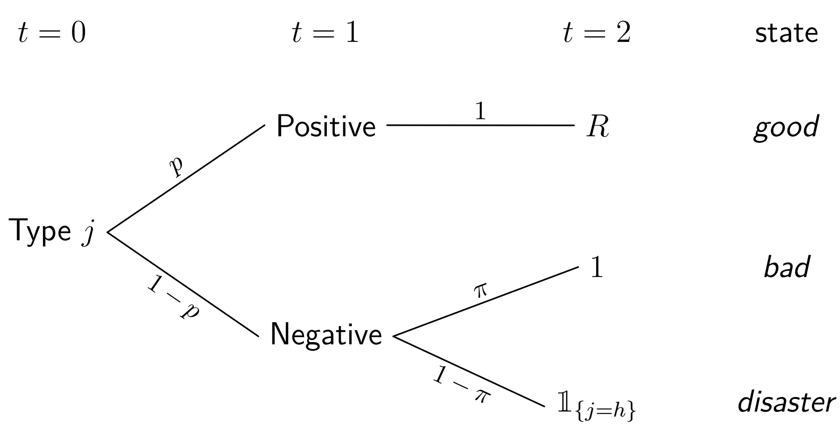
$$U = \mathbb{E}_0\left[\sum_{t=0}^{2} C_t\right] + \gamma A, \tag{3}$$

where C_t is consumption in period t, and A is the $t = 0$ holding of riskless financial claims that pay off at $t = 2$. From every unit of these claims, investors derive a non-pecuniary benefit γ because of the convenience services provided by safe assets.

Intermediaries. There is a continuum of asset managers uniformly populated on $\mathcal{I} = [0, 1]$. Their preference is the same as (3), except for that they do not benefit from holding safe assets. Each manager, indexed by $i \in \mathcal{I}$, has zero endowment and operates an intermediary that lends at $t = 0$ to generate a risky payoff at $t = 2$. Intermediaries can finance their lending by issuing any safe and risky financial claims. In particular, a claim is called *safe debt* if it is backed by loans whose payoff is enough for repayment with certainty. There exists a securitization technology that allows managers to commit to future portfolio choices and thereby credibly issue safe debt. Issuing safe debt incurs an exogenous variable cost $\xi_i \geq 0$, which captures a manager's ability to adopt the technology.

A key friction in this economy is that financial markets are incomplete: agents cannot create or trade claims contingent on future states. For this reason, in the absence of securities issued by intermediaries, the supply of safe assets is zero. Investors take security prices as given when making investment and consumption decisions. I assume e to be sufficiently large, so the nonnegativity constraint on investor consumption is never binding.

Investment Technology. Investors cannot invest directly. Asset managers have identical and independent access to two types of scalable investment projects $j \in \{h, l\}$. Every unit of capital in projects generates a gross payoff R_j^ω that depends on state $\omega \in \Omega = \{g, b, d\}$ at $t = 2$. In period $t = 1$, a piece of public news s arrives, which can be either positive ("+") or negative ("−") with probabilities p and $1 - p$, respectively. If s is positive, state g ("good") will realize with certainty, and both types of projects will pay $R_j^g = R > 1$ units of consumption goods. If s is negative, then $t = 2$ state remains uncertain. With probability $\pi \in (0, 1)$, state b ("bad") will realize, and the two types both pay $R_j^b = 1$. With probability $1 - \pi$, state d ("disaster") realizes. While type h still pays $R_h^d = 1$ in this state, type l pays $R_l^d = 0$. Hence, the two project types only differ in the payoff in state d.[20]



[20]The assumed payoff distribution is stronger than necessary but keeps the model's mechanism transparent. Subsection 5.1 analyzes a setting with generalized conditional payoff distributions.

Converting consumption goods into x units of capital incurs $c(x)$, where c is twice differentiable and satisfies $c(0) = 0$, $c'(\cdot) > 0$, and $c''(\cdot) < 0$. I assume that project payoffs are fully pledgeable, and asset managers enjoy full bargaining power.[21] By investing in projects, an intermediary originates risky loans.[22] Depending on project types, I refer to the loans as h (high-quality, or "good") and l (low-quality, or "bad") loans, respectively.

Financial Markets. Primary market events in period $t = 0$ occur in the following order. Each intermediary $i \in \mathcal{I}$ originates x_i units of loans without knowing their types. Immediately after origination, a quality shock determines loan types exogenously. Specifically, $\tilde{x}_{i,l}$ units of loans become type l, and the remaining $x_{i,h} = x_i - \tilde{x}_{i,l}$ units become type h. Across intermediaries, $\tilde{x}_{i,l}$ is independently drawn from a common distribution with support $[0, \bar{x}_l]$ and mean $x_L \in (0, \bar{x}_l)$. The realization of quantity $\tilde{x}_{i,l}$ is publicly observed, but which loans are low-quality is unknown in this period.

To finance the investment cost $c(x_i)$, the intermediary issues safe debt with face value $a_i \geq 0$ and external equity shares. The equity can be interpreted as any risky liability, such as junior debt. Intermediaries only hold loans because consumption goods are non-storable, cross-holdings of claims are unprofitable, and bilateral contracts between managers are not enforceable. The intermediary balance sheet in the end of period $t = 0$ is:

Assets	**Liabilities**
$x_{i,h}$ and $x_{i,l}$	safe debt: a_i
	external equity + internal equity

[21]This assumption abstracts from contractual frictions between intermediaries and firms and simplifies the welfare analysis.

[22]In practice, underwriters originate leveraged loans and sell them to nonbanks. Since nonbanks typically pre-commit to buying loans from banks (Taylor and Sansone, 2006), and lead arrangers' loan shares drop to negligible levels shortly after syndication (Lee et al., 2019), my model abstracts from the underwriting process and refer to the nonbank lending activity as "origination".

In period $t = 1$, loan quality types become publicly observable, and intermediaries can trade loans in a Walrasian secondary market. The two types of loans' secondary market prices given news s are $(q_l^s, q_h^s) \in \mathbb{R}_+^2$. In period $t = 2$, projects generate payoffs, and capital fully depreciates. Asset managers repay investors based on the securities and collect residual portfolio payoffs. All goods are consumed, and the economy ends.

The Intermediary's Optimization Problem. Asset managers make sequential choices to maximize their own payoffs. I describe their optimization problem backwardly and only consider repayment in the final period. The option of early debt repayment, as I show in Section 5, can be ignored without loss of generality under the setup in this section.

After news s realizes in period $t = 1$, given the intermediary's balance sheet $(x_{i,h}, x_{i,l}, a_i)$, manager i chooses net trades $\Delta x_{i,h}^s, \Delta x_{i,l}^s$ of the two types of loans to maximize conditional expected payoff to equity

$$v(x_{i,h}, x_{i,l}, a_i; s) = \max_{\Delta x_{i,h}^s, \Delta x_{i,l}^s} \sum\nolimits_j (x_{i,j} + \Delta x_{i,j}^s)\mathbb{E}[R_j^\omega | s] - a_i. \tag{P1}$$

These trades are subject to a budget constraint

$$\sum\nolimits_j (x_{i,j} + \Delta x_{i,j}^s) q_j^s \leq \sum\nolimits_j x_{i,j} q_j^s, \tag{BC}$$

a maintenance collateral constraint

$$a_i \leq \sum\nolimits_j (x_{i,j} + \Delta x_{i,j}^s) \min_{\omega \in \Omega^s} R_j^\omega \tag{MCC}$$

where Ω^s is the subset of $t = 2$ states that have positive probabilities conditional on news s, and short-sale constraints $\Delta x_{i,h}^s \geq -x_{i,h}, \Delta x_{i,l}^s \geq -x_{i,l}$. The budget constraint (BC) requires the intermediary's trades to be self-financed by its loan portfolio. The maintenance collateral constraint (MCC) requires that after secondary market trades, safe debt investors receive the face value with probability one. Note that the latter constraint ensures that the portfolio stays in the solvent region, and equity payoff is linear in portfolio payoff.

Managers rationally anticipate loan trades in period $t = 1$ when making lending and financing decisions in period $t = 0$. Because investors are price-taking, managers optimally price securities such that investors break even in expectation. This implies that by issuing one unit of safe debt, an intermediary effectively raises $1 + \gamma - \xi_i$, and the cost of external equity is $c(x_i) - (1 + \gamma - \xi_i)a_i$. Taking anticipated loan prices as given, the manager chooses investment x_i and safe debt a_i to maximize the expected payoff to internal equity

$$V_i = \max_{x_i, a_i \geq 0} \quad \mathbb{E}_0[v(x_{i,h}, x_{i,l}, a_i; s)] - \Big(c(x_i) - (1 + \gamma - \xi_i)a_i\Big), \tag{P0}$$

where $v(x_{i,h}, x_{i,l}, a_i; s)$ is the $t = 1$ maximum expected payoff to equity as a function of choices x_i, a_i, and quality shock $\tilde{x}_{i,l}$. Importantly, the maximization is subject to an endogenous initial collateral constraint:

$$a_i \leq \Big(\sum\nolimits_j x_{i,j} q_j^s\Big) \max_j \min_{\omega \in \Omega^s} \frac{R_j^\omega}{q_j^s}, \;\; \forall s \tag{ICC}$$

which requires the portfolio's market value at $t = 1$ to be enough for the manager to satisfy constraint (MCC) through loan trades.

I impose two parametric assumptions to simplify the analysis. First, the convenience yield is large enough for any manager to lower the cost of financing by issuing safe debt.

Assumption 1. *Investors' non-pecuniary benefit is greater than any asset manager's safe debt issuance cost:* $\gamma > \xi_i$ *for all* $i \in \mathcal{I}$.

Second, the magnitude of loan quality deterioration, $\tilde{x}_{i,l}$, is bounded from above.

Assumption 2. *The marginal cost of real investment at scale* $\bar{x}_l$ *satisfies* $c'(\bar{x}_l) < pR + 1 - p$.

This inequality ensures that the sequential choices within period $t = 0$ can be equivalently formulated as a simultaneous decision problem.

2.2 Equilibrium Definition

The maintenance collateral constraints create a path dependency in intermediary balance sheets. Since the initial collateral constraints depend on future loan prices, the equilibrium features an intertemporal feedback loop between primary and secondary markets.

Definition 1 (Competitive Equilibrium)**.** *An equilibrium consists of balance sheet choices* (x_i, a_i) *and secondary market trades* $(\Delta x_{i,h}^s, \Delta x_{i,l}^s)$ *for each manager* i*, state* s *and secondary market prices* (q_h^s, q_l^s) *for each state* s *such that (i) given prices, balance sheet choices solve the manager's lending and financing problem (P0), (ii) given prices, secondary market trades solve the manager's trading problem (P1), and (iii) the secondary market clears, that is,*

$$\int_i \Delta x_{i,j}^s \, \mathrm{d}i = 0 \quad \text{for } j \in \{h, l\}, s \in \{+, -\}. \tag{4}$$

2.3 Discussion of Model Setup

The model builds on two main assumptions. First, investors get utility from safe assets, which is standard in the literature (e.g., Krishnamurthy and Vissing-Jorgensen, 2012; Stein, 2012; Diamond, 2020). Because of this preference, safe debt can be priced at a premium, and an intermediary's capital structure is relevant to its value, breaking the Modigliani and Miller (1958) theorem. Second, investment exhibits decreasing returns to scale, and thus intermediaries face a scarcity of risky loans. This is consistent with the large number of CLOs and managers and the relatively small size of their loan portfolios.

A unique feature of this model is that secondary market trading allows for a higher worst-possible portfolio payoff than that of a static portfolio. Gains from trade come from the inability of agents to perfectly identify the quality of originated loans and a resulting mismatch between intermediaries' assets and liabilities when quality is publicly revealed. Having two quality types parsimoniously captures this feature.

The securitization technology is crucial in the model because for debt backed by dynamic portfolios to be safe, managers must commit to satisfying the collateral constraints. In practice, CLOs only hold fairly standardized corporate loans, which allows enforceable contracts to discipline the manager's portfolio choices. With simple collateral, CLOs are in sharp contrast to collateralized debt obligations (CDOs), which held enormous complex derivatives such as credit default swaps (Cordell, Huang, and Williams, 2011). Consistent with these facts, intermediaries in the model cannot hold state-contingent bilateral contracts. Another assumption is that managers may have different safe debt issuance costs. A lower cost can be interpreted as a technological advantage that arises from the manager's other businesses. For example, it may be less costly for KKR than Fidelity to securitize loans and raise funding from global private markets.

3 Equilibrium

This section characterizes the equilibrium. First, I analyze individual managers' lending, financing, and trading choices for given secondary market loan prices. I then study intermediary balance sheets and loan prices that clear the secondary market. To provide a basic benchmark, I begin with a setting where collateral is restricted to be static.

3.1 Benchmark: Static Securitization

Consider the case where no secondary loan market exists, and intermediaries have to hold static portfolios. Let $c'^{-1}(\cdot)$ be the inverse function of the first-order derivative of c.

Lemma 1. *In the absence of a secondary loan market, intermediary balance sheet choices satisfy* $x_i^{STA} = c'^{-1}(pR + 1 - p + \gamma - \xi_i)$ *and* $a_i^{STA} = x_i^{STA} - x_{i,l}$ *for all* $i \in \mathcal{I}$.

Without a secondary market, every intermediary fully pledges its static loan portfolio as collateral to issue safe debt. The size of an intermediary's balance sheet decreases in the manager's safe debt issuance cost. This market structure resembles traditional banking, where risky loans stay on bank balance sheets, and a bank's deposit productivity plays a key role in its value creation (Egan, Lewellen, and Sunderam, 2021).

3.2 Secondary Market Trades

The lending and financing choices at $t = 0$ depend on continuation value v. To derive v, this subsection analyzes the manager's secondary market problem in period $t = 1$ for given balance sheets and loan prices.

Problem (P1) can be simplified as follows. First, the budget constraint (BC) binds because the objective is strictly increasing in net trades. Given constraint (ICC), this implies that if positive news arrives, the maintenance collateral constraint (MCC) is slack for every manager, and secondary market trading is trivial with $q_h^+ = q_l^+ = R$. Therefore, I restrict attention to optimal trades in the negative-news stage at $t = 1$ and suppress the superscripts in net trades and loan prices hereafter. In this stage, since $a_i \geq 0$, (MCC) implies that $\Delta x_{i,h} \geq -x_{i,h}$ is slack. Omitting terms predetermined at $t = 1$, the problem is equivalent to

$$\max_{\Delta x_{i,l}} \quad \Delta x_{i,l}\Big(\pi - \frac{q_l}{q_h}\Big), \tag{P1a}$$

subject to constraints $\Delta x_{i,l} \frac{q_l}{q_h} + a_i \leq x_{i,h}$ and $\Delta x_{i,l} \geq -x_{i,l}$.

Intuitively, the manager exchanges the two types of loans, subject to a constraint imposed by safe debt outstanding and a short-sale constraint. Note that the arrival of negative news updates loan h's and loan l's fundamental values to 1 and π, respectively. I proceed to solve this problem based on the following lemma.

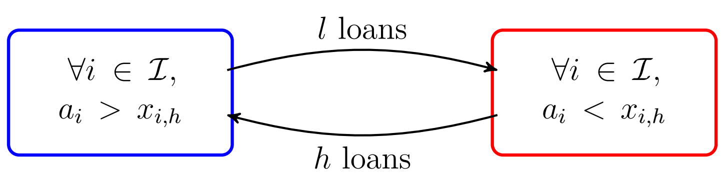
Lemma 2. *In the negative-news stage, the ratio of secondary market loan prices is lower* *than the ratio of fundamental values:* $\frac{q_l}{q_h} \leq \pi$.[23]

In bad times, secondary market trades push loan prices away from fundamental values. Unlike managers facing binding collateral constraints who are forced to buy additional good loans, other managers only care about returns. Low-quality loans, which have a lower collateral value, must offer a higher expected return, so that the unconstrained managers are willing to trade as counterparties. As a result, the price-to-fundamental ratio of bad loans decreases relative to that of good loans.

Lemma 2 indicates that the manager's optimal trades lead to portfolio substitution:

$$\Delta x_{i,h} = a_i - x_{i,h}, \;\; \Delta x_{i,l} = -\frac{(a_i - x_{i,h})q_h}{q_l} \tag{5}$$

for any given $x_{i,h}$ and a_i. As illustrated by the graph below, these trades reallocate risky loans among intermediaries. A manager with $a_i > x_{i,h}$ optimally sells just enough bad loans to increase the holding of good loans to keep debt safe. By contrast, a manager with $a_i < x_{i,h}$ sells its extra good loans and buys bad loans to profit from the deviation of loan prices from fundamentals. As the trading volume of good loans is driven by binding collateral constraints, it is price-inelastic.



3.3 Balance Sheet Choices

This subsection characterizes the manager's optimal lending and financing choices at $t = 0$ for given loan prices. The analysis in the previous subsection shows that equity holders'

[23] This inequality will be shown to be generally strict in equilibrium, so I ignore the corner case (i.e., $\frac{q_l}{q_h} = \pi$) throughout this section.

continuation value v in the positive- and negative-news stages are $x_i R - a_i$ and $\pi\Big(x_{i,l} + (x_{i,h} - a_i)\frac{q_h}{q_l}\Big)$, respectively. By no arbitrage, $0 < q_l < q_h$, so initial collateral constraint (ICC) is equivalent to

$$a_i \leq x_i - x_{i,l} + x_{i,l}\frac{q_l}{q_h}. \tag{ICCa}$$

Substitute v into (P0), the manager's lending and financing problem becomes[24]

$$\max_{x_i, a_i}\ p(x_i R - a_i) + (1-p)\pi\Big((x_i - x_{i,l} - a_i)\frac{q_h}{q_l} + x_{i,l}\Big) - \Big(c(x_i) - (1 + \gamma - \xi_i)a_i\Big) \tag{P0a}$$

subject to constraints (ICCa) and $a_i \geq 0$. Let η_i and μ_i respectively be the Lagrangian multipliers of the two constraints above. The manager's Kuhn-Tucker conditions for optimal choices are

$$pR + (1-p)\pi\frac{q_h}{q_l} - c'(x_i) + \eta_i = 0, \tag{6}$$

$$\gamma - \xi_i - (1-p)\Big(\pi\frac{q_h}{q_l} - 1\Big) - \eta_i + \mu_i = 0, \tag{7}$$

and

$$\eta_i \geq 0, \eta_i\Big(a_i - \Big(x_{i,h} + x_{i,l}\frac{q_l}{q_h}\Big)\Big) = 0, \mu_i \geq 0, \mu_i a_i = 0. \tag{8}$$

Equation (7) states that a manager's financing choice is based on a tradeoff between ex-ante funding benefit of safe debt, $\gamma - \xi_i$, and expected losses from loan trades in bad times, $(1-p)\Big(\pi\frac{q_h}{q_l} - 1\Big)$. It follows that two cases are possible. In the first case, the benefit is less than the cost, hence no safe debt would be issued ($\mu_i > 0$), and the collateral constraint would be slack ($\eta_i = 0$). Accordingly, the lending choice in (6) is simply based on a tradeoff between the expected payoff and the marginal cost of investment.

In the second case, the funding benefit exceeds the losses from trading, and collateral constraint (ICCa) binds. On the liability side, the manager fully uses safe debt capacity

[24] Assumption 2 guarantees that the realization of $\tilde{x}_{i,l} = x_{i,l}$ does not affect the choice of x_i, so the realized quantity is used in the optimization problem.

in (ICCa) to exploit cheap financing. On the asset side, as characterized by equation (6), lending exceeds what the payoff–cost tradeoff suggests. The additional investment, captured by $\eta_i = \gamma - \xi_i - (1-p)(\pi \frac{q_h}{q_l} - 1) > 0$, reflects the collateral value of loans. As η_i decreases in ξ_i, a manager with better securitization technology lends more and issues more safe debt.

3.4 Equilibrium Market Structure and Safe Asset Supply

This subsection analyzes the market structure that is jointly determined with intermediary balance sheets in equilibrium. A key metric in the intertemporal feedback loop is price ratio $\frac{q_l}{q_h}$, which captures the marginal rate of collateral substitution. When this ratio is higher, replacing deteriorated loans is less costly, and providing collateral to others is less profitable, so issuing safe debt is more attractive. However, safe debt issuance increases the secondary market demand for (supply of) high-quality (low-quality) loans, and the market cannot clear unless the price ratio drops sufficiently. Such equilibrium forces drive the two sides of the intermediary balance sheet.

The market-clearing condition (4) and optimal trades in (5) imply an equilibrium relationship that is consistent with Walras law:

$$\int_i a_i \, \mathrm{d}i = \int_i x_{i,h} \, \mathrm{d}i. \tag{9}$$

In aggregate, safe debt cannot exceed the worst-possible payoff of risky loans, and this capacity is always exhausted by managers. Given the loans' payoff distributions, total safe debt equals the quantity of high-quality loans in the economy.

I proceed to characterize the equilibrium in two steps. First, I consider a knife-edge case in which asset managers are homogeneous. This special case provides intuition useful for understanding the competitive allocation and its efficiency. Next, I analyze the equilibrium market structure when managers have different securitization technology.

3.4.1 Equilibrium without Heterogeneity

Suppose managers are identical ex ante: $\xi_i = \xi^* \in [0, \gamma)$ for all $i \in \mathcal{I}$. The set of equilibria has the same loan prices and lending choices but indeterminate financing choices.

Lemma 3. *If managers are homogeneous,* $\frac{q_l}{q_h} = \frac{(1-p)\pi}{1-p+\gamma-\xi^*}$, $x_i = c'^{-1}(pR + 1 - p + \gamma - \xi^*)$, *and any* $\left\{a_i : a_i \leq x_{i,h} + x_{i,l}\frac{q_l}{q_h}\right\}_{i\in\mathcal{I}}$ *that satisfies equation (9) is an equilibrium. The supply of safe assets is the same as in static securitization.*

The intuition of this result follows from the tradeoff captured in equation (7). When mangers are homogenous, secondary market prices must adjust until everyone is indifferent about financing choices. That is, the benefit of issuing one more unit of safe debt equals the profit of selling one more unit of collateral to others. This indifference condition implies that lending choices, and hence by equation (9), the supply of safe assets, coincide with the setting where nobody sells collateral to others, namely, the static benchmark.

3.4.2 Equilibrium with Heterogeneity in Securitization Technology

For various reasons, asset managers may face a technological difference in securitization. My analysis of the equilibrium under this heterogeneity is based on a setting where every manager in the continuum has a different type. This setting allows for a clean characterization that incorporates intuition from settings with discrete manager types, for which I provide an analysis in Appendix B.1.

Without loss of generality, let manager i's variable safe debt issuance cost be $\xi_i = 2\xi i$ for constant $\xi \in (0, \gamma/2)$. Managers are thus ranked by issuance cost. Intuitively, a manager with a higher issuance cost benefits less from safe debt and is more willing to issue only equity, and equation (7) indicates that the constraints on safe debt choices will bind for almost everyone. Hence, financing choices at the extensive margin can be summarized by a cutoff $\lambda \in [0, 1]$: managers $i \leq \lambda$ issue safe debt, and managers $i > \lambda$ issue only equity. By construction, the cutoff type is indifferent between issuing safe debt and providing collateral to others:

$$\gamma - \xi_\lambda = (1-p)\Big(\pi \frac{q_h}{q_l} - 1\Big). \tag{10}$$

The equilibrium is reached when the price ratio adjusts to (i) satisfy this indifference condition and (ii) clear the secondary market.

Proposition 1 (Competitive Equilibrium)**.** *There exists a unique equilibrium.*[25] *In equilibrium, there is an interior cutoff $\lambda^{CE} \in (0,1)$ such that*

$$x_i^{CE} = \begin{cases} c'^{-1}\Big(pR + 1 - p + \gamma - \xi_i\Big), & \textit{if } i \le \lambda^{CE} \\ c'^{-1}\Big(pR + 1 - p + \gamma - \xi_{\lambda^{CE}}\Big), & \textit{if } i > \lambda^{CE} \end{cases}, \tag{11}$$

$$a_i^{CE} = \begin{cases} x_i^{CE} - x_{i,l} + x_{i,l}\frac{q_l}{q_h}, & \textit{if } i \le \lambda^{CE} \\ 0, & \textit{if } i > \lambda^{CE} \end{cases}, \tag{12}$$

and

$$\frac{q_l}{q_h} = \frac{(1-p)\pi}{1-p+\gamma-\xi_{\lambda^{CE}}} \tag{13}$$

Proposition 1 characterizes intermediary balance sheets and the market structure. In particular, two distinct groups of intermediaries, like CLOs and mutual funds, endogenously coexist. The first group optimally exhausts safe debt capacity, which they maximize by promising to replace the entirety of deteriorated loans after negative news.[26] This promise allows the managers to enjoy high payoffs after positive news.

By contrast, managers of the second group completely give up issuing safe debt. They do so because market-clearing loan prices deviate from fundamental values (i.e., $q_l/q_h < \pi$), making providing collateral in the secondary market more attractive to them. As the profit of collateral provision is independent to the manager's safe debt issuance cost, intermediaries in this group have identical lending choices.

[25] The uniqueness is with respect to the quantities of choices and the price ratio. The levels of loan prices are not uniquely identified. Subsection 5.1 generalizes the setting to allow for identified price levels.

[26] To see this, substitute the safe debt choice (12) into optimal trades in (5).

Corollary 1.1. *In equilibrium, the market produces a greater supply of safe assets at a lower average cost than the static benchmark.*

An immediate corollary of proposition 1 is that the market produces more safe assets than the static benchmark. Consistent with equation (9), this greater safe asset supply is accompanied by a larger quantity of high-quality loans. The collateral providers, despite having no need for collateral, lend more than they would in static securitization: equation (11) shows that $x_i^{CE} > x_i^{STA}$ for every $i > \lambda^{CE}$. This is because their anticipated profits from secondary market trades translate into a higher return from loan origination. Moreover, as safe debt is issued by managers with relatively better securitization technology, the market also has a lower average cost of safe asset production than the static benchmark.

Figure 7 provides a numerical illustration of the equilibrium and compares the market structure with and without a secondary market. Unlike that everyone issues safe debt in static securitization, the market has an interior mix of intermediaries with distinct liabilities. Managers with better securitization technology issue safe debt and have larger balance sheets. Their increased safe debt capacity from dynamic collateral management can be seen in the wedge between $\mathbb{E}[a_i^{CE}]$ and $\mathbb{E}[a_i^{STA}]$. From an equilibrium perspective, this increase comes from the lending choices of the the other side of the market, which is reflected by the wedge between x_i^{CE} and x_i^{STA}.

4 Welfare and Policy Implications

This section analyzes the equilibrium's welfare properties and their policy implications.

4.1 Social Planner's Problem

Consider a planner who controls every intermediary's lending and financing choices in period $t = 0$. The planner respects all the individual constraints faced by asset managers but does not take secondary market prices as given. Instead, by choosing quantities, he can target specific prices that (i) admit his choices at $t = 0$ and (ii) clear the secondary market at $t = 1$.

The market-clearing condition (4) imposes an additional constraint on the planner. As shown in the previous section, in the negative-news stage, binding constraints trigger loan trades given in equation (5). The secondary market clears if and only if $\int_i (a_i - x_{i,h})\,\mathrm{d}i \le 0$, which gives rise to an aggregate collateral constraint.[27]

The planner's optimization problem is as follows. Let the total quantity of loans be $X = \int_i x_i\,\mathrm{d}i$. By law of large numbers, aggregate low-quality loan is $\int_i \tilde{x}_{i,l}\,\mathrm{d}i = x_L$. Since the planner can transfer payoffs before they are consumed by investors and asset managers, his objective is to maximize the sum of investment payoffs and safe asset non-pecuniary benefits, minus the total costs of investment and securitization:

$$\max_{\{x_i, a_i\}_{i \in \mathcal{I}}} \quad pXR + (1-p)(X - x_L + \pi x_L) + \gamma A - \int_i \Big(c(x_i) + \xi_i a_i \Big)\,\mathrm{d}i \tag{SP}$$

$$s.t. \;\; A \le X - x_L, \tag{ACC}$$

$$a_i \le x_i - x_{i,l} + x_{i,l}\frac{q_l}{q_h}, \;\; \forall i \in \mathcal{I}, \tag{ICC}$$

$$a_i \ge 0, \;\; \forall i \in \mathcal{I}.$$

The aggregate collateral constraint (ACC) binds at the optimum: otherwise, there would be some i such that $a_i \in [0, x_{i,h})$, and since $\gamma > \xi_i$, increasing a_i would improve the objective, a contradiction to optimality. This implies that equation (9) holds in the planned economy as well. Moreover, the slackness of individual collateral constraint (ICC) strictly increases in

[27] When the inequality is strict, market clears if $q_l/q_h = \pi$, a special case in which unconstrained managers are indifferent between the two types of loans.

price ratio $\frac{q_l}{q_h}$, and loan prices do not affect the planner's objective or any other constraint. Therefore, a higher price ratio at least weakly improves the maximized total surplus, and the planner targets the highest market-clearing price ratio, which is $q_l/q_h = \pi$.

Let ψ^{SP}, η_i^{SP}, and μ_i^{SP} be the Lagrangian multipliers for the three (sets of) constraints. For each $i \in \mathcal{I}$, the Kuhn-Tucker conditions for optimality are

$$pR + 1 - p - c'(x_i) + \psi^{SP} + \eta_i^{SP} = 0, \tag{14}$$

$$\gamma - \xi_i - \psi^{SP} - \eta_i^{SP} + \mu_i^{SP} = 0, \tag{15}$$

and

$$\eta_i^{SP} \geq 0, \eta_i^{SP}(a_i - x_{i,h} - x_{i,l}\pi) = 0, \mu_i^{SP} \geq 0, \mu_i^{SP} a_i = 0. \tag{16}$$

The planner internalizes the externalities of intermediary balance sheets. His choice of lending, as characterized by (14), accounts for both individual (η_i^{SP}) and social (ψ^{SP}) collateral values. The social collateral value captures that an intermediary's lending increases collateral available to others because loans can be reallocated through trades. For financing choices characterized by (15), the planner trades off between the net benefit from producing safe asset and the reduction in aggregate safe debt capacity. This social cost differs from a manager's private cost, which is calculated given the loan prices.

4.1.1 Welfare without Heterogeneity

Before the main welfare analysis, I revisit the knife-edge case in subsection 3.4.

Lemma 4. *If managers are homogeneous, welfare is the same as in static securitization, and every competitive allocation is constrained efficient.*

In this case, reallocating loans before their payoffs realize does not improve welfare because no manager is better at securitizing loans than others. The planner cannot do better than the competitive market. Although he can change individual financing choices, which manager issues more or less safe debt is welfare-irrelevant given that all managers have the same securitization technology.

4.1.2 Welfare with Heterogeneity in Securitization Technology

Back to the setting where managers have different securitization technology, I now characterize the socially optimal allocation as follows.

Proposition 2 (Planner's Allocation)**.** *The planner's choices lead to* $\frac{q_l}{q_h} = \pi$ *and a unique cutoff* $\lambda^{SP} \in (0,1)$ *such that*

$$x_i^{SP} = \begin{cases} c'^{-1}\Big(pR + 1 - p + \gamma - \xi_i\Big), & \text{if } i \leq \lambda^{SP} \\ c'^{-1}\Big(pR + 1 - p + \gamma - \xi_{\lambda^{SP}}\Big), & \text{if } i > \lambda^{SP} \end{cases}, \tag{17}$$

$$a_i^{SP} = \begin{cases} x_i^{SP} - x_{i,l} + x_{i,l}\pi, & \text{if } i \leq \lambda^{SP} \\ 0, & \text{if } i > \lambda^{SP} \end{cases}. \tag{18}$$

The social value of every unit of collateral is $\psi^{SP} = \gamma - \xi_{\lambda^{SP}}$.

Similar to the competitive market, the planner divides intermediaries into two groups with distinct liabilities. Cutoff λ^{SP} reflects the socially optimal entry into safe asset production. If this cutoff differs from λ^{CE}, the planner's allocation would be different from the competitive allocation in both the asset and liability sides of the intermediary balance sheet.

Proposition 3 (Welfare Properties)**.** *While every manager is strictly better off than in static securitization, the equilibrium is constrained inefficient. In particular, there is excessive entry into safe asset production, collateral providers underinvest, and the market underproduces safe assets:* $\lambda^{CE} > \lambda^{SP}$, $x_i^{CE} < x_i^{SP}$ *for* $i \in [\lambda^{SP}, 1]$, $A^{CE} < A^{SP}$.

Since managers could choose static securitization but nonetheless prefer their choices in equilibrium, they are better off with secondary market trading. The welfare improvement arises from specialization. The collateral providers, who lack superior technology to securitize loans and thus have smaller balance sheets, specialize in supplying collateral to others. Since the investment technology exhibits diminishing returns to scale, their lending is relatively more productive. Meanwhile, the increased collateral allows the safe debt issuers, who have better securitization technology, to produce a greater supply of safe assets. Despite these benefits, the equilibrium is socially suboptimal.

Figure 8 illustrates the differences between the competitive and planner's allocations. The planner assigns managers $i \in [0, \lambda^{CE}]$ to issue safe debt, and each of them on average issues more than their competitive quantities: $\mathbb{E}[a_i^{SP}] > \mathbb{E}[a_i^{CE}]$. Meanwhile, the planner forces the rest of intermediaries, which are equity financed, to lend more than their competitive levels: $x_i^{SP} > x_i^{CE}$. The area of the shaded region measures aggregate underinvestment, which, by equation (9), equals the quantity of safe asset underproduction.

4.2 Source of Inefficiency

The source of inefficiency is a pecuniary externality that arises from dynamic collateral management: secondary market trades move loan prices, which in turn affect the constraints commonly faced by all managers. At the root of these price-dependent constraints is the inability of agents to allocate current and future quantities with state-contingent contracts. Individual managers take loan prices as given when maximizing their own payoffs and do not internalize the externality.

Given that managers have different securitization technology, efficiency hinges on an optimal specialization of safe debt issuance and collateral provision at both the intensive and extensive margins. However, competitive prices tighten binding collateral constraints in period $t = 0$, which prevents such an ideal specialization. By internalizing the effects of individual choices on secondary market demand and supply, the planner achieves a price ratio that is unsustainable in the competitive market. This price ratio relaxes collateral constraints for all intermediaries, thereby allowing the planner to implement the ideal specialization.

An intuitive interpretation of the constrained inefficiency is that secondary market trading gives rise to a "public goods problem": managers have a tendency to exploit the collateral provided by others rather than originate loans that benefit others. The discrepancy between individual and social tradeoffs that causes the welfare loss is twofold.

Corollary 3.1. *Equity-financed intermediaries' private profit from providing collateral in the secondary market is lower than the social value of collateral:* $(1-p)(\pi\frac{q_h}{q_l} - 1) < \psi^{SP}$.

On the asset side, there is an underinvestment among managers with inferior securitization technology.[28] The planner forces these managers to lend beyond their privately-optimal quantities, which allows other managers, who have superior technology, to issue more safe debt. In the competitive market, the collateral providers do not fully internalize the social value of collateral, and their lending choices limit the secondary market supply of high-quality loans and cause the underproduction of safe assets.

Corollary 3.2. *For managers with mediocre securitization technology, the private benefit of issuing safe debt is lower than the social value of collateral:* $\gamma - \xi_i < \psi^{SP}$ *for* $i \in (\lambda^{SP}, \lambda^{CE})$.

On the liability side, safe debt issuance by managers with mediocre technology crowds out managers with superior technology. Unlike the planner who cares about the efficiency of safe asset production, managers only care about their own cost of financing. As a result, too large a fraction of intermediaries find it privately optimal to issue safe debt, and the market produces safe assets at a inefficiently high average cost.

[28]For managers in $[0, \lambda^{SP}]$, individually and socially optimal lending choices coincide, because they directly benefit from, and hence fully internalize, the collateral value of risky loans.

4.3 Policy Intervention

The previous subsection has shown that the equilibrium has excessive entry into safe asset production. In this subsection, I analyze a particular policy that imposes an entry cost on managers who operate safe debt-financed intermediaries.

Suppose the policy incurs a cost $\zeta_i \in \mathbb{R}_+$ in the beginning of period $t = 0$ if manager i issues safe debt of any quantity $a_i > 0$.[29] For generality, the cost can be an arbitrary (weakly) increasing function of index $i \in \mathcal{I}$. This allows for any monotonic heterogeneity in the policy's impact: it's possible that a less resourceful manager (i.e., having a higher safe debt issuance cost ξ_i) also faces a higher policy-induced entry cost.

Under this policy, the manager's optimization problem in period $t = 0$ exhibits a discontinuity at $a_i = 0$. Given a binary choice between $a_i = 0$ and $a_i > 0$, I call the solution to (P0a) as *locally optimal* choices. These choices are characterized by the same conditions (6)–(8).

The policy distorts manages' financing choices, which in turn affect their lending choices. If an intermediary issues only equity, the manager's payoff is

$$V_i^e = y_i^e c'^{-1}(y_i^e) - c(c'^{-1}(y_i^e)) - (1-p)\pi x_L\left(\frac{q_h}{q_l} - 1\right), \tag{19}$$

where $y_i^e := pR + (1-p)\pi\frac{q_h}{q_l}$ is the marginal payoff of lending. If the same intermediary issues a locally optimal quantity of safe debt, the manager's payoff is

$$V_i^d = y_i^d c'^{-1}(y_i^d) - c(c'^{-1}(y_i^d)) - (1-p)\pi x_L\left(\frac{q_h}{q_l} - 1\right) - x_L\eta_i\left(1 - \frac{q_l}{q_h}\right) - \zeta_i, \tag{20}$$

where $y_i^d := y_i^e + \eta_i$ is the manager's marginal payoff from lending, which includes collateral value η_i. Note that V_i^d is strictly increasing in η_i, which itself decreases in index i.[30] This implies that V_i^d is strictly larger for a smaller i. Since V_i^e is identical across i, others equal,

[29] This timing convention is for simplicity: the financing choice does not depend on the realization of idiosyncratic loan quality shocks.

[30] The monotonicity in η_i can be seen from $\frac{\partial V_i^d}{\partial \eta_i} = c'^{-1}(y_i^d) - x_{i,l}(1 - \frac{q_l}{q_h}) > c'^{-1}(y_i^d) - x_{i,l} > 0$, where the last inequality follows from assumption 2 because $y_d > pR + 1 - p$ by lemma 2.

only managers better at securitization issue safe debt.

To be consistent with previous sections, I use λ to denote the manager type that is *locally indifferent* between issuing safe debt and issuing only equity, so this type satisfies equation (10). Since the indifference is local (i.e., it is conditional on $a_i > 0$) and does not reflect globally optimal choices, $\lambda \leq 1$ no longer has to hold; Instead, lemma 2 and equation (10) imply that λ is now upper bounded by $\frac{\gamma}{2\xi} > 1$. I denote the new cutoff type $\iota : [0, \frac{\gamma}{2\xi}] \mapsto [0, 1]$ as a function of λ. This type satisfies a global indifference condition

$$V^d_{\iota(\lambda)} = V^e_i. \tag{21}$$

Given loan prices, and hence λ, there will be a unique cutoff type $\iota(\lambda) < \lambda$ because $\zeta_i > 0$ and V^d_i is monotonic in i. When the entry cost approaches zero, the new cutoff converges to λ: $\lim_{\bar{\zeta}\to 0+} \iota(\lambda) = \lambda$, where $\bar{\zeta} := \max_{i\in\mathcal{I}} \zeta_i$, .

4.3.1 Equilibrium under an Entry Cost

Equilibrium under the policy can be defined similarly as definition 1, except for that the manager's $t = 0$ problem takes the entry cost into consideration. The limiting property of $\iota(\lambda)$ indicates that, by continuity of the equilibrium in model parameters, an interior equilibrium exists when $\bar{\zeta}$ is relatively small. Let λ^{DE} and $\iota(\lambda^{DE})$ respectively denote the locally indifferent type and the cutoff type in the policy-distorted equilibrium.

Proposition 4 (Distorted Equilibrium)**.** *The entry-cost policy reduces the fraction of safe debt issuers, allows the remaining issuers to issue more safe debt, but worsens the underproduction of safe assets:* $\iota(\lambda^{DE}) < \lambda^{CE}$, $\mathbb{E}[a_i^{DE}] > \mathbb{E}[a_i^{CE}]$ *for* $i \in [0, \iota(\lambda^{DE})]$, $A^{DE} < A^{CE}$.

Proposition 4 demonstrates that, while the policy corrects the excessive entry into safe asset production, it may exacerbate the welfare loss through equilibrium effects. Since the entry cost deters managers from issuing safe debt, there is less pressure on secondary market prices. One the one hand, a higher price ratio relaxes the remaining issuers' collateral constraints and allows them to issue more safe debt. On the other hand, providing collateral in the secondary market becomes less profitable, which discourages the collateral providers' investment. As a larger fraction of managers become collateral providers and choose the decreased investment level, the policy leads to a reduction in collateral. In aggregate, the aforementioned increase in safe debt issuance is overwhelmed by the decrease in collateral, and the market ends up producing even fewer safe assets after the policy intervention.

Figure 9 compares the competitive allocation (same as Figure 7) and the policy-distorted allocation. While managers $i \in [0, \iota(\lambda^{DE})]$ do not change their lending choices, managers currently operating equity-financed intermediaries ($i \in [\iota(\lambda^{DE}), 1]$) all lower their investment levels. This leads to a reduction in aggregate high-quality loans, the quantity of which equals the area of the shaded region. Despite that every safe-debt financed intermediary on average issues more than before ($\mathbb{E}[a_i^{DE}] > \mathbb{E}[a_i^{CE}]$), the market underproduces safe assets to an even greater extent because of a shortage of collateral.

4.3.2 Credit Risk Retention Regulation

The above analysis sheds light on a controversial regulation in the leveraged loan market. The regulation, generally referred to as Credit Risk Retention Rule, was initially proposed by 6 federal agencies (collectively, "regulators") in 2011 to implement the credit risk retention requirements of the Dodd-Frank Act. The rule requires "sponsors" of securitization transactions to retain at least 5% of un-hedged credit risk of collateral assets for any asset-backed securities (ABS). Sponsors can choose to retain 5% of each class of securities ("vertical retention"), a part of the first-loss interest that has a fair value of 5% of all ABS interests ("horizontal retention"), or any convex combination of the two.[31] The final rule became effective for residential mortgage-backed securities (RMBS) in December 2015 and for other

[31] See SEC Final Rules 34-73407 for more details.

ABS, including CLOs, in December 2016.

Since the rule's initial proposal, its inclusion of CLOs received considerable resistance from practitioners. The major complaint is that the rule imposes substantial capital and operational costs on asset managers and might drive them out of the CLO business.[32] In November 2014, the Loan Syndications and Trading Association (LSTA), representing CLO managers, filed a lawsuit against the Federal Reserve and the SEC. In February 2018, the US Court of Appeals for the D.C. Circuit concluded that managers of open-market CLOs are not "sponsors" under the Dodd-Frank Act and are not subject to the requirements of the Risk Retention Rule. Consequently, CLO managers became exempted from the rule in May 2018.

I empirically investigate the regulation's effect, which the LSTA and CLO managers claimed to be devastating, by exploiting the fact that virtually the same policy was imposed on the European CLO market before the US market. Figure 10 shows the timing of the regulatory events and annual average CLO entry rate in the US and European markets between 2000–2019. Before the crisis, an average manager issued more CLOs in the US, but the time trends were similar. Perhaps due to a quick introduction of the policy in the end of 2010, the European CLO market recovered slowly compared to the US market. Since the finalization of the US risk retention policy in late 2014, there has been a salient drop in CLO entry in the US.[33] This drop reversed quickly after the policy got revoked in early 2018.

This regulation's impact on CLO entry has important welfare implications. Proposition 4 has shown the equilibrium outcomes under an entry cost imposed by such a regulation. By deterring CLO entry, the policy potentially worsens the underproduction of safe assets and exacerbates the inherent inefficiency of the leveraged loan market. Therefore, my analysis points to an unintended consequence. As the debate over whether the risk retention rule

[32]See Figure A.8 in the Appendix for additional information on practitioner responses to the regulation.

[33]The US policy became effective in 2016, and this response is likely due to the fact that CLO equity enjoys the option to refinance debt tranches after 2–3 years of non-call period, and the anticipated retention cost at refinancing deterred CLO entry.

should be reapplied to the US market continues, policymakers should take this consequence into consideration.

5 Model Extensions and Discussion

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.

5.1 Safe Debt Maturity

The loan payoff distributions in section 2, 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.[34] The support of the conditional distribution can be any compact subset of $\mathbb{R}_+$ such that $f_h^+, f_h^- > 0$. To simplify

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

the analysis while preserving the intuition, I assume $f_j^+ > F_j^-$ for $j \in \{h, l\}$ and $f_l^- = 0$.[35]

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

$$\int_i \Delta x_{i,j}^s \, \mathrm{d}i + \frac{z_j^s}{q_j^s} = 0 \quad \text{for } j \in \{h, l\}, s \in \{+, -\}. \tag{22}$$

5.1.1 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 repays. The rollover case 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 to earlier sections, I suppress superscripts in net trades, repayment, and loan prices. When

[35] 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.

negative news arrives at $t = 1$, the manager takes prices as given and solves

$$v(x_{i,h}, x_{i,l}, a_i) = \max_{\Delta x_{i,h}, \Delta x_{i,l}, \Delta a_i} \sum_j (x_{i,j} + \Delta x_{i,j}) F_j^- - (a + \Delta a_i), \tag{23}$$

where Δa_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

$$\Delta x_{i,l} f_h^- \frac{q_l}{q_h} + \Delta a_i \Big(1 - \frac{f_h^-}{q_h} \Big) \leq x_{i,h} f_h^- - a_i, \tag{24}$$

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 Appendix, 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 pre-determined by inequality (ICC'). If a desirable action is ex-post infeasible, the manager has to choose an undesirable action to satisfy the collateral constraint.[36]

5.1.2 Outsider Purchase

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

$$z_j(q_j) = \begin{cases} +\infty, & (1-p)\Big(\frac{F_j^-}{q_j} - 1\Big) > \kappa \\ \forall z \in \mathbb{R}_+, & (1-p)\Big(\frac{F_j^-}{q_j} - 1\Big) = \kappa \\ 0, & (1-p)\Big(\frac{F_j^-}{q_j} - 1\Big) < \kappa \end{cases}. \tag{25}$$

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.

5.1.3 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 5 (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.*

[36] For instance, when short-term contract allows for greater safe debt capacity (i.e., $a_i \leq x_{i,h}q_h + x_{i,l}q_l < a_i \frac{q_h}{f_h^-}$), a manager with short-term safe debt outstanding has to repay in the negative-news stage even if her ex-post desired action is to rollover debt.

(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.[37]

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

[37]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.

5.2 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

$$\hat{x}_{i,h} + \Delta x_{i,h} + \rho(x_{i,l} + \Delta x_{i,l}) \geq m_i. \tag{26}$$

The left hand side of (26) 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 ρ thus captures the manager's limited commitment due to noises in loan quality proxies. The larger ρ is, the more low-quality loans the manager can mix into the required quantity m_i of qualified holdings. As ρ 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.[38]

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 ρ units towards the requirement. When ρ 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}

[38]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 ρ 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 6 (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*

$$\rho\Big((x_{i,h} - a_i)\frac{q_h}{q_l} + x_{i,l}\Big) + \bar{\epsilon} \leq a_i^{oc} \leq \Big((x_{i,h} - a_i)\frac{q_h}{q_l} + x_{i,l}\Big)\frac{q_l}{q_h}. \tag{27}$$

Proposition 6 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 ρ for condition (27) to be feasibly satisfied.

6 Concluding Remarks

Securitization is the transformation of risky loans into tranches with different cash flow priorities. Facing the demand for safe assets, the private sector has created large quantities senior tranches, but many of these securities defaulted in or after the 2008–2009 financial crisis. They failed because the quality of their underlying loans deteriorated and subsequently generated insufficient cash flows for repayment.

This paper analyzes an innovative form of securitization that is based on dynamic collateral management. The most important application of this approach is in the rapidly growing leveraged loan market, where CLOs have been producing AAA-rated securities for more than two decades and have not ever failed.

The assets and liabilities of CLOs are dynamically governed by a contract design that obligates the managers to maintain collateral quality thorough secondary market loan trading. To understand how this contract facilitates safe asset production, I develop an equilibrium model in which asset managers flexibly choose liabilities and can commit to future loan trades. The model explains the unique market structure whereby CLOs and other intermediaries coexist and trade as counterparties in economic downturns. While the market produces more safe assets beyond static securitization, the competitive equilibrium tends to be constrained Pareto inefficient. My analysis provides an equilibrium view of the leveraged loan market and new policy implications.

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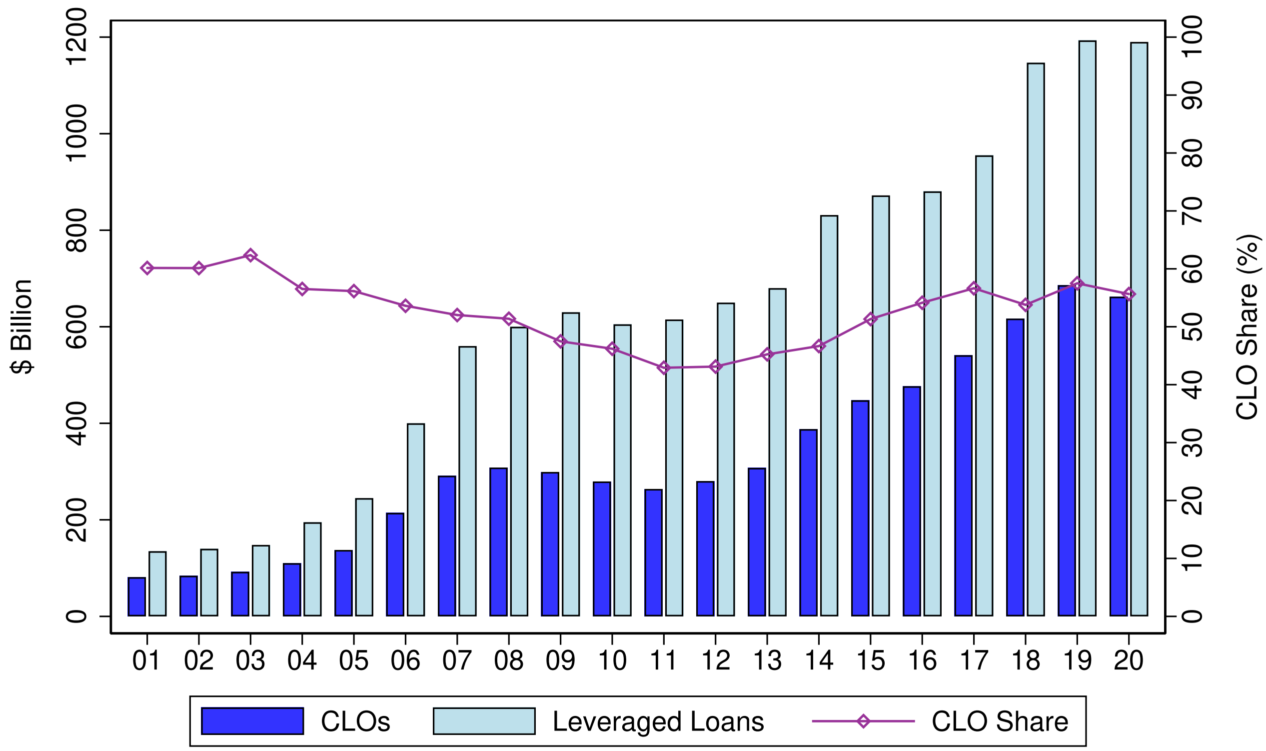


Figure 1: **Leveraged loans and CLOs outstanding, 2001–2020.**
This figure plots annual aggregate par values outstanding for leveraged loans (i.e., institutional term loan facilities) and CLOs in the US market. Data source: SIFMA.

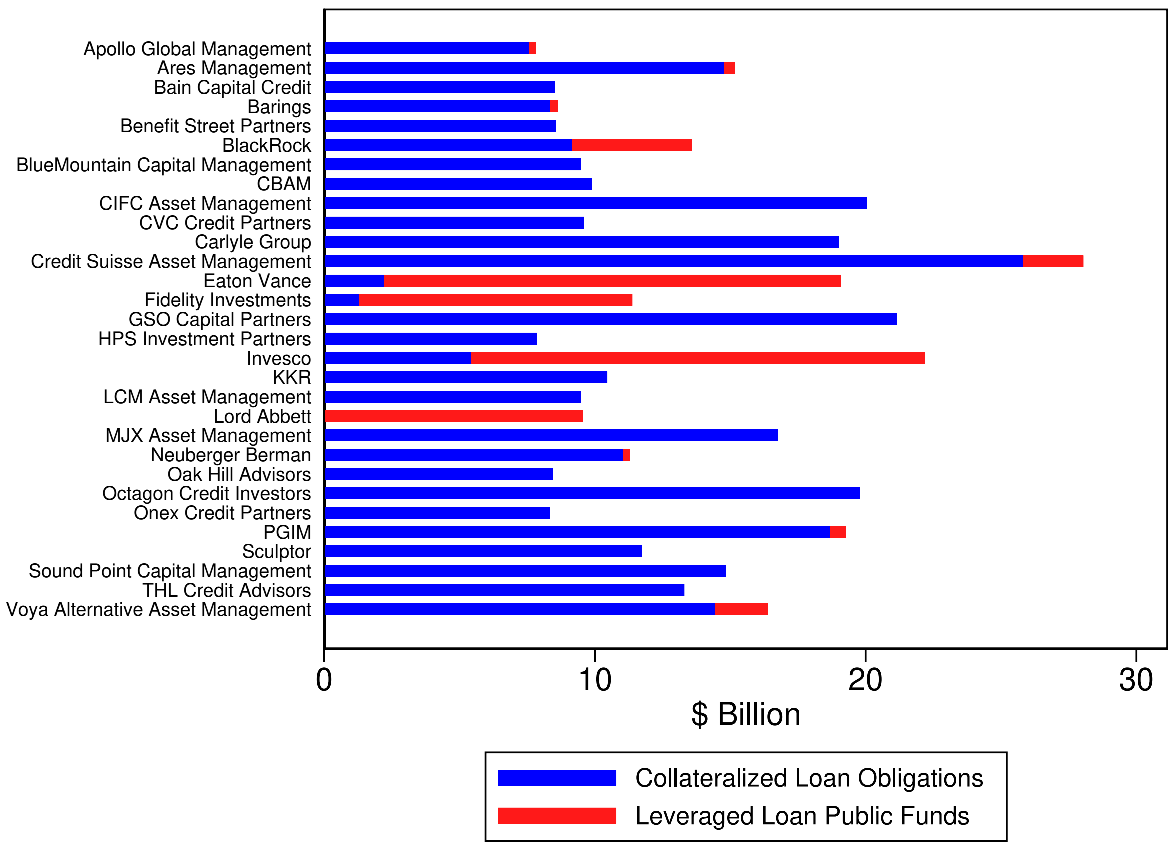
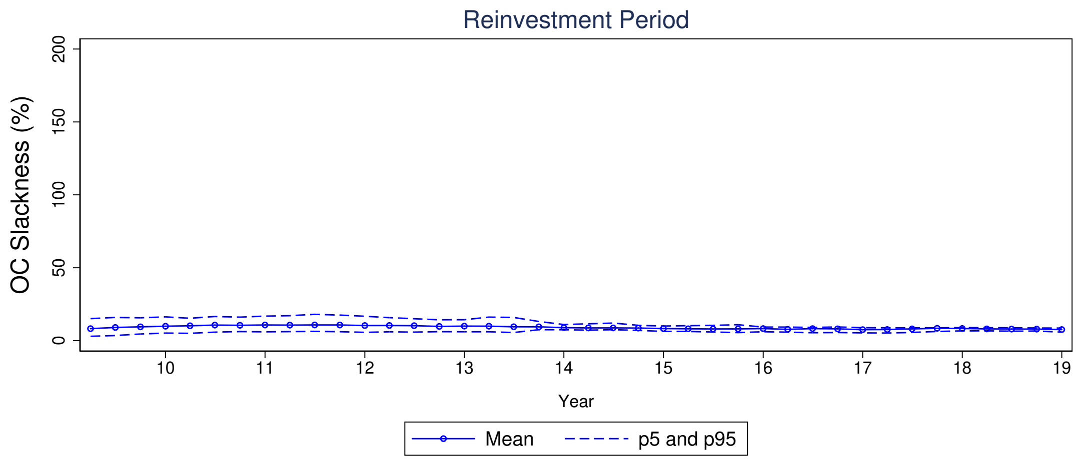
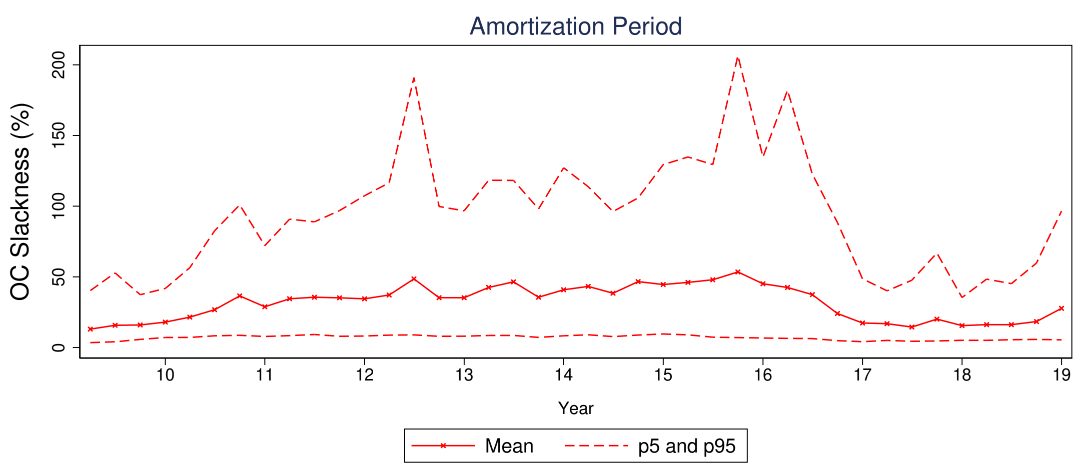


Figure 2: **Asset managers and nonbank intermediaries.**
This figure presents the size of assets under management for US CLOs and leveraged loan funds (open-end and closed-end mutual funds and exchange-traded funds) operated by the 30 largest asset managers at the end of 2019. Data come from Creditflux CLO-i, Morningstar, and the SEC's Form ADV databases.

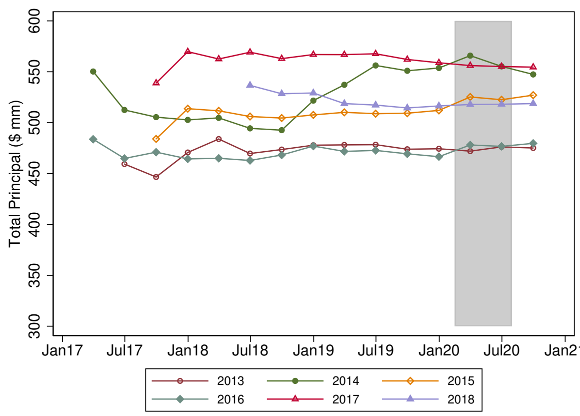


(a) CLOs in Reinvestment Period

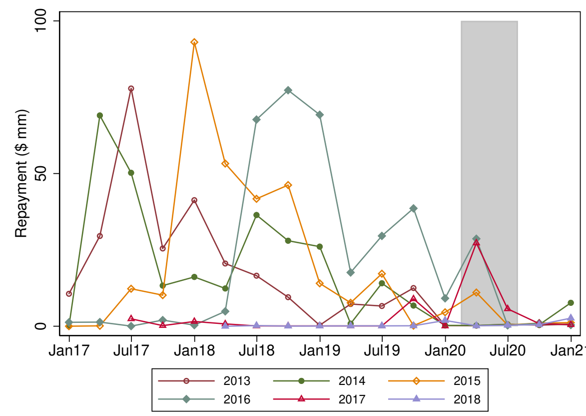


(b) CLOs in Amortization Period

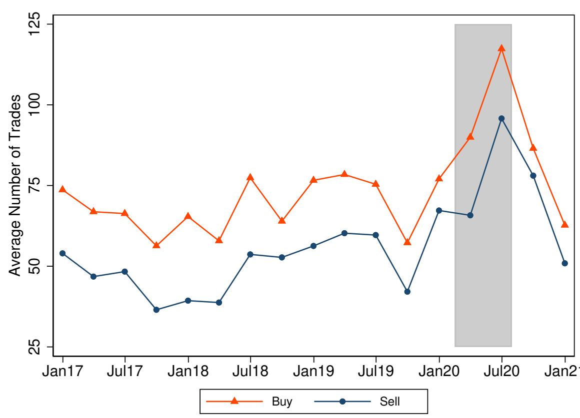
Figure 3: **Slackness of senior tranche over-collateralization constraint.**
This figure presents quarterly time series of cross-sectional dispersion in the slackness of CLO senior tranche over-collateralization (OC) constraints between 2010–2019. The slackness is defined as extra OC score scaled by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



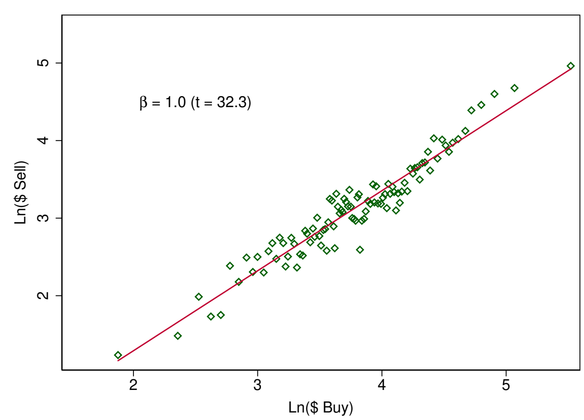
(a) Portfolio Total Loan Holdings



(b) Accelerated Debt Repayment

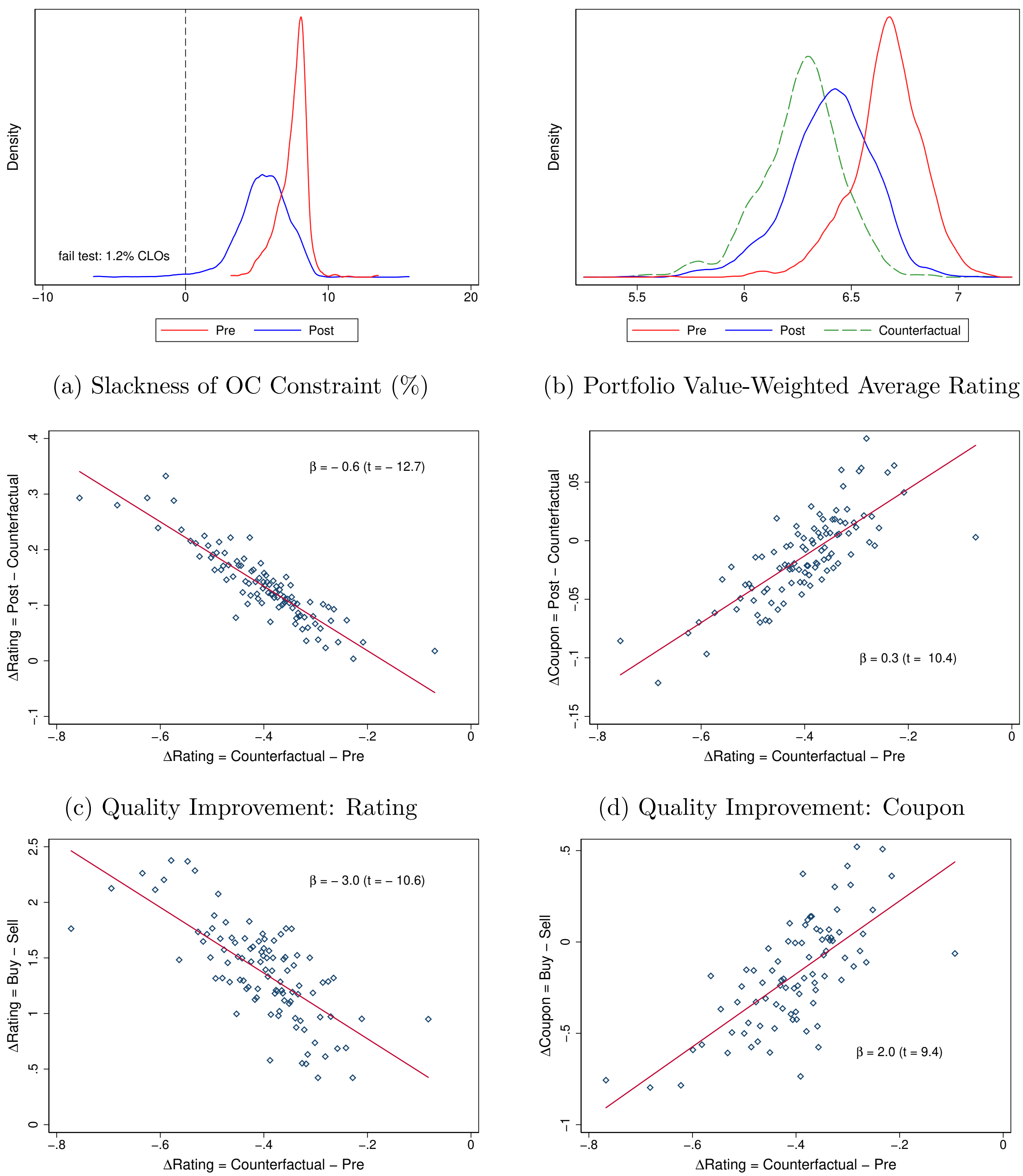


(c) Quarterly Loan Trades



(d) Individual CLOs' Purchases and Sales

Figure 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

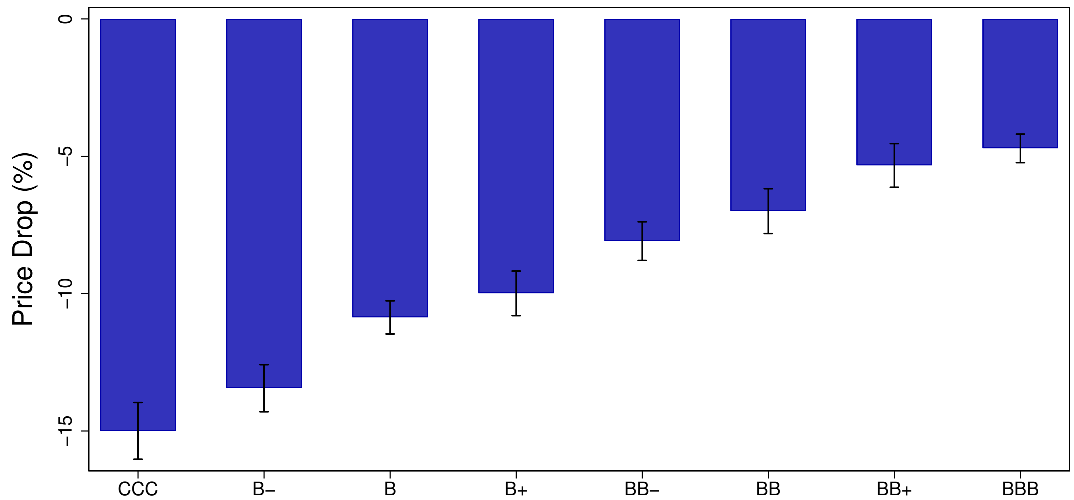
(c) Quality Improvement: Rating

(d) Quality Improvement: Coupon

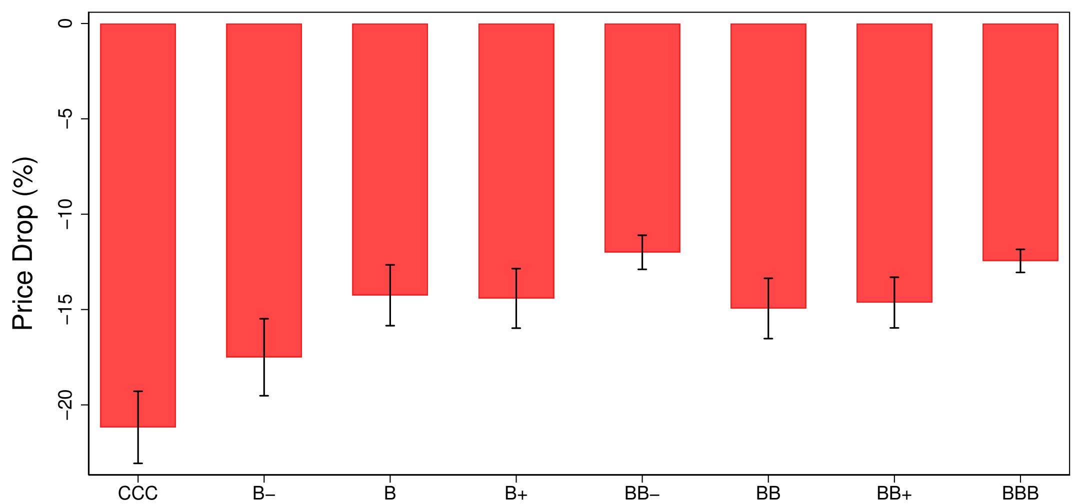
(e) Trading Direction: Rating

(f) Trading Direction: Coupon

Figure 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 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.

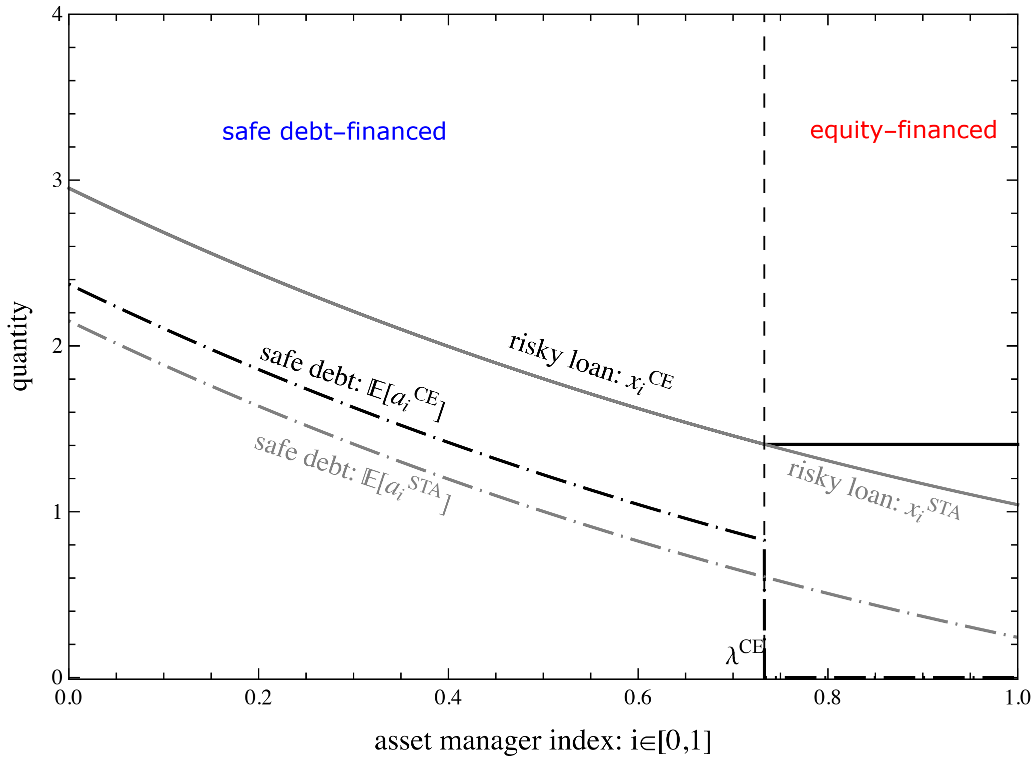


Figure 7: **Competitive equilibrium.**
This figure illustrates the lending and financing choices in competitive equilibrium. Superscripts CE and STA indicate the equilibrium with a secondary market and the static benchmark, and x_i and $\mathbb{E}[a_i]$ denote manager i's quantities of loan origination and average safe debt issuance, respectively. Functional form and parameter values: $c(x) = x^{1.2}$, $p = 0.95$, $R = 1.2$, $\pi = 0.8$, $\gamma = 0.3$, $\xi = 0.14$, $x_L = 0.8$.

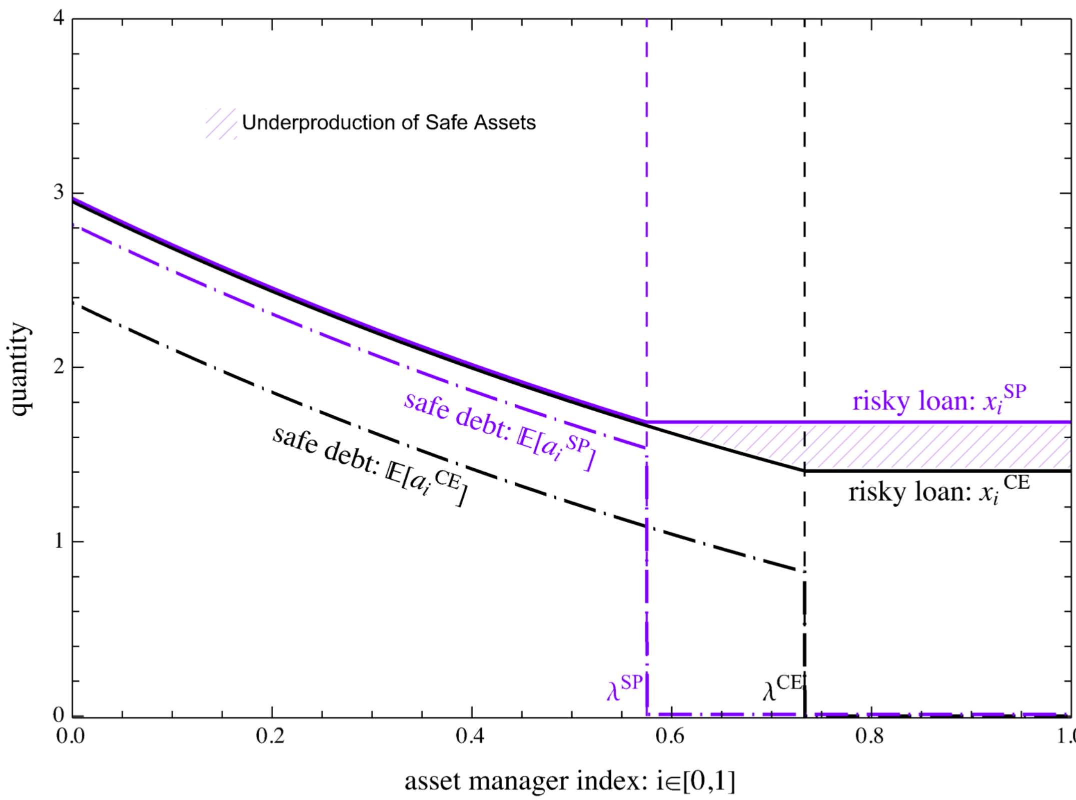


Figure 8: **Constrained inefficiency.**
This figure illustrates the constrained efficiency of the equilibrium. Superscripts CE and SP indicate the competitive and the social planner's allocations, and x_i and $\mathbb{E}[a_i]$ denote manager i's quantities of loan origination and average safe debt issuance, respectively. The area of the shaded region represents the quantity of underproduction of safe assets in equilibrium. Functional form and parameter values are the same as in Figure 7.

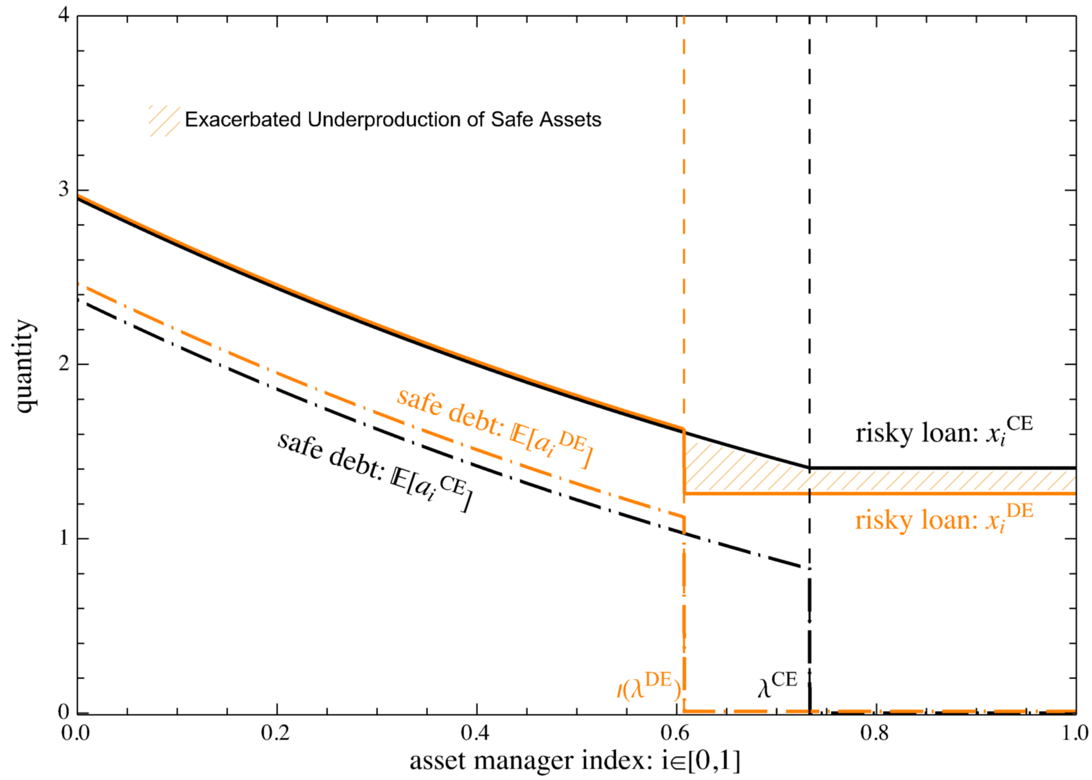


Figure 9: **Equilibrium under the entry cost policy.**
This figure illustrates the equilibrium when an entry cost is imposed any intermediaries that issue safe debt. Superscripts CE and DE indicate the original and distorted competitive allocations, and x_i and $\mathbb{E}[a_i]$ denote manager i's quantities of loan origination and average safe debt issuance, respectively. The area of the shaded region represents the quantity of incremental underproduction of safe assets in distorted equilibrium. Entry cost $\zeta_i = \zeta i$, $\zeta = 0.1$, and other functional form and parameter values are the same as in Figure 7.

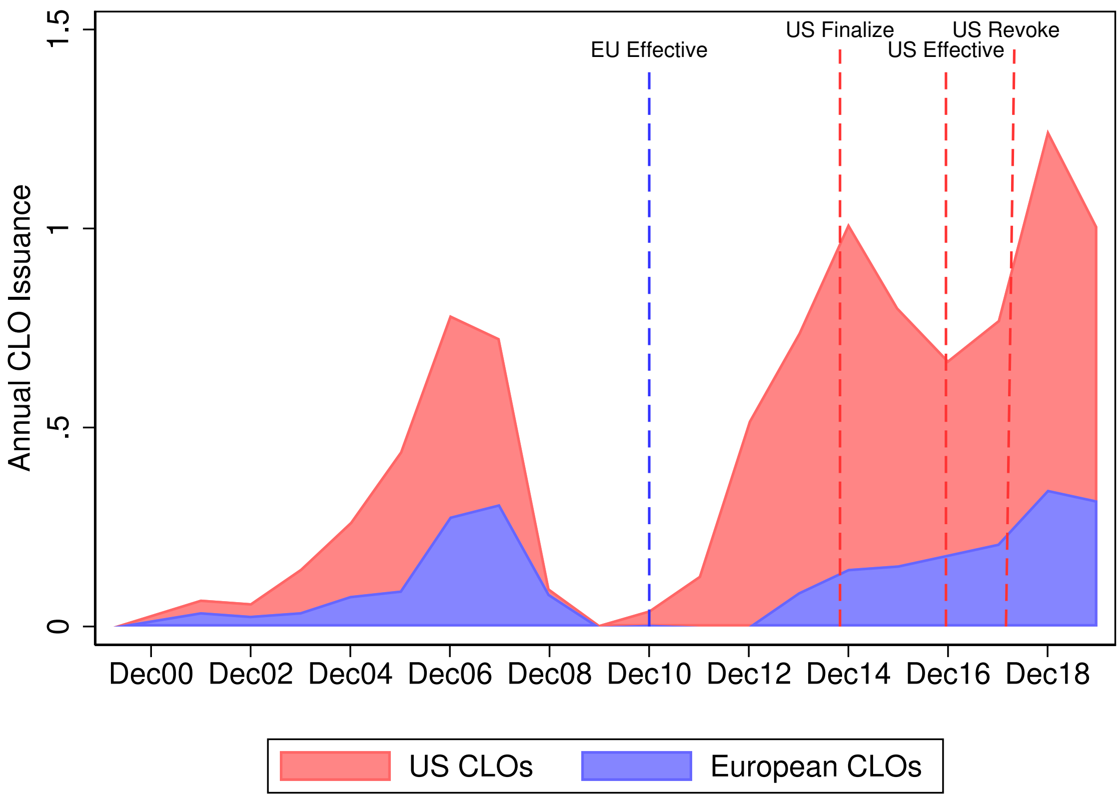


Figure 10: **Risk retention and CLO entry in the US and European markets.** This figure plots the timing of regulatory events and annual average number of an asset manager's CLO deals issued in the US and European markets. The Capital Requirements Directive II introduced in Europe requires 5% risk retention for all new securitization deals issued after January 2011. These provisions were superseded by an equivalent requirement in Capital Requirements Regulation in January 2014. In the US, the Credit Risk Retention Rule, finalized in October 2014 to require a 5% risk retention, became effective for CLOs in December 2016 and got revoked in February 2018.

Online Appendices

Appendix A Proofs

Proof of Lemma 1. Without a secondary market, $\Delta x_{i,h}^s = \Delta x_{i,l}^s = 0$ for all i, s, and constraint (ICC) becomes $a_i \leq x_{i,h}$. The objective in (P0) is strictly increasing in a_i by assumption 1, so this constraint binds at a_i^{STA}. The first-order condition with respect to x_i is $pR + 1 - p - c'(x_i) + \gamma - \xi_i = 0$, which characterizes the lending choice x_i^{STA}.

Proof of Lemma 2. Suppose otherwise (i.e., $\frac{q_l}{q_h} > \pi$), the objective in program (P1a) would be strictly decreasing in $\Delta x_{i,l}$, and the optimal choice would be $\Delta x_{i,l} = -x_{i,l}$ for all $i \in \mathcal{I}$. This contradicts the low-quality loan's market clearing condition in (4).

Proof of Lemma 3. The complementary slackness condition (8) requires $\eta_i, \mu_i \geq 0$ to not be simultaneously positive for any $i \in \mathcal{I}$. Suppose $\xi_i = \xi^*$ for all i, the manager's first-order condition (7) implies that $\eta_i - \mu_i$ is a constant across all i. If $\eta_i > 0$ for all i or if $\mu_i > 0$ for all i, equation (9) is violated, so $\eta_i = \mu_i = 0$ for all $i \in \mathcal{I}$. This implies that $\frac{q_l}{q_h} = \frac{(1-p)\pi}{1-p+\gamma-\xi^*}$, $x_i = c'^{-1}(pR + 1 - p + \gamma - \xi^*)$, and any $\left\{a_i : a_i \leq x_{i,h} + x_{i,l}\frac{q_l}{q_h}\right\}_{i\in\mathcal{I}}$ that satisfies equation (9) is an equilibrium. Also, by equation (9), the supply of safe assets is the same as in the static benchmark because that $x_i = x_i^{STA}$ in lemma 1 for all $i \in \mathcal{I}$.

Proof of Proposition 1. If a competitive equilibrium exists, the cutoff type's indifference condition (10) implies that

$$\frac{q_l}{q_h} = \frac{(1-p)\pi}{1-p+\gamma-\xi_\lambda}, \tag{A1}$$

which is well-defined and strictly positive by assumption 1. The two groups of intermediaries' lending choices follow from substituting η_i and (A1) into (6). Given the two groups' optimal safe debt choices and secondary market trades in (5), the market clearing condition (4) can be rewritten as

$$\frac{q_l}{q_h}\int_0^{\lambda} x_{i,l}\,\mathrm{d}i = \int_{\lambda}^{1} x_{i,h}\,\mathrm{d}i. \tag{A2}$$

By law of large numbers, $\int_0^{\lambda} x_{i,l}\,\mathrm{d}i = \lambda x_L$, and $\int_{\lambda}^{1} x_{i,h}\,\mathrm{d}i = (1-\lambda)(x_i - x_L)$. Both $\frac{q_l}{q_h}$ and x_i can be written as functions of λ, so the two equations (A1) and (A2) are equivalent to a single condition $\chi^{CE}(\lambda) = 0$, where the aggregate excess demand $\chi^{CE} : [0,1] \mapsto \mathbb{R}$ is defined as:

$$\chi^{CE}(\lambda) = \frac{\lambda(1-p)\pi x_L}{1-p+\gamma-2\xi\lambda} - (1-\lambda)\Big(c'^{-1}\Big(pR + 1 - p + \gamma - 2\xi\lambda\Big) - x_L\Big). \tag{A3}$$

The excess demand function satisfies $\chi^{CE}(0) = x_L - c'^{-1}(pR + 1 - p + \gamma) < 0$ by assumption 2 and $\chi^{CE}(1) = \frac{(1-p)\pi x_L}{1-p+\gamma-2\xi} > 0$, so the existence of a real root follows from intermediate value theorem. Moreover, by the properties of c, χ^{CE} is continuous and strictly increasing on $[0,1]$, so the root is unique.

Proof of Lemma 4. Substitute the equilibrium price ratio in lemma 3 into problem (P0a), it follows that the objective is independent to a_i. Manager welfare is the same as in static securitization because the lending choice x_i coincides with that in lemma 1.

Apply similar arguments as in the proof of lemma 3 to the planner's optimality conditions (14)-(16), it follows that $\eta_i^{SP} = \mu_i^{SP} = 0$, $\psi^{SP} = \gamma - \xi^*$, $x_i = c'^{-1}(pR + 1 - p + \gamma - \xi^*)$, and any $\{a_i : a_i \le x_{i,h} + x_{i,l}\pi\}_{i\in\mathcal{I}}$ that satisfies the binding aggregate collateral constraint (ACC) is constrained efficient. Note for any realization of $\{\tilde{x}_{i,l}\}_{i\in\mathcal{I}}$, the set of competitive allocation is a subset of the planner's allocation, so every competitive allocation is constrained efficient.

Proof of Proposition 2. Individual collateral constraint (ICC) faced by the planner must be slack for a proper subset of intermediaries, otherwise aggregate collateral constraint (ACC) would be violated. By monotonicity of ξ_i in i, equation (15) implies that there exists some $\lambda \in (0,1)$, such that $\eta_i^{SP} = \gamma - \xi_i - \psi^{SP} > 0, \mu_i^{SP} = 0$ for each $i \in [0,\lambda)$, and $\eta_i^{SP} = 0, \mu_i^{SP} > 0$ for each $i \in (\lambda, 1]$. The planner is indifferent with debt issuance for the cutoff type $i = \lambda$, which satisfies $\psi^{SP} = \gamma - \xi_\lambda$.

The planner's lending choices follow from substituting $\eta_i^{SP} = \max\{\xi_\lambda - \xi_i, 0\}$ and $\psi^{SP} = \gamma - \xi_\lambda$ into (14). Given the cutoff property, the binding constraint (ACC) is equivalent to

$$\pi \int_0^\lambda x_{i,l}\,\mathrm{d}i = \int_\lambda^1 (x_i - x_{i,l})\,\mathrm{d}i, \tag{A4}$$

and the cutoff type λ solves $\chi^{SP}(\lambda) = 0$, where

$$\chi^{SP}(\lambda) = \pi\lambda x_L - (1-\lambda)\Big(c'^{-1}\Big(pR + 1 - p + \gamma - 2\xi\lambda\Big) - x_L\Big). \tag{A5}$$

Similar to χ^{CE} defined in (A3), $\chi^{SP} : [0,1] \mapsto \mathbb{R}$ is continuous, strictly increasing, and satisfies $\chi^{SP}(0) < 0$, $\chi^{SP}(1) > 0$. So cutoff $\lambda^{SP} \in (0,1)$ exists and is unique.

Proof of Proposition 3. I first show that every manager in either of the two groups is strictly better off and then characterize the constrained inefficiency of the equilibrium.

Manager Welfare. The manager payoff in static securitization is

$$V_i^{STA} = px_i^{STA}R + (1-p)(x_i^{STA} - x_{i,l} + \pi x_{i,l}) + (\gamma - \xi_i)a_i^{STA} - c(x_i^{STA}). \tag{A6}$$

For any manager $i \in [0, \lambda^{CE})$, $x_i^{CE} = x_i^{STA}$ and $a_i^{CE} > a_i^{STA} = x_i^{STA} - x_{i,l}$. Substitute x_i^{CE}, a_i^{CE} into (P0a) and collect terms, it follows that $V_i^{CE} = V_i^{STA} + (\gamma - \xi_i)(a_i^{CE} - a_i^{STA}) > V_i^{STA}$. For any manager $i \in (\lambda^{CE}, 1]$, $x_i^{CE} > x_i^{STA}$, $a_i^{CE} = 0$, and $\gamma - \xi_i < (1-p)(\pi\frac{q_h}{q_l} - 1)$. Define $\phi^{CE} = (1-p)(\pi\frac{q_h}{q_l} - 1)$ and $\phi^{STA} = \gamma - \xi_i$. Recognize that x_i^{CE} and x_i^{STA} are solutions to

$$V_i(\phi_i) = \max_{x_i}\ px_iR + (1-p)(x_i - x_{i,l} + \pi x_{i,l}) + \phi_i(x_i - x_{i,l}) - c(x_i). \tag{A7}$$

By the envelope theorem, $\frac{\partial V_i}{\partial \phi_i} > 0$, so $\phi^{CE} > \phi^{STA}$ implies $V_i^{CE} > V_i^{STA}$.

Constrained Inefficiency. By construction, $\chi^{SP}(0) = \chi^{CE}(0)$ and $\chi^{SP}(\lambda) > \chi^{CE}(\lambda), \forall\lambda \in (0,1]$. This implies $\chi^{SP}(\lambda^{CE}) > \chi^{CE}(\lambda^{CE}) = 0$, and hence $\lambda^{SP} \in (0, \lambda^{CE})$ by properties of

χ^{SP}. Using aggregate relationship $A = X - x_L$, it follows that

$$A^{SP} - A^{CE} = X^{SP} - X^{CE} = \int_{\lambda^{SP}}^{1} (x_i^{SP} - x_i^{CE})\,\mathrm{d}i > 0 \tag{A8}$$

because $x_i^{SP} > x_i^{CE}$ for any $i \in (\lambda^{SP}, 1]$ by equations (11) and (17).

Proof of Proposition 4. If an equilibrium exists, the secondary market clearing condition (4) requires

$$\frac{q_l}{q_h} \int_0^{\iota(\lambda)} x_{i,l}\,\mathrm{d}i = \int_{\iota(\lambda)}^{1} \Delta x_{i,h}\,\mathrm{d}i. \tag{A9}$$

The proof is based on an auxiliary lemma on the relationship among equilibrium cutoff types. Given this lemma, the proposition follows immediately from the lending choices as functions of λ in proposition 1 and the aggregate relationship in equation (9).

Lemma A.1. $\iota(\lambda^{DE}) < \lambda^{CE} < \lambda^{DE}$.

I prove the lemma above by contradiction in two steps. Both steps are constructed using the cutoff type condition (10), the market clearing condition (A9), and individually optimal lending choices (11) in proposition 1. The aggregate excess demand equation in policy-distorted market is

$$\chi^{DE}(\lambda) = \frac{q_l}{q_h} \int_0^{\iota(\lambda)} x_{i,l}\,\mathrm{d}i - \int_{\iota(\lambda)}^{1} (x_i - x_{i,l})\,\mathrm{d}i. \tag{A10}$$

For expositional convenience, I use superscript CE to label variables in competitive equilibrium, and I use DE to label variables in the distorted equilibrium under consideration.

Step 1: Suppose $\lambda^{DE} < \lambda^{CE}$, and hence $\iota(\lambda^{DE}) < \lambda^{DE} < \lambda^{CE}$. By equation (10), this implies $(\frac{q_l}{q_h})^{DE} < (\frac{q_l}{q_h})^{CE}$, and hence

$$\left(\frac{q_l}{q_h}\right)^{DE} \int_0^{\iota(\lambda^{DE})} x_{i,l}\,\mathrm{d}i < \left(\frac{q_l}{q_h}\right)^{DE} \int_0^{\lambda^{CE}} x_{i,l}\,\mathrm{d}i < \left(\frac{q_l}{q_h}\right)^{CE} \int_0^{\lambda^{CE}} x_{i,l}\,\mathrm{d}i. \tag{A11}$$

For equity-financed intermediaries, by equation (11), the hypothesized inequality also implies

$x_i^{DE} > x_i^{CE}$, which further implies

$$\int_{\iota(\lambda^{CE})}^1 x_i^{DE}\,\mathrm{d}i > \int_{\lambda^{CE}}^1 x_i^{DE}\,\mathrm{d}i > \int_{\lambda^{CE}}^1 x_i^{CE}\,\mathrm{d}i. \tag{A12}$$

Given equation (A2),

$$\left(\frac{q_l}{q_h}\right)^{CE} \int_0^{\lambda^{CE}} x_{i,l}\,\mathrm{d}i = \int_{\lambda^{CE}}^1 (x_i^{CE} - x_{i,l})\,\mathrm{d}i, \tag{A13}$$

so inequalities (A11) and (A12) jointly imply

$$\left(\frac{q_l}{q_h}\right)^{DE} \int_0^{\iota(\lambda^{DE})} x_{i,l}\,\mathrm{d}i < \int_{\iota(\lambda^{CE})}^1 (x_i^{DE} - x_{i,l})\,\mathrm{d}i. \tag{A14}$$

This contradicts that λ^{DE} solves the zero aggregate excess demand equation $\chi^{DE}(\lambda) = 0$. Clearly, $\lambda^{DE} \neq \lambda^{CE}$ as $\iota(\lambda^{DE}) < \lambda^{DE}$, therefore $\lambda^{DE} > \lambda^{CE}$ if an equilibrium exists.

Step 2: Suppose $\lambda^{CE} < \iota(\lambda^{DE}) < \lambda^{DE}$. Using similar arguments as in Step 1, this inequality implies

$$\left(\frac{q_l}{q_h}\right)^{DE} \int_0^{\iota(\lambda^{DE})} x_{i,l}\,\mathrm{d}i > \int_{\iota(\lambda^{CE})}^1 (x_i^{DE} - x_{i,l})\,\mathrm{d}i, \tag{A15}$$

which is a contradiction as well. This completes the proof.

Proof of Proposition 5. 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 (24) 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 Δa_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 Δa_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 κ is relatively large with respect to γ.

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.[1] Hence, constraint (24) 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

$$V_i^e = y_i^e c'^{-1}(y_i^e) - c(c'^{-1}(y_i^e)) - x_{i,l}\Big(p(F_h^+ - F_l^+) + (y_i^e - pF_h^+)\Big(1 - \frac{q_l}{q_h}\Big)\Big). \quad \text{(A16)}$$

(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

$$V_i^{lt} = y_i^{lt} c'^{-1}(y_i^{lt}) - c(c'^{-1}(y_i^{lt})) - x_{i,l}\Big(p(F_h^+ - F_l^+) + (y_i^{lt} - pF_h^+)\Big(1 - \frac{q_l}{q_h}\Big)\Big). \quad \text{(A17)}$$

(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 $\eta_i^{st} =$

[1] 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

$$V_i^{st} = y_i^{st} c'^{-1}(y_i^{st}) - c(c'^{-1}(y_i^{st})) - x_{i,l}\Big(p(F_h^+ - F_l^+) + (y_i^{st} - pF_h^+)\Big(1 - \frac{q_l}{q_h}\Big)\Big). \quad \text{(A18)}$$

The following observations indicate a pecking order among these liability types. 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 η_i^{lt} and η_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, η_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 (22) 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 (22). So this case cannot exist in equilibrium.

Proof of Proposition 6. 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).

Appendix B Additional Theoretical Analyses

B.1 A Discrete-Type Case

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, constraints on safe debt choices 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, and hence allocations, depend on fraction α. To illustrate the inefficiency in this case, the result below focuses on a subset of α values before the complete analysis of the two-type case. 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 the competitive and planner's choices for the two types, respectively.[2]

Proposition A.1. *Suppose $\xi_i \in \{\underline{\xi}, \bar{\xi}\}$, $\underline{x}^{CE} = \underline{x}^{SP}$ for any $\alpha \in (0, 1)$. When $\alpha \in (\underline{\alpha}^{CE}, \bar{\alpha}^{SP})$ for endogenous cutoffs $0 < \underline{\alpha}^{CE} < \bar{\alpha}^{SP} < 1$, $\underline{a}^{CE} < \underline{a}^{SP} = x_{i,h} + x_{i,l}\pi$, $\bar{a}^{CE} = \bar{a}^{SP} = 0$. Competitive allocation is constrained inefficient: $\bar{x}^{CE} < \bar{x}^{SP}$, and $A^{CE} < A^{SP}$.*

Proof. 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 (6)–(8) and (14)–(16) and the market clearing condition. Figure A.1 summarizes these results. There are four endogenous cutoffs, $0 < \underline{\alpha}^{SP} < \underline{\alpha}^{CE} < \bar{\alpha}^{SP} < \bar{\alpha}^{CE} < 1$, that

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

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 $\underline{\alpha}^{CE} := (\underline{x}-x_L)\Big(\underline{x} - (1 - \frac{(1-p)\pi}{1-p+\gamma-\underline{\xi}}x_L)\Big)^{-1}$. For the planner, both types binding 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 secondary 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 $\underline{\xi}$ slack 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 $\bar{\xi}$ slack 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 α. 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 (9).[3] The

[3]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.

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 $\bar{x}^{CE} < \bar{x}^{SP}$. $\square$

In equilibrium, the price ratio tightens the low-cost type's binding collateral constraints, preventing these managers from issuing socially optimal quantities of safe debt. Behind the direct impact of loan prices, the inefficiency is driven by a deficiency of aggregate collateral. While the low-cost type's lending is socially efficient, high-cost managers underinvest as they fail to fully internalize the social benefits of collateral. As a result, the market underproduces safe assets because of a deficiency of aggregate collateral.

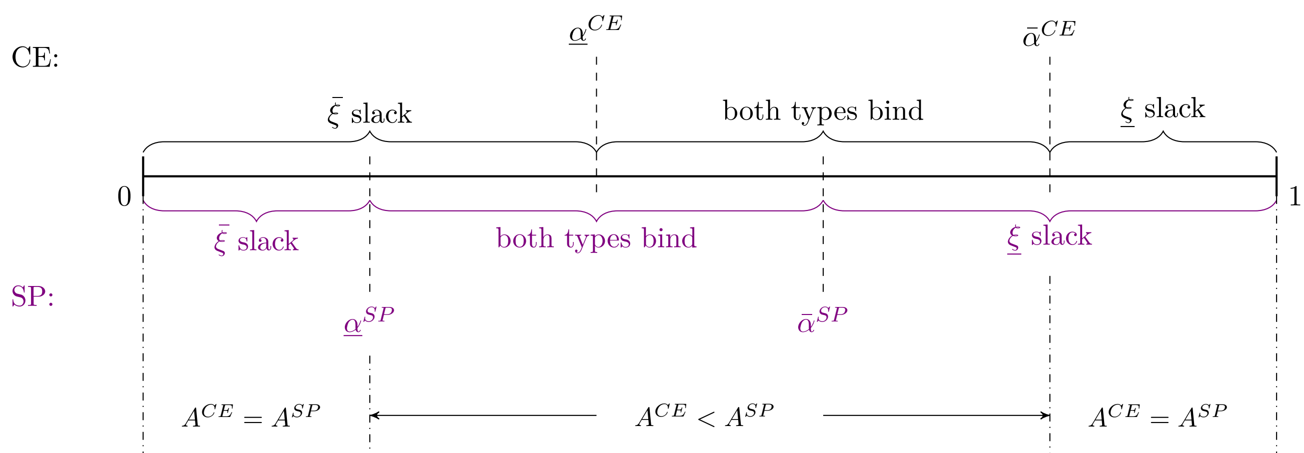


Figure A.1: **Two-type case: competitive and planner's allocations.**
This figure illustrates how the competitive and planned allocations in the two-type case depend on $\alpha \in (0, 1)$, the fraction of low-cost manager type.

B.2 Ideal Policy Intervention

Subsection 4 shows that competitive equilibrium exhibits inefficiency on both sides of the intermediary balance sheet and that policies reducing 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 correct the inefficiency, it is important to design a policy that improves both sides of intermediary balance sheets. Specifically, the policymaker should both reduce entry into safe debt issuance and increase equity-financed intermediaries' lending choices.

If the policymaker's information set includes all model parameters, the implementation of 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 can have a perverse effect if it incentivizes asset managers to lower screening standard and originate large quantities of low-quality loans.[4]

Appendix C Data and Sample Construction

C.1 Data and Sample

The main data used in this study come from Creditflux CLO-i, a database compiled from CLO trustee bank reports. This database provides information on CLO tranches, portfolio loan

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

holdings, loan trades, and collateral test results. To examine safe debt-financed intermediaries' 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 nonmissing, and if its portfolio includes at least 50 leveraged 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.[5] 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 A.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.

[5]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.

C.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), CLO trustee reports do not have fixed scheduled dates, and report dates are usually not 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 non-missing 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 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.[6] 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.[7] 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. 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.

[6]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.

[7]These duplicates are generated when the data vendor scrap data from original trustee reports.

C.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.[8] I then calculate ex-post credit rating (coupon rate) for an ex-ante loan holding as the value-weighted average rating (coupon rate) across all CLOs’ ex-post matched holdings.[9] 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).

Appendix D Supplementary Empirical Results

D.1 CLO Issuance

Figure A.2 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.

[8] 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.

[9] 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.

D.2 Interdependence of Portfolio Choice and Safe Debt Financing

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

$$Quality_{it} = \beta AAA\%_i + \Gamma' Control_{it} + \delta_t + \epsilon_{it}, \tag{D19}$$

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 δ_t, thereby estimating β using only cross-sectional variation. This accounts for the impact of time-varying market conditions on overall leveraged loan quality.

Panel B of Table A.3 presents summary statistics, and Table A.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.[10] 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

[10] CLO age is absorbed by the two groups of fixed effects in columns (3) and (6).

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.[11]

D.3 Estimating the Effect of Risk Retention

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 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 estimate panel regression

$$Entry_{imt} = \beta_0 + \beta_1 USmkt_{im} \times CRR_t + \beta_2 USmkt_{im} + \beta_3 CRR_t + \Gamma' Control_{m,t-1} + \epsilon_{imt}, \quad \text{(D20)}$$

where every observation is an asset 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 β_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.[12]

Panel B of Table A.3 presents summary statistics for this sample, and Table A.5 reports the estimation results. Columns (1) and (4) indicate that the policy reduces the number and

[11] After partialling out time fixed effects, the standard deviation of coupon rate is 0.48%.

[12] While this is admittedly a strong assumption that is unlikely to hold exactly, I argue that estimates tend to understate true magnitude of the effect and thus provide useful lower bounds. This is because, first, without any intervention during 2000–2007, the European market grew slower, and second, the regulation was already imposed on the European market, making it a even slower-growing benchmark.

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.

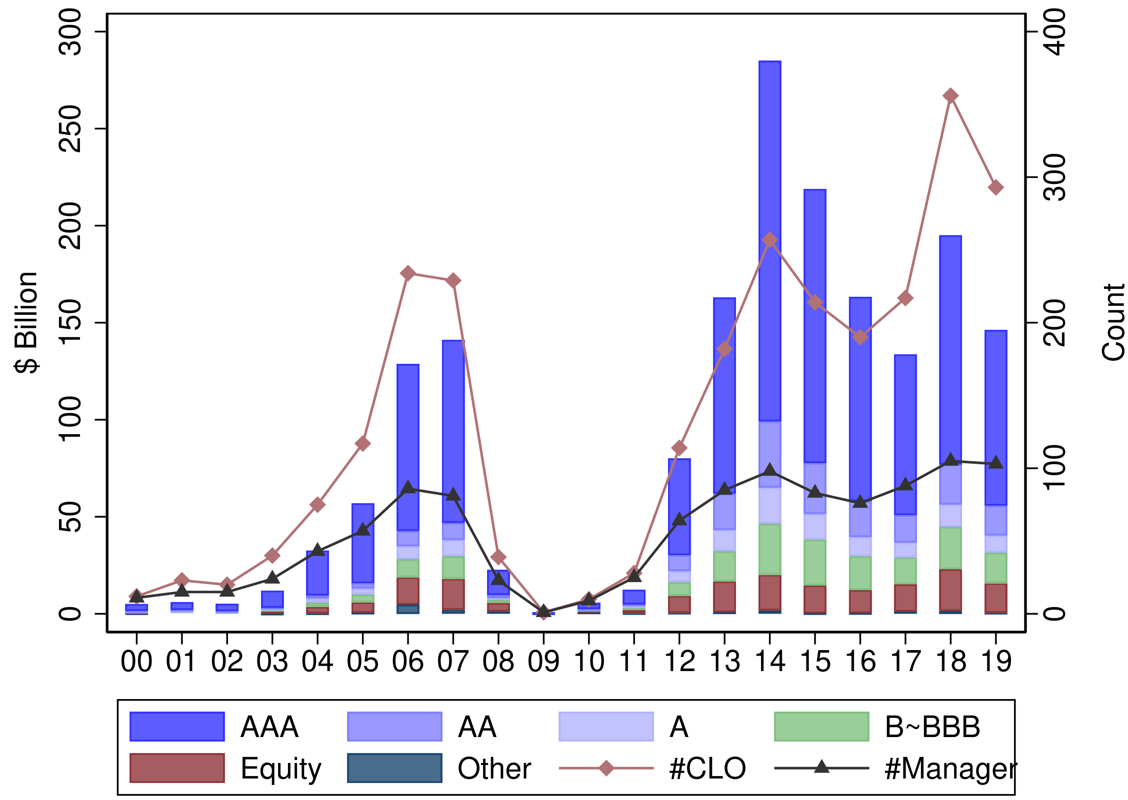


Figure A.2: **Annual CLO issuance, 2000–2019.**
This figure plots annual issuance amount and the numbers of deals and asset managers of open-market CLOs issued in the US and Europe. The issuance amount is decomposed by CLO liability tranches based on initial credit ratings, and tranche size denominated 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.

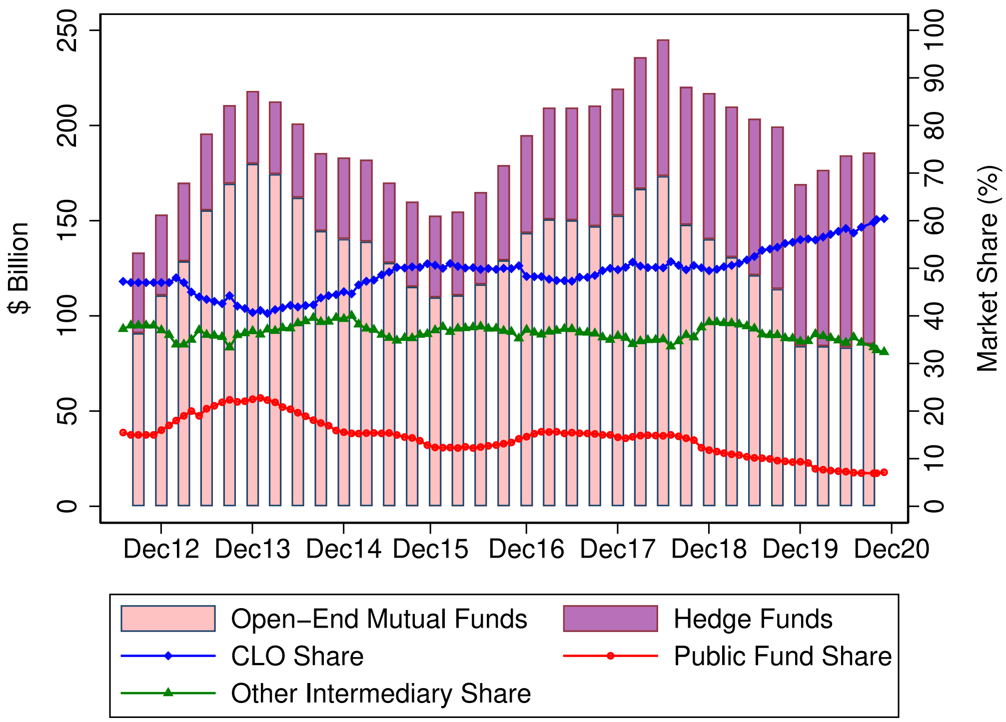


Figure A.3: **Intermediaries in the leveraged loan market, 2012–2020.**
This figure provides more detailed information on the composition of intermediaries in the leveraged loan market. The stacked bars plot total values of leveraged loans held by open-end mutual funds and hedge funds (left axis). The 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.

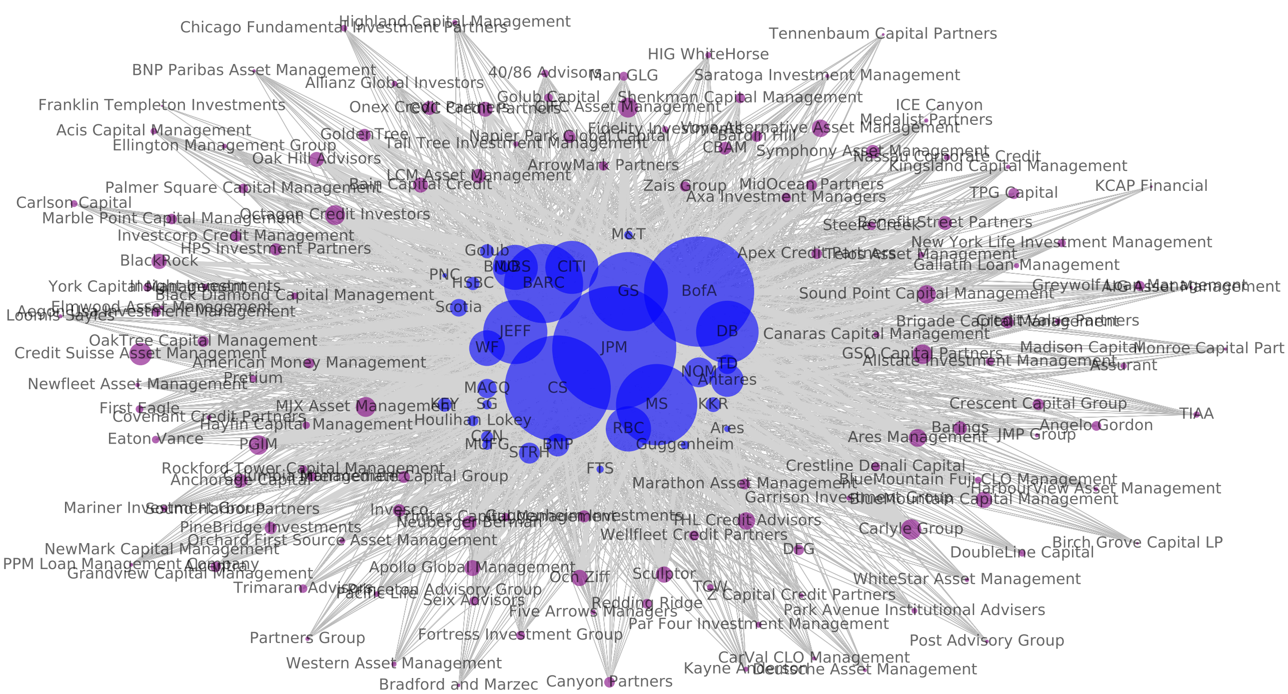
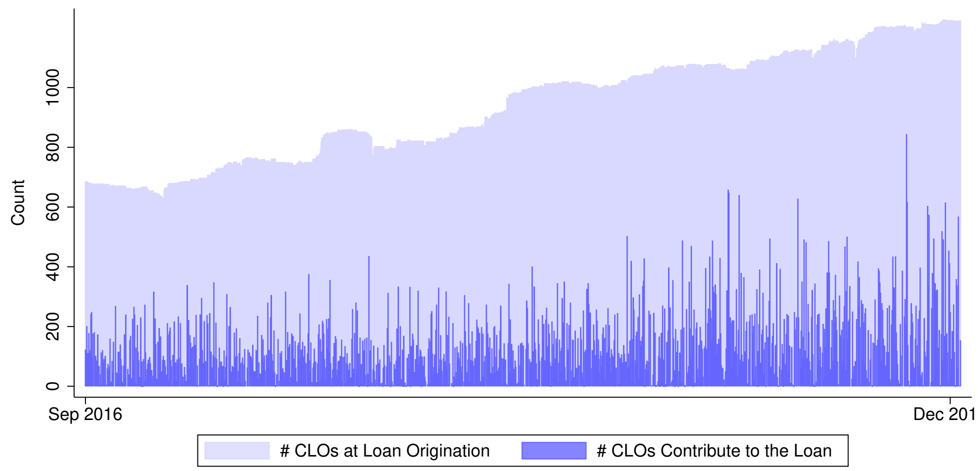
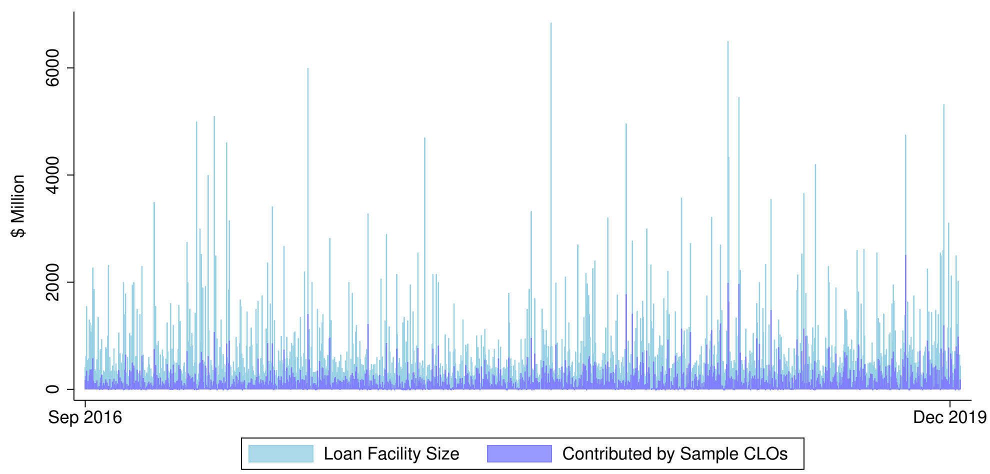


Figure A.4: **Leveraged loan underwriters and CLO managers.**
This figure plots underwriter banks ("lead arranger") and CLO managers between 2016–2019. The size of a blue circle is proportional to the total amount of loans arranged by an underwriter, and the size of a purple circle is proportional to the total amount of loans purchased by a CLO manager. The width of each gray line connecting a lead arranger and a CLO manager represents the total amount of loan sale between the two institutions.



(a) Extensive Margin



(b) Intensive Margin

Figure A.5: **CLO primary market participation.**
This figure presents CLO participation in leveraged loan primary market, as reflected in portfolio reports shortly after the syndication completion. Each vertical bar represents a loan facility. Panel (a) shows the number of CLOs observed at the end of syndication, and the number of CLOs that contribute to the loan. Panel (b) shows the size the each loan and the amount contributed by sample CLOs.

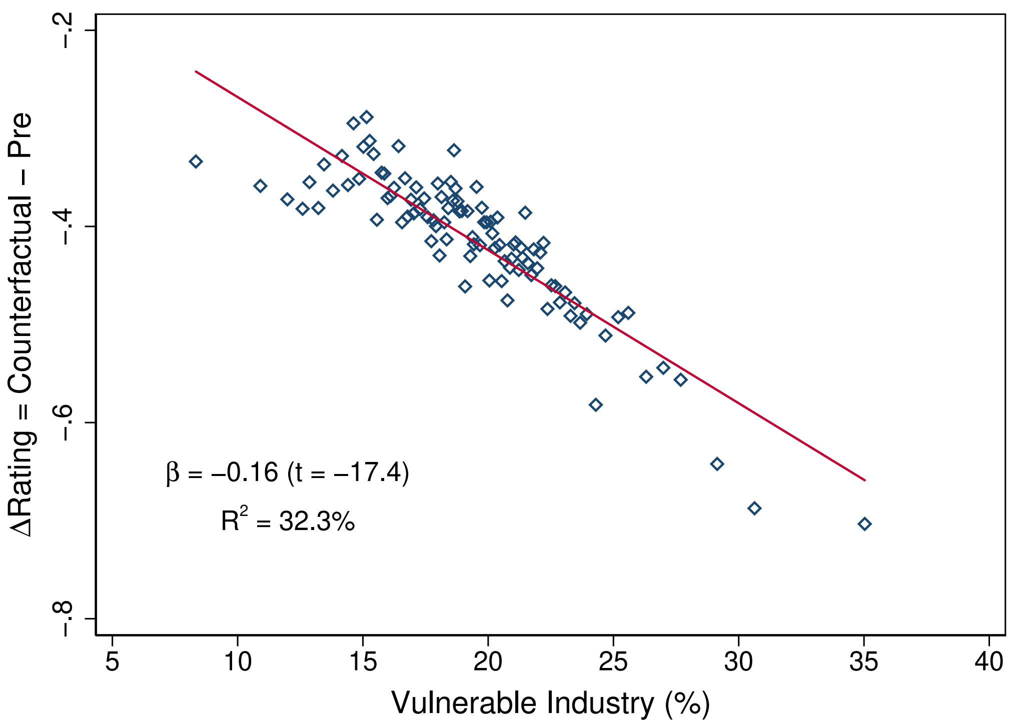


Figure A.6: **Vulnerable industry exposure and counterfactual collateral quality deterioration.**
This figure is a scatter plot that groups CLOs into 100 bins by portfolio weight in industries vulnerable to the COVID-19 pandemic before February 15, 2020 and depict the average counterfactual portfolio 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.

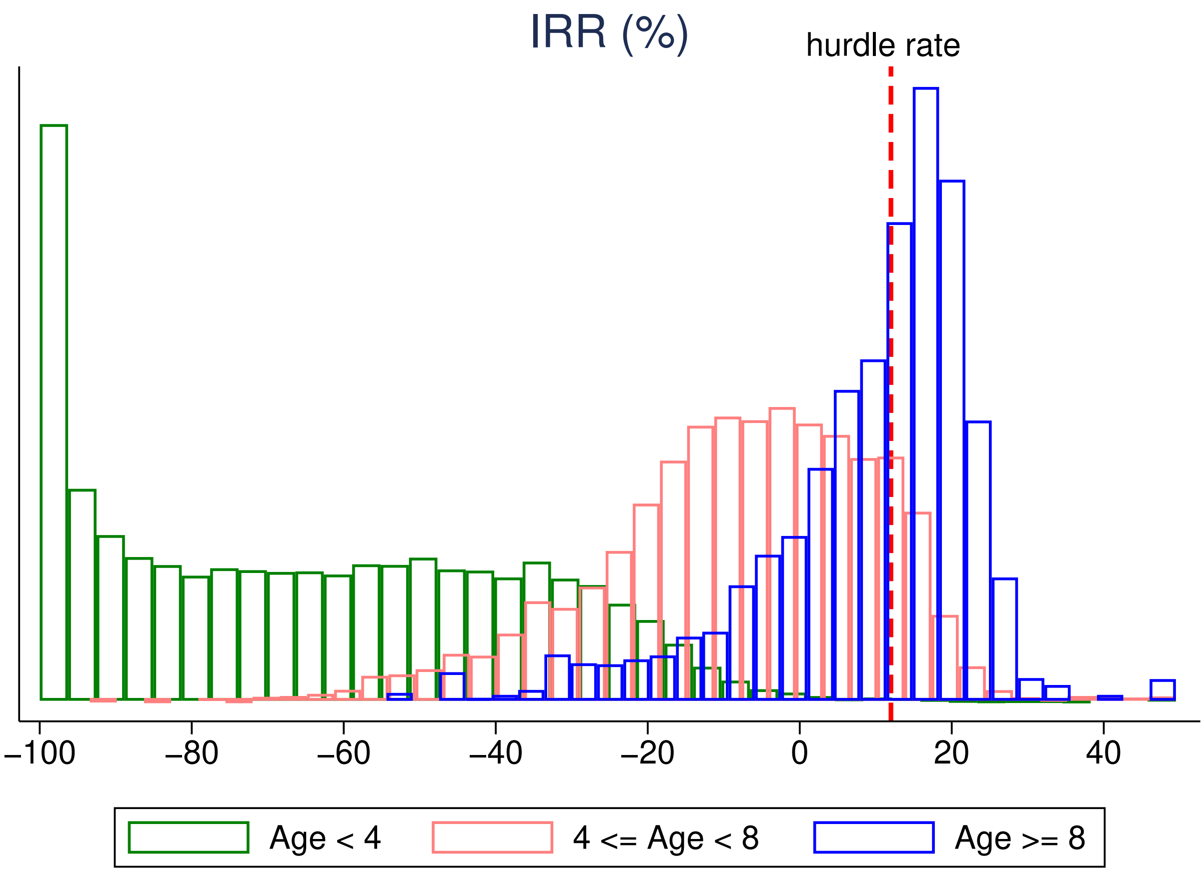
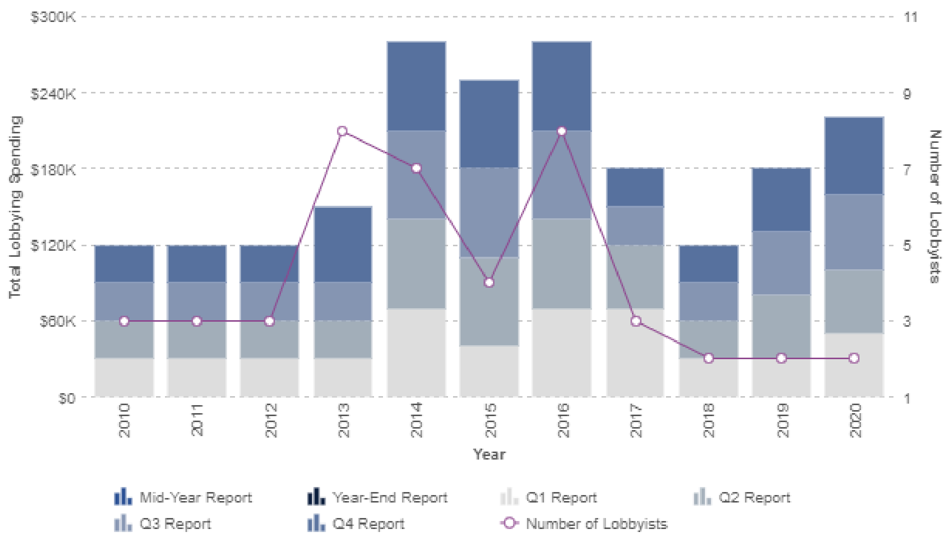
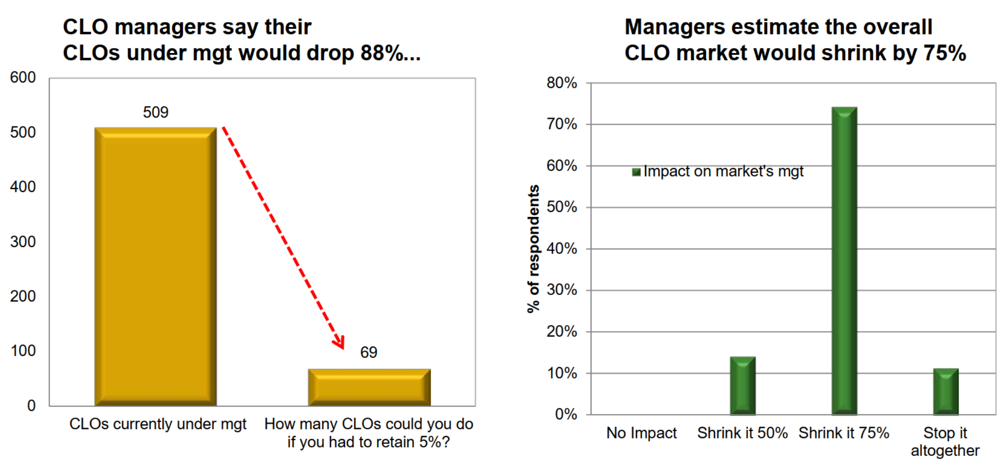


Figure A.7: **CLO equity IRR.**
This figure plots empirical distributions of US CLO equity tranche internal rate of return (IRR) by the deal's age. The vertical dashed line indicates the typical hurdle rate, 12%, maintaining a deal's IRR above which allows the asset manager to receive 20% of incentive fee from equity dividends.



(a) LSTA Lobbying by Year



(b) Asset Manager Survey, 2013

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

Table A.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 A.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 A.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 C.

	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 A.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 A.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