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) produce long-term low-risk bonds backed by leveraged loans. To increase safe debt capacity, CLO managers commit to dynamically maintaining portfolio quality through selling low-quality loans and buying high-quality loans. This paper develops an equilibrium model in which CLOs endogenously arise and shows that this commitment generates investment and financing externalities across asset managers in the leveraged loan market. As a result, the market has too many CLOs, but under-produces safe assets relative to a constrained efficient benchmark. Policies targeting only one side of intermediary balance sheets, including the Credit Risk Retention regulation, exacerbate the welfare loss.

Keywords: Safe Asset, Institutional Leveraged Loan, Portfolio Substitution, Pecuniary Externality, Collateralized Loan Obligation, Credit Risk Retention

JEL classifications: G11, G23, G28.

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1 Introduction

An important function of the financial system is to produce debt securities that are extremely unlikely to default.[1] These assets provide monetary services and help satisfy regulatory requirements because they are safe and liquid, and as a result, may be priced at a premium. The private sector exploits this premium by transforming risky assets into safe assets. For example, asset managers operate collateralized loan obligations (CLOs), which I will describe in detail, to produce AAA-rated bonds backed by risky syndicated corporate loans (known as "leveraged loans"). This paper examines how the leveraged loan market is organized to increase the supply of safe assets. Moreover, I analyze the market's welfare properties and shed light on a regulatory debate about CLOs.

The leveraged loan market presents two interesting facts. First, loans are held by nonbank intermediaries with two types of capital structures.[2] Figure 1 shows that CLOs consistently hold roughly half of US leveraged loans outstanding, which has quickly grown to $1.2 trillion in 2020, while other intermediaries, such as mutual funds and hedge funds, hold the rest of the loans. In contrast to CLOs, these funds do not issue any debt securities backed by their loan holdings. Second, leveraged loans are rated by third parties and actively traded in the secondary market. By contracting on loan ratings, CLO managers commit to dynamically maintaining portfolio quality, which triggers trades among intermediaries.[3]

I propose a theoretical model in which this unique commitment facilitates safe asset production and drives market structure. Unlike bank deposits, safe debt produced by CLOs are collateralized long-term bonds, whose safety depends on the underlying risky asset portfolios.

[1] See, for example, Krishnamurthy and Vissing-Jorgensen (2012), Gorton, Lewellen, and Metrick (2012), Caballero and Farhi (2018), and Van Binsbergen, Diamond, and Grotteria (2021).

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

[3] In securitization, CLOs' active collateral management was unique. More recently, this contractual design gained its popularity in the commercial real estate mortgage market, where the securitized product is called "CRE CLO". In 2019, 20% of commercial real estate securitization deals are structured as CRE CLOs.

Because asset quality changes over time, static portfolios are vulnerable to adverse systemic shocks, making it difficult to produce meaningful quantities of bonds that are truly safe. My model shows that committing to replacing deteriorated assets increases safe debt capacity, and precisely because commitment triggers trades, two types of intermediaries coexist in the same market. This market structure increases the supply of safe assets but presents unique policy challenges.

The model considers a three-period incomplete-market economy in which households derive utilities from privately-produced safe assets. At $t = 0$, intermediaries originate risky assets that can be traded in a Walrasian secondary market at $t = 1$ and yield uncertain payoffs at $t = 2$.[4] Asset managers choose intermediary balance sheets at $t = 0$ to maximize their own payoffs. Their investment exhibits a decreasing returns to scale, and their financing choices endogenously generate safe debt. In particular, debt is safe if the manager credibly commits that after secondary market trades, portfolio payoff perfectly secures repayment. As such, ex-post trades both depend on and affect ex-ante safe debt issuance, giving rise to an intertemporal feedback loop between primary and secondary markets.

The commitment increases an intermediary's safe debt capacity by relaxing its collateral constraint. When a negative shock hits the economy at $t = 1$, selling low-quality assets and buying high-quality assets improve the portfolio's minimum possible payoff, thereby keeping a greater quantity of debt safe. Hence, managers can issue a larger safe tranche by ex ante committing to such contingent portfolio substitution trades.

Secondary market trades increase the supply of safe assets by reallocating risky assets of different quality across intermediaries. In this process a pecuniary externality arises: trades push up (down) the prices of high-quality (low-quality) assets, which in turn affects all

[4] In practice, underwriters ("lead arrangers") originate leveraged loans and sell them to nonbanks. However, 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). Since the demand from nonbanks determines the size, pricing, and completion of loan deals, I abstract away the underwriting process and refer to the nonbank lending activity as origination.

managers' budget and collateral constraints. The effect on budget constraints makes fulfilling the commitment costly and providing liquidity profitable. As a result, every manager's balance sheet choice is based on a tradeoff between current ($t = 0$) financing and future ($t = 1$) trades. The effect on collateral constraints reduces safe debt capacity by lowering the rate of portfolio substitution.

Equilibrium market structure and welfare depend on asset managers' securitization expertise.[5] As a benchmark, I show that pecuniary externality is innocuous if managers are ex ante identical: the equilibrium is constrained efficient. This is because all managers face slack collateral constraints, and no manager fully exhausts safe debt capacity.[6] By contrast, in presence of any heterogenous expertise, "CLOs" and "funds" endogenously arise: managers' balance sheet choices generate intermediaries with two distinct types of capital structures. A subset of managers operate CLOs and face binding collateral constraints, as they do in the data. The rest of managers issue zero safe debt and profit from providing liquidity to CLOs. In this case, pecuniary externality tightens binding collateral constraints, and the equilibrium is constrained inefficient.

Behind the impact of asset prices on constraints, the ultimate source of this inefficiency is a separation of debt issuance and collateral origination. The extent to which CLO managers' commitment increases the supply of safe assets depends on high-quality assets available in the secondary market. On the asset side, managers who could originate high-quality assets at lower marginal costs under-invest because they do not need collateral. On the liability side, managers less skilled at securitization ignore that operating CLOs reduces collateral available to others, thus crowding out efficient safe debt issuance. Consequently, the market has too many CLOs, but under-produces safe assets because of a shortage of aggregate collateral.

[5] This expertise affects a manager's marginal benefit from safe debt issuance. Similar to that deposit productivity drives a traditional bank's balance sheet (Egan, Lewellen, and Sunderam, 2021), here a shadow bank with better expertise issues more safe debt and thereby finances a larger risky asset portfolio.

[6] If identical managers face binding constraints on safe debt choices, secondary market fails to clear.

Through the lens of the model, I provide a new perspective on a controversial regulation. This regulation, called Credit Risk Retention Rule, requires managers to contribute 5% of capital to the CLOs they operate.[7] Because the rule imposes substantial costs on managers, its finalization in the US in 2014 led to complaints and lawsuits against regulators. After winning a lawsuit in 2018, CLO managers got exempted from the rule, but whether to reapply it is still an ongoing debate. My finding that there is an excessive entry into operating CLOs seems to suggest that this policy improves welfare by imposing an entry cost.[8] However, the model shows that deterring managers from operating CLOs actually destroys welfare. This is because the resultant reduction in CLO trades lowers the return to liquidity provision. Lower expected return discourages fund managers' asset origination, which worsens the shortage of collateral and exacerbates the under-production of safe assets. Such equilibrium effects do not seem to be taken into consideration by regulators.

More generally, the misallocation is unique to the commitment mechanism, and policies targeting only one side of intermediary balance sheets exacerbate the welfare loss. Only policies that correct both sides of intermediary balance sheets can potentially move the equilibrium towards constrained efficiency.

My model focuses on long-term debt, which prevents externalities generated by financing illiquid investments with short-term debt (e.g., Diamond and Dybvig 1983; Stein 2012). But it is difficult for the private sector to issue long-term safe debt. When are asset managers willing and able to alleviate this difficulty through the commitment? In the final part of this paper, I explore two model extensions to address this question. First, I allow maturity choices and asset trades to be jointly determined with secondary market liquidity provided by outsiders.[9] Intuitively, if outside buyers are scarce, managers prefer to use long-term contracts to prevent costly liquidation and maximize safe debt capacity. Second, I consider

[7] This rule applies to all asset-backed securities, including CLOs. See Subsection 5.3 for more information.

[8] This type of policies (e.g., requiring a charter to enter the market) are widely adopted in bank regulation.

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

imperfect information, under which managers might strategically respond to contracts. In that case, the extent to which debt covenants constrain managers from reaching for yield is crucial to the feasibility of this mechanism.

This paper contributes to the literature on 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.[10] 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).[11] In the existing literature, there is no role for dynamic asset portfolios in intermediaries' production of safe liabilities. My innovation is to analyze a new mechanism in which secondary market trades reallocate risky assets across intermediaries, thereby increasing the market's supply of safe debt beyond static pooling and tranching. The idea of collateral reallocation is shared by Holmström and Tirole (1998, 2001), where trading mitigates the impact of liquidity shocks on firms' real investment.

This paper's theoretical analysis also complements the empirical literature on leveraged loans and CLOs. Existing research generally takes CLO contracts as given. For example, several recent studies find that CLO covenants trigger costly secondary market loan sales (Loumioti and Vasvari, 2019; Elkamhi and Nozawa, 2020; Kundu, 2020). Focusing on CLO securities, Foley-Fisher, Gorton, and Verani (2020) study investor reactions to changes in information sensitivity, and Griffin and Nickerson (2020) assess potential staleness of CLO debt tranche ratings. Different from these studies, my analytical modelling starts from economic

[10]Empirical evidence for the valuation of safe assets and the interactions among different safe assets include Krishnamurthy and Vissing-Jorgensen (2012), Sunderam (2015), Nagel (2016), Gissler and Narajabad (2018), and Infante (2020).

[11]One strand of this literature considers that an excessive production of private safe assets can lead to financial fragility when short-term debt causes fire sales (Stein, 2012; Greenwood, Hanson, and Stein, 2015) or when investors neglect risks (Gennaioli, Shleifer, and Vishny, 2012, 2013).

forces behind observed contract designs.[12] This systemic approach clarifies manager trading behaviors and generates new insights on this market's equilibrium and welfare implications. My results explain that ex-post costly trades are an endogenous outcome of a value-creating commitment. Consistent with my model in which managers extracting rents from addressing market incompleteness, Cordell, Roberts, and Schwert (2021) find that CLO equity yields abnormal returns because of cheap safe debt financing. My analysis also suggests that part of these rents pass to other managers through secondary market trades.

The remainder of this paper proceeds as follows. Section 2 presents motivating empirical evidence. Section 3 introduces the model and derives asset managers' and social planner's optimal choices. Section 4 characterizes the equilibrium and its welfare properties, based on which Section 5 analyzes the effects of policy interventions and discusses the Credit Risk Retention regulation. Section 6 extends the model to more general settings to explore the boundaries of the commitment mechanism. Section 7 concludes.

2 Empirical Evidence

To motivate my theoretical analysis, this section presents facts about CLOs and leveraged loans and provides new evidence for the commitment mechanism of safe asset production. Details on data sources and sample construction are provided in Appendix B.

2.1 Institutional Background

Collateralized loan obligations (CLOs) are investment vehicles that specialize in the leveraged loan market. Leveraged loans are private debt extended to corporations that have a high

[12] Existing studies on leveraged loan primary markets do not find adverse selection or moral hazard to be important frictions (Shivdasani and Wang, 2011; Benmelech, Dlugosz, and Ivashina, 2012; Blickle et al., 2020.

existing leverage and substantial credit risk.[13] A leveraged loan is originated through a syndication deal, in which an underwriter (called "lead arranger") organizes a select group of lenders to privately contract with the borrower.[14]

An important feature of CLOs is active management. Unlike other securitized products that have static collateral portfolios, CLO managers can reinvest cash flows generated by loan holdings during a predetermined reinvestment period. This allows the manager to both acquire new loans in primary market and make discretionary secondary market trades. A CLO's life lasts around 10 years, and the reinvestment period is typically the first 5 years. After the reinvestment period expires, the CLO enters its amortization period, during which debt principals will be repaid over time.[15] Manager compensation consists of fixed fees (based on size) and incentive fees (based on equity performance).

2.1.1 CLOs as Safe Asset Producers

CLOs finance their loan investments by issuing debt and equity securities at birth. These securities have different riskiness because of a "waterfall" rule that requires any portfolio losses to be first borne by relatively junior tranches before a relatively senior tranche's payoff is affected. CLO debt tranches have maturities between 6–12 years.[16] Despite that most leveraged loans have below-investment grade ratings, the majority of CLO liabilities (about 65%) are rated at AAA.

The ratings of portfolio loans and senior tranches differ significantly for three reasons.

[13] For example, 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.

[14] Figure A.3 summarizes primary market relationships for underwriters and CLO asset managers between 2016–2019. Figure A.4 summarizes CLO participation in primary market.

[15] After the reinvestment period, CLOs cannot buy additional loans using cash generated by discretionary loan sales and existing loans' pre-scheduled payoffs (coupons and principals). But this does not prevent managers from using cash generated by existing loans' prepayments. See Fitch's report for more details: Reinvestment in Amortization Period of U.S. CLOs.

[16] Table A.1 shows the distribution of CLO debt maturity by tranche seniority.

First, CLO portfolios typically consist of 100–300 small pieces of leveraged loans to diversify away idiosyncratic credit risk. Second, historical leveraged loan default rate is below 5%, and average recovery rate of defaulted loans has been around 75% during recent years because corporate loans are senior to bonds and usually explicitly secured by collateral.[17] Third, CLO contracts include covenants that constrain managers, which will be introduced in detail in Subsection 2.2. These facts imply that senior tranches are extremely unlikely to default.[18] AAA-rated tranches have zero default record in history, and exhibited considerable resilience during the financial crisis and COVID-19 pendemic. Therefore, CLO senior tranches are privately-produced safe assets by definition of Caballero, Farhi, and Gourinchas (2017): they are debt instruments that are expected to preserve values during adverse systemic events.[19]

2.1.2 Other Intermediaries in Leveraged Loan Market

In addition to CLOs, other financial intermediaries also hold hundreds of billions of leveraged loans. These intermediaries, including mutual funds, hedge funds, pension funds, and private equity funds, primarily rely on equity financing and do not issue any safe debt backed by their leveraged loan portfolios.[20]

Investing in the same class of risky assets requires similar skills, regardless of financing choices. Hence, asset managers should be able to choose which type(s) of investment vehicles to operate. Indeed, Figure 2 shows that asset managers active in the leveraged loan market exhibit a salient heterogeneity in their choices between operating CLOs and operating mutual funds. For example, CVC Credit Partners only offers CLOs, whereas Fidelity

[17]Recovery rate is substantially lower during the Great Financial Crisis. See S&P report for more details on recovery rates: LossStats.

[18]See SEC report (Kothari et al., 2020, p.41–p.49) for related discussion on why CLO "AAA-rated senior tranches will not incur losses unless economic conditions worsen dramatically".

[19]Moreover, CLO debt tranches are floating rate notes. This further insulates investors from interest rate fluctuations, which is the source of short-term risk in long-term safe assets such as US Treasury bonds.

[20]Figure A.2 in the Appendix provides more detailed information on the size of different intermediary types in this market based on alternative data sources.

Investments predominantly manages leveraged loan mutual funds. Such financing choices lead to coexistence of intermediaries with two distinct types of capital structures.

2.2 Commitment and Collateral Constraint

Thanks to market infrastructure such as third-party credit rating, CLO managers can commit to long-term contracts that discipline their future loan portfolio choices. This allows managers to credibly promise to maintain sufficient collateral for any given amount of debt, which increases safe debt capacity ex ante.

CLO contracts implement this commitment with regular (e.g., monthly) collateral tests. These tests evaluate whether the portfolio can secure debt outstanding. In each period, test scores are compared with predetermined threshold levels. Test failure prevents the manager from receiving compensation until test scores recover.

The most important collateral test is the over-collateralization (OC) test.[21] 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.[22] 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

[21] 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.

[22] 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.

distribution for the slackness of senior OC constraints between 2010–2019. Among CLOs in reinvestment period, the average OC score is only slightly (8%) above the minimum required level and is fairly stable over time.[23] 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.

2.3 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

[23]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 B.2 for details on this data limitation.

sales both nearly doubled upon the arrival of the COVID-19, which indicates that managers were actively buying and selling loans in the secondary market. To understand the nature of these trades, Panel (d) examines loan trades within individual CLOs during the first two quarters of 2020. As the bin scatter plot shows, there is a strong positive (and nearly one-to-one) relationship between a CLO's loan purchases and sales. Therefore, secondary market trades achieved portfolio substitution at the individual CLO level.

2.4 Portfolio Substitution Improves Collateral Quality

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

Figure 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.[24] 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.[25] 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

[24] 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.

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

for details). Clearly, the pandemic lowered overall ratings, but managers' trading mitigated deterioration, improving the realized ex-post distribution relative to the counterfactual.

Although CLOs faced similarly binding constraints, their portfolios had different exposures to COVID-19. CLOs experiencing larger portfolio 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 portfolios.[26] Panel (c) shows that almost all CLOs replaced deteriorated loans, and the effect monotonically 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 collateral constraints triggered portfolio substitution trades that substantially improved collateral quality.

2.5 CLO Loan Trades and Secondary Market Prices

More than a thousand CLOs' portfolio substitution trades in the same direction are likely to affect the prices of leveraged loans. 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.

[26] Figure A.5 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.[27] 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 also 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.

[27] 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 B.1 for details on price measurement.

3 Model

Motivated by the evidence, this section develops an equilibrium model to analyze CLO safe asset production. The model focuses on how the unique commitment affects intermediary balance sheet choices and secondary market prices. To this end, the setup considers long-term contracts under full commitment and relegates the analysis of maturity choice and limited commitment to Section 6.

3.1 Environment

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

Households. There is a measure one of households who are risk neutral and indifferent about the timing of consumption. In the beginning of period $t = 0$, households are endowed with non-storable consumption goods, which can be also invested into financial claims. The amount of endowment is always greater than households' investment opportunities (which will be introduced). In addition, households derive a non-pecuniary benefit γ from owning every unit of safe assets, which are securities that pay off a fixed quantity of goods at $t = 2$ with certainty. Households' utility function is additively separable in consumption and safety:[28]

$$U = \mathbb{E}_0[C_0 + C_1 + C_2] + \gamma A, \tag{3}$$

where C_t is consumption in period t, and A is the aggregate quantity of safe assets available in period $t = 0$. This preference isolates the benefit of privately-produced safe assets from conventional risk and liquidity considerations.

A key friction in this economy is that the financial market is incomplete: households

[28]This simplifying assumption is widely adopted in the literature. For example, see Krishnamurthy and Vissing-Jorgensen (2012), Stein (2012), and Diamond (2020).

cannot create or trade claims contingent on states at $t = 2$. For this reason, in the absence of intermediaries, the supply of safe asset is zero. Households take securities prices as given when making consumption and investment decisions.

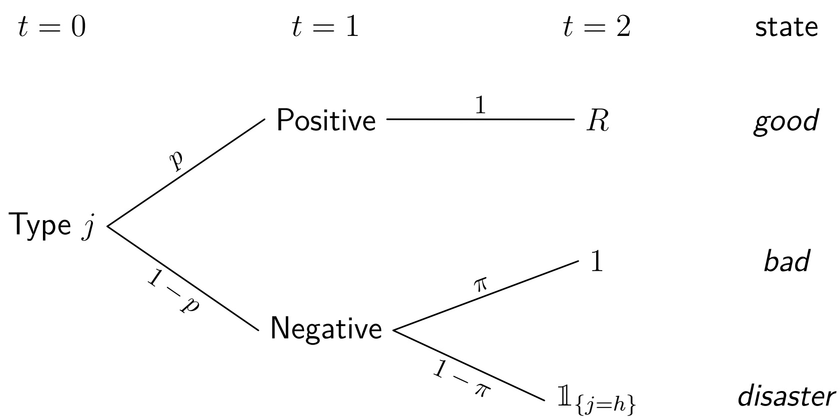
Intermediaries. There is a continuum of asset managers uniformly populated on $\mathcal{I} = [0, 1]$. Their preference is the same as (3), except for that they do not benefit from holding safe assets. Crucially, managers can credibly commit to future portfolio choices and repayment. Each manager, indexed by $i \in \mathcal{I}$, operates an intermediary that has zero capital and issues securities to finance its risky investment. Intermediaries can issue two types of securities: debt and equity.[29] In particular, debt is safe if the manager commit to ensuring that even the minimum-possible portfolio payoff is enough for repayment. Such debt contracts are privately-produced safe assets.

Asset managers are ex ante identical except for an exogenous variable cost of safe debt issuance $\xi_i \geq 0$. Similar to a bank's deposit productivity (Egan, Lewellen, and Sunderam, 2021), this cost captures managers' skill in efficiently securitizing assets and raising capital from safe debt investors.

Investment Technology. There are two types (h and l) of scalable real projects. Every unit of investment in a project generates a gross payoff that depends on a non-contractible state $\omega \in \Omega = \{g, b, d\}$ that realizes at $t = 2$. In period $t = 1$, a piece of public news arrives, which can be either positive or negative with probabilities p and $1 - p$, respectively. If the news is positive, state g ("good") will realize with certainty, and both types of projects' payoffs will be $R > 1$. If the news is negative, whether the state is b or d remains uncertain. With probability $\pi \in (0, 1)$, state b ("bad") will realize, and the two types both pay one unit of consumption good. With probability $1 - \pi$, state d ("disaster") realizes. While a project of type h still pays 1 in this state, a project of type l pays zero.

The tree graph illustrates project payoff distributions: the two types only differ in the

[29] Equity can be equivalently interpreted as junior debt that has risky payoffs.



minimum possible payoff. Operating projects at scale x incurs cost $c(x)$, and c is increasing, twice differentiable, and strictly convex, and satisfies $c(0) = 0$. For simplicity, I assume that project payoffs are fully pledgeable, and asset managers enjoy full bargaining power.[30] By providing capital to projects, an intermediary originates risky financial assets. Depending on project types, I refer to originated assets as high-quality (h) and low-quality (l) assets, respectively.

Financial Markets. Households do not have access to real projects and can only invest through intermediaries, which originate risky assets and issue securities in period $t = 0$. Events in this period occur in the following order. Each intermediary $i \in \mathcal{I}$ first originates x_i units of assets without knowing their types. Immediately after the origination, an idiosyncratic quality shock realizes and exogenously determines the type composition of originated assets. Specifically, $\tilde{x}_{i,l}$ units of assets 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 assets are low-quality is unknown in this period.

To finance the invested capital $c(x_i)$, the intermediary issues safe debt with face value

[30] This assumption, following Stein (2012), abstracts away contractual frictions between intermediaries and firms and simplifies the welfare analysis. An intuitive interpretation of this assumption is that all operating income of borrowers will be paid to intermediaries as interest expense.

$a_i \geq 0$ and raises the remaining capital with external equity.[31] Since consumption goods are non-storable, intermediaries do not hold "cash" on their balance sheets. After these choices, an intermediary's balance sheet in period $t = 0$ is:

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

In period $t = 1$, asset quality becomes observable, and intermediaries can trade in a Walrasian secondary market. Let the two risky assets' prices in secondary market be $(q_l, q_h) \in \mathbb{R}^2_+$. In period $t = 2$, the macro state ω realizes, and risky assets generate payoffs accordingly. Households receive payments from securities issued by intermediaries, and asset managers 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. Now I describe their optimization problems backwardly. In period $t = 1$, given the intermediary's balance sheet $(x_{i,h}, x_{i,l}, a_i)$, asset manager i chooses net trades $\Delta x_{i,h}, \Delta x_{i,l}$ to maximize conditional expected equity payoff

$$v(x_{i,h}, x_{i,l}, a_i) = \max_{\Delta x_{i,h}, \Delta x_{i,l}} x_{i,h} + \Delta x_{i,h} + \pi(x_{i,l} + \Delta x_{i,l}) - a_i. \tag{P1}$$

Her trades are subject to a budget constraint

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

a maintenance collateral constraint

$$a_i \leq x_{i,h} + \Delta x_{i,h}, \tag{MCC}$$

[31]The assumed order of events is consistent with industry practice: the asset manager acquires assets to form a portfolio using short term financing during the "warehouse phase" and then issues securities to repay the borrowed short-term capital.

and short-sale constraints $\Delta x_{i,h} \geq -x_{i,h}, \Delta x_{i,l} \geq -x_{i,l}$. The budget constraint (BC) requires that the intermediary's trades must be self-financed by its asset portfolio. The maintenance collateral constraint (MCC) requires that after secondary market trades, debtholders can receive the promised payoff with probability one. For example, if initial holding of asset h is less than safe debt outstanding ($x_{i,h} < a_i$), after observing negative news, the manager has to acquire additional high-quality assets to fulfill the commitment.

Asset managers rationally anticipate trades in period $t = 1$ when making balance sheet choices in period $t = 0$. Facing price-taking households, asset managers optimally price safe debt at $1 + \gamma$ to extract all rents from safe asset production. So, by issuing one unit of safe debt, an intermediary effectively raises $1 + \gamma - \xi_i$ units of capital. Taking asset prices (q_h, q_l) as given, the manager chooses risky asset origination x_i and safe debt issuance a_i to maximize expected payoff to internal equity

$$\max_{x_i, a_i \geq 0} \quad \mathbb{E}_0[v(x_{i,h}, x_{i,l}, a_i)] - \underbrace{\Big(c(x_i) - (1 + \gamma - \xi_i)a_i\Big)}_{\text{cost of external equity}} \tag{P0}$$

where $v(x_{i,h}, x_{i,l}, a_i)$ is the $t = 1$ maximum expected payoff to equity as a function of choices x_i, a_i, and quality shock $\tilde{x}_{i,l}$ realized in period $t = 0$. Importantly, the maximization is subject to an endogenous initial collateral constraint:

$$a_i q_h \leq x_{i,h} q_h + x_{i,l} q_l, \tag{ICC}$$

which requires the portfolio's market value at $t = 1$ to be enough for the manager to secure safe debt by acquiring additional high-quality asset.[32][33]

Equilibrium. In equilibrium, secondary market trades and asset prices must be consistent with the commitment embedded in intermediary balance sheet choices; Meanwhile, balance sheets are chosen based on anticipated secondary market outcomes. This generates

[32] Since asset h pays 1 even in the disaster state, $a_i q_h$ is the minimum portfolio market value that allows the manager to achieve a minimum portfolio possible payoff a_i.

[33] Section 6 shows that it is without loss of generality to ignore the possibility of early debt repayment under the setup in the current section.

an intertemporal feedback loop between primary and secondary markets. The equilibrium is formally defined as follows.

Definition 1 (Competitive Equilibrium)**.** *An equilibrium consists of balance sheet choices* (x_i, a_i) *and secondary market trades* $(\Delta x_{i,h}, \Delta x_{i,l})$ *for each manager* $i \in \mathcal{I}$ *and secondary market prices* (q_h, q_l) *such that (i) balance sheet choices solve the manager's investment and financing problem (P0) given* (q_h, q_l)*, (ii) secondary market trades solve the manager's trading problem (P1) given* (q_h, q_l)*, and (iii) secondary market clears:* $\int_{i \in \mathcal{I}} \Delta x_{i,j} = 0$ *for* $j \in \{h, l\}$*.*

I introduce two parametric conditions to restrict the analysis to interesting cases. First, the variable safe debt issuance cost is sufficiently small.

Condition 1. *Households' non-pecuniary benefit is greater than asset managers' safe debt issuance costs:* $\gamma > \xi_i$ *for all* $i \in \mathcal{I}$*.*

This condition implies that despite the heterogeneity in securitization expertise, any intermediary can lower its cost of capital by issuing safe debt. Second, I impose an inequality between the magnitude of asset quality shock and risky asset payoff.

Condition 2. *The marginal cost of real investment at scale* $\bar{x}_l$ *is bounded from above:*

$$c'(\bar{x}_l) < pR + 1 - p.$$

This inequality ensures that optimal choice $x_i > \bar{x}_i$ for all $i \in \mathcal{I}$, so $x_{i,h}$ is always positive. Therefore the quality shock's realization is irrelevant to the manager's choice of origination quantity, and the sequential choices within period $t = 0$ can be equivalently formulated as a simultaneous decision problem.

Discussion of Assumptions. The model has two primary assumptions. First, households exogenously benefit from safe assets. Because of this preference, safe debt can be priced at a premium, which reduces the issuer's cost of financing. As a result, capital structure is relevant to an intermediary's value, thus violating the Modigliani and Miller (1958) theorem. Second, intermediaries' investment technology exhibits a decreasing returns to scale, which is standard in the asset management literature. Another important assumption is that asset managers can have heterogenous expertise in securitization. How this heterogeneity affects the equilibrium will be extensively discussed in Section 4.

The key feature of this model is that secondary market trades can generate a higher minimum possible portfolio payoff than that of a static portfolio. This occurs because idiosyncratic quality shocks cause intermediaries to hold risky assets of different quality.[34] Having two risky assets parsimoniously allows for this effect. The assumed asset payoff distribution is not crucial but simplifies the model and keeps the mechanism transparent.[35]

3.2 Balance Sheets and Secondary Market Trades

This subsection characterizes managers' optimal choices given asset prices. Since every asset manager's choices (x_i, a_i) depend on secondary market trades $(\Delta x_{i,h}, \Delta x_{i,l})$, asset prices (q_h, q_l), and continuation value v, I first analyze the secondary market trading problem in period $t = 1$.

In the positive-news stage, no trade occurs because all collateral constraints are slack. If negative news arrives, binding collateral constraints generate trading needs. The objective in problem (P1) strictly increases in both $\Delta x_{i,h}$ and $\Delta x_{i,l}$, so the budget constraint binds: $\Delta x_{i,h} q_h + \Delta x_{i,l} q_l = 0$. Moreover, since $a_i \geq 0$, collateral constraint (MCC) implies that short-sale constraint $\Delta x_{i,h} \geq -x_{i,h}$ is slack. Omitting terms predetermined at $t = 1$, the

[34] The upper-bounded shock quantity eases the aggregation across intermediaries but is not critical. In the Online Appendix, I provide an alternative setup with a random fractional shock that generates qualitatively same results.

[35] Subsection 6.1 analyzes intermediaries' safe debt maturity choices in a setting with generalized conditional payoff distributions.

intermediary's secondary market problem simplifies to

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

subject to constraints $\Delta x_{i,l}\frac{q_l}{q_h}+a_i \leq x_{i,h}$ and $\Delta x_{i,l} \geq -x_{i,l}$. Essentially, each manager chooses the quantities of substitution between the two risky assets through secondary market trades. Note that the arrival of negative news updates asset h's and asset l's fundamental values to 1 and π, respectively. I proceed to solve this problem based on the following lemma.

Lemma 1. *In the negative-news stage, the ratio between low- and high-quality assets' secondary market prices is smaller than the ratio of their fundamental values:* $\frac{q_l}{q_h} \in (0, \pi]$.

Proof. See the Appendix. □

In bad times, intermediaries facing binding constraints are forced to seek additional collateral, whereas intermediaries facing slack constraints trade for better returns. Since intermediaries trade among themselves, the market clears only if risky assets change hands between these two groups. The low-quality asset, which has zero collateral value, must offer a higher return relative to the high-quality asset, so that unconstrained asset managers are willing to provide liquidity. As a result, the ratio of secondary market asset prices diverges from asset fundamentals.[36]

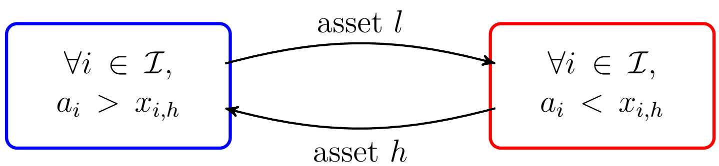
Lemma 1 indicates that the manager's optimal secondary market trades lead to portfolio substitution:

$$\Delta x_{i,h} = a_i - x_{i,h}, \;\; \Delta x_{i,l} = -\frac{(a_i - x_{i,h})q_h}{q_l} \tag{4}$$

for any given $x_{i,h}$ and a_i. As illustrated by the graph below, these trades reallocate risky assets among intermediaries. An intermediary with $a_i > x_{i,h}$ optimally sells just enough low-quality asset so that she can increase her holding of high-quality asset to keep debt safe.

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

Hence, such intermediaries' secondary market trading needs are price-inelastic. By contrast, an intermediary with $a_i < x_{i,h}$ sells its extra high-quality asset and buys low-quality asset, thereby profiting from the divergence of asset prices from fundamentals.



The optimal trades in (4) imply that the manager's continuation value in the negative-news stage is

$$v(x_{i,h}, x_{i,l}, a_i) = \pi\Big(x_{i,l} + (x_{i,h} - a_i)\frac{q_h}{q_l}\Big). \tag{5}$$

In equation (5), the high-quality asset's payoff exceeds its fundamental: $\pi\frac{q_h}{q_l} > 1$. This is so because this asset reduces costly portfolio substitution (if $x_{i,h} < a_i$) and can be sold for a higher return (if $x_{i,h} > a_i$). The marginal payoff from safe debt has the same magnitude and an opposite sign, because of the costly forced trades. Substitute $v(x_{i,h}, x_{i,l}, a_i)$ into (P0), an intermediary's assets and liabilities choice problem is equivalent to[37]

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

$$s.t. \;\; a_i \le x_i - x_{i,l} + x_{i,l}\frac{q_l}{q_h}, \tag{ICCa}$$

$$a_i \ge 0.$$

Let η_i and μ_i respectively be Lagrangian multipliers of the two inequality constraints above. The manager's Kuhn-Tucker conditions for optimal choices are

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

[37]Condition 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.

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

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) shows that a manager's decision to issue safe debt depends on a tradeoff between the debt's net cheap financing advantage, $\gamma - \xi_i$, and expected cost of portfolio substitution, $(1-p)\big(\pi \frac{q_h}{q_l} - 1\big)$. Suppose that the former is smaller than the latter, no debt would be issued ($\mu_i > 0$), and the collateral constraint would be slack ($\eta_i = 0$). In this case, asset choices in (6) are solely based on a tradeoff between expected payoff and origination costs. Note that because of potential secondary market interactions, the high-quality asset's expected payoff is greater than its expected buy-and-hold payoff.

When safe debt financing is sufficiently beneficial, the initial collateral constraint (ICCa) binds, and its shadow price is

$$\eta_i = \gamma - \xi_i - (1-p)\Big(\pi \frac{q_h}{q_l} - 1\Big) > 0, \tag{9}$$

which measures the net benefit of cheap financing in excess of expected cost of portfolio substitution. In this case, intermediary i issues its maximum quantity of safe debt: $a_i = x_{i,h} + x_{i,l}\frac{q_l}{q_h}$. Such a safe debt-financed intermediary exploits a low cost of capital and invests in risky assets beyond what the NPV rule suggests. The additional investment, as characterized by equation (6), is increasing in η_i due to the collateral value of risky assets. As η_i decreases in ξ_i, an intermediary with a lower debt issuance cost originates more risky assets in the primary market as collateral for its larger-sized safe debt.

Recall from equation (4) that given an intermediary's safe debt outstanding, the optimal portfolio substitution upon the arrival of negative news is to acquire *just enough* high-quality asset that keeps debt safe. This result per se suggests that an intermediary with $a_i \in (0, x_{i,h})$

would sell asset h and buy asset l. However, the manger's ex ante optimal choice is to exhaust its safe debt capacity, which is achieved by committing to substitute *the entirety* of low-quality asset for high-quality asset when negative news arrives. To see this, substitute the binding collateral constraint (ICCa) into (4) and obtain the following result.

Proposition 1 (Portfolio Substitution)**.** *When negative news arrives, safe debt-financed intermediaries sell their holdings of low-quality asset and use the proceeds to buy high-quality asset:*

$$\Delta x_{i,h} = x_{i,l}\frac{q_l}{q_h},\ \ \Delta x_{i,l} = -x_{i,l},\ \ \textit{if } a_i = x_{i,h} + x_{i,l}\frac{q_l}{q_h}, \tag{10}$$

and equity-financed intermediaries sell their holdings of high-quality asset to buy low-quality asset:

$$\Delta x_{i,h} = -x_{i,h},\ \ \Delta x_{i,l} = x_{i,h}\frac{q_h}{q_l},\ \ \textit{if } a_i = 0. \tag{11}$$

Managers of safe debt-financed intermediaries maximize their own payoffs by committing to a contingent "flight to quality". Risky assets in their portfolios back safe debt in two ways. The high-quality asset protects debt with its minimum possible payoff, whereas the low-quality asset does so with its secondary market value. The commitment allows the equity holders (including managers) to achieve extra leverage: they enjoy high payoffs from larger-sized risky investments after positive news, but receive zero payoff after the negative news triggers promised trades.

Equity-financed intermediaries give up safe debt's cheap funding advantage. In return, they profit from a price dislocation among risky assets in the negative-news stage. With no obligation to protect debt safety, these intermediaries trade in the secondary market in the opposite direction to safe debt-financed intermediaries' trades. They realize profit by substituting their holdings of high-quality asset, which has a lower return, for low-quality asset, which has a higher return.

3.3 Social Planner's Problem

In this subsection, I consider a benevolent social planner who organizes intermediaries to efficiently make risky investments and produce safe assets. Similar to the decentralized economy, secondary market trading can improve safe debt capacity. But unlike asset managers, the planner does not calculate individual payoffs based on secondary market prices. By internalizing the price impact generated by individual managers' choices, the planner can potentially improve the economy's total welfare.

The planner controls intermediaries' balance sheet choices at $t = 0$, and asset managers trade without any intervention at $t = 1$. In the negative-news stage, same as characterized in equation (4), collateral constraints trigger predetermined quantities of asset trades. Specifically, an intermediary facing a binding constraint sells just enough (i.e., $(a_i - x_{i,h})q_h/q_l$ units) low-quality asset and uses the proceeds to buy $(a_i - x_{i,h})$ units of high-quality asset. Unconstrained intermediaries accommodate such liquidity needs by trading in the opposite direction. The binding collateral constraints imply that the trading volume of the high-quality asset is inelastic to prices. For any price ratio $\frac{q_l}{q_h} \in (0, \pi]$, secondary market clears if and only if $\int_{i \in \mathcal{I}} (a_i - x_{i,h}) \, \mathrm{d}i \leq 0$, which gives rise to an aggregate collateral constraint faced by the social planner.[38]

To establish a sensible welfare benchmark, I do not allow the planner to freely redistribute assets among intermediaries in period $t = 1$. So for the promised trades to be feasible, the same initial collateral constraint (ICCa) in the decentralized economy, $a_i \leq x_{i,h} + x_{i,l}\frac{q_l}{q_h}$, must be satisfied for every intermediary. Recognize that the slackness of these constraints strictly increases in price ratio $\frac{q_l}{q_h}$, and asset prices do not affect the planner's objective or any other constraint (see the formalized problem below). Therefore, a higher price ratio (at least weakly) improves the maximized total surplus, and the planner implements the highest

[38]The inequality can be strict only if $\frac{q_l}{q_h} = \pi$, a special case in which unconstrained intermediaries are indifferent between the two risky assets and thus do not attempt to sell their entire holdings of asset h in the secondary market.

possible market-clearing price ratio $\frac{q_l}{q_h} = \pi$.

The planner's optimization problem is as follows. Let the aggregate asset origination be $X = \int_0^1 x_i \, \mathrm{d}i$. By law of large numbers, aggregate low-quality asset $\int_0^1 \tilde{x}_{i,l} \, \mathrm{d}i = x_L$. Since all investment payoffs will be consumed by households and asset managers, the planner's objective is to maximize the sum of aggregate risky asset payoff and safe asset non-pecuniary benefits, minus the aggregate costs of investment and safe debt issuance:

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

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

$$a_i \leq x_i - x_{i,l} + x_{i,l}\pi, \;\; \forall i \in \mathcal{I}, \tag{ICC}$$

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

The Lagrangian for problem (SP) can be written as

$$\begin{aligned} \mathcal{L}^{\mathcal{SP}} = \; & pXR + (1-p)(X - x_L + \pi x_L) + \gamma A - \int_{i \in \mathcal{I}} \Big(c(x_i) + \xi_i a_i \Big) \, \mathrm{d}i \\ & - \psi^{SP}(A - (X - x_L)) - \int_0^1 \eta_i^{SP}(a_i - x_{i,h} - x_{i,l}\pi) \, \mathrm{d}i + \int_0^1 \mu_i^{SP} a_i \, \mathrm{d}i. \end{aligned} \tag{12}$$

For each $i \in \mathcal{I}$, the Kuhn-Tucker conditions for optimality are

$$pR + 1 - p - c'(x_i) + \psi^{SP} + \eta_i^{SP} = 0, \tag{13}$$

$$\gamma - \xi_i - \psi^{SP} - \eta_i^{SP} + \mu_i^{SP} = 0, \tag{14}$$

and

$$\eta_i^{SP} \geq 0, \eta_i^{SP}(a_i - x_{i,h} - x_{i,l}\pi) = 0, \mu_i^{SP} \geq 0, \mu_i^{SP} a_i = 0. \tag{15}$$

Asset managers perceive safe debt issuance as a way to reduce financing costs, whereas the planner recognizes its valuable service to the society. The different tradeoffs behind managers' and the planner's choices can be seen from comparing first-order conditions (6)–

(7) and (13)–(14). The planner's choice of an intermediary's origination, as characterized by (13), accounts for both individual (η_i^{SP}) and social (ψ^{SP}) collateral values. For safe debt issuance characterized by (14), the planner trades off between the net marginal benefit from producing safe asset and the reduction in social safe debt capacity ($\psi^{SP} + \eta_i^{SP}$), instead of a private cost due to contingent portfolio substitution.

4 Equilibrium and Welfare

This subsection characterizes the equilibrium and analyzes its welfare properties. In the equilibrium's feedback loop, a key metric that links managers' intertemporal choices is price ratio $\frac{q_l}{q_h}$. This ratio captures the rate of substitution between two risky assets. When it is higher, portfolio substitution triggered by collateral constraints is less costly, so safe debt financing is more attractive. However, safe debt issuance increases secondary market demand (supply) for the high-quality (low-quality) asset, and the market cannot clear unless the price ratio drops sufficiently. In equilibrium, the price ratio adjusts intermediary balance sheet choices to equalize secondary market demand and supply.

As such, the commitment to dynamically maintaining portfolio quality gives rise to a *pecuniary externality*, making this commitment costly ($\frac{q_l}{q_h} < \pi$) for every manager in equilibrium. Managers take asset prices as given when maximizing their own payoffs and do not internalize this externality.

The market-clearing condition $\int_i \Delta x_{i,j}\, \mathrm{d}i = 0$ and optimal trades in (4) jointly imply an equilibrium relationship that is consistent with Walras law: aggregate safe debt issuance must equal aggregate high-quality asset in the economy:

$$\int_{i \in \mathcal{I}} a_i \, \mathrm{d}i = \int_{i \in \mathcal{I}} x_{i,h} \, \mathrm{d}i. \tag{16}$$

Equation (16) arises from the fact that only the high-quality asset, which pays off even in the disaster state, is the ultimate collateral that secures safe debt. In aggregate, the intermediary sector's total holding of this asset equals total safe debt outstanding, so that its secondary market demand equals its supply.

This relationship also holds in the planned economy. To see this, note that in the planner's problem (SP), the aggregate collateral constraint (ACC) binds at the optimum: otherwise, there would be some $i \in \mathcal{I}$ 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. Intuitively, aggregate high-quality asset determines social safe debt capacity, and it is optimal to fully exploit this capacity. This observation will be useful for understanding equilibrium allocations in this economy.

4.1 Special Cases

While managers are ex ante identical on the asset side, the difference in their securitization expertise leads to different balance sheet and trading choices. I use two special cases to clarify the intuition behind the heterogeneity's effects on equilibrium allocation and welfare.

4.1.1 Homogeneous Case

As a benchmark, let us first consider a homogeneous manager case: $\xi_i = \xi^* \in [0, \gamma)$ for all $i \in \mathcal{I}$. Hence, all managers are ex ante completely identical. Let $c'^{-1}(\cdot)$ be the inverse function of first-order derivative of the origination cost c. The following lemma presents the set of competitive equilibria in this case.

Lemma 2. *Suppose managers are homogeneous, then* $\frac{q_l}{q_h} = \frac{(1-p)\pi}{1-p+\gamma-\xi^*}$, $x_i = c'^{-1}(pR + 1 - p + \gamma - \xi^*)$, *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 (16) is an equilibrium. Every competitive allocation is constrained efficient.*

Proof. See Appendix A. □

Homogenous managers invest the same quantity and face slack collateral constraints: The price ratio makes them indifferent between issuing one unit of safe debt and providing one unit of liquidity to others. So it is possible that every intermediary issues safe debt while no manager exhausts its capacity. Secondary market trades facilitate safe asset production by reallocating collateral among intermediaries. The equilibrium is unique up to aggregate quantities, but there are infinite possible combinations of individual choices.

In this case, the planner cannot do better than the competitive market. This is because the planner also faces slack individual constraints: he does not care which manager issues more or less safe debt given that all managers are equally skilled. Hence, the pecuniary externality does not affect the efficiency of allocation.

4.1.2 Two-Type Case

It is natural that asset managers have different securitization expertise. Consider the simplest heterogenous case: 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 benefits from safe debt issuance. Market clearing, and hence allocations, depend on fraction α. To highlight a source of inefficiency, the following lemma focuses on a subset of α values and leaves the complete analysis of the two-type case to the appendix. 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 planned choices for the two types, respectively.[39]

Lemma 3. *Suppose $\xi_i \in \{\underline{\xi}, \bar{\xi}\}$, $\underline{x}^{CE} = \underline{x}^{SP}$ for any $\alpha \in (0,1)$. When $\alpha \in (\underline{\alpha}^{SP}, \bar{\alpha}^{CE})$ for endogenous cutoffs $0 < \underline{\alpha}^{SP} < \bar{\alpha}^{CE} < 1$, $\underline{a}^{CE} < \underline{a}^{SP} = x_{i,h} + x_{i,l}\pi$, $\bar{a}^{CE} = \bar{a}^{SP} = 0$. Competitive allocation is constrained inefficient: $\bar{x}^{CE} < \bar{x}^{SP}$, and $A^{CE} < A^{SP}$.*

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

Proof. See Appendix A. □

Unlike the homogenous case, the pecuniary externality can cause inefficiency when managers are heterogenous. Since the financial market is incomplete, an intermediary's trades affect not only other intermediaries' secondary market budget constraints, but also their collateral constraints. When collateral constraints are binding, as in the case of lemma 3, the effect on these constraints compromises the standard envelope-theorem argument for welfare irrelevance of prices in complete markets. In equilibrium, the price ratio tightens the low-cost type's collateral constraints, preventing these managers from issuing socially optimal quantities of safe debt.

Behind the direct impact of asset prices, the ultimate source of this inefficiency is an aggregate deficiency of collateral. While the low-cost type's investment level is socially efficient, high-cost managers under-invest because they do not benefit from the collateral value: They do not internalize the social benefits of additional safe assets, which exceed their private costs of additional origination. Hence, this market's unique separation of debt issuance and collateral origination leads to an under-production of safe assets. A policymaker can correct the inefficiency by simply forcing equity-financed intermediaries to invest at the socially optimal level.

4.2 Equilibrium with Continuous Types

My equilibrium analysis mainly focuses on a more realistic and interesting case where every manager's securitization expertise is different from others'. As I will show, analyzing this case provides policy implications that are *qualitatively different* from that in the previous subsection. Without loss of generality, let manager i's variable safe debt cost be $\xi_i = 2\xi i$ for positive constant $\xi \in (0, \gamma/2)$. Thus, managers are ranked by issuance cost, which is uniformly distributed on $[0, 2\xi]$.

In this case, constraints on safe debt choices will be binding for almost everyone, so "CLOs" and "funds" endogenously arise. A manager with a higher issuance cost benefits less from safe debt financing and is more willing to issue only equity. Hence, financing choices at the extensive margin can be summarized by a cutoff $\lambda \in [0, 1]$: managers $i \leq \lambda$ issue both safe debt and equity, and managers $i > \lambda$ issue only equity. In equilibrium, the price ratio makes the cutoff type λ indifferent between issuing debt and issuing only equity:

$$\gamma - \xi_\lambda = (1-p)\Big(\pi\frac{q_h}{q_l} - 1\Big). \tag{17}$$

In the appendix, I show that the system of two equations, the indifferent cutoff condition and the market-clearing condition, is equivalent to a single equation $\chi(\lambda) = 0$ for aggregate excess demand function $\chi : [0, 1] \mapsto \mathbb{R}$, and that this equation has a unique real root. The following proposition characterizes the competitive and planned allocations.[40]

Proposition 2 (Cutoff Allocations)**.** *There exists a unique competitive equilibrium. In equilibrium, there is an interior cutoff $\lambda^{CE} \in (0, 1)$ such that*

$$x_i^{CE} = \begin{cases} c'^{-1}\Big(pR + 1 - p + \gamma - \xi_i\Big), & \textit{if } i \leq \lambda^{CE} \\ c'^{-1}\Big(pR + 1 - p + \gamma - \xi_{\lambda^{CE}}\Big), & \textit{if } i > \lambda^{CE} \end{cases}, \tag{18}$$

$$a_i^{CE} = \begin{cases} x_i^{CE} - x_{i,l} + x_{i,l}\frac{q_l}{q_h}, & \textit{if } i \leq \lambda^{CE} \\ 0, & \textit{if } i > \lambda^{CE} \end{cases}, \tag{19}$$

and

$$\frac{q_l}{q_h} = \frac{(1-p)\pi}{1 - p + \gamma - \xi_{\lambda^{CE}}} < \pi. \tag{20}$$

The social planner's choices lead to $\frac{q_l}{q_h} = \pi$ and a unique interior cutoff $\lambda^{SP} \in (0, 1)$ such that

[40] Here the uniqueness is with respect to quantities and the price ratio. The levels of asset prices are not uniquely identified. Subsection 6.1 generalizes the setting to allow for identified price levels.

$$x_i^{SP} = \begin{cases} c'^{-1}\Big(pR + 1 - p + \gamma - \xi_i\Big), & \textit{if } i \leq \lambda^{SP} \\ c'^{-1}\Big(pR + 1 - p + \gamma - \xi_{\lambda^{SP}}\Big), & \textit{if } i > \lambda^{SP} \end{cases}, \tag{21}$$

$$a_i^{SP} = \begin{cases} x_i^{SP} - x_{i,l} + x_{i,l}\pi, & \textit{if } i \leq \lambda^{SP} \\ 0, & \textit{if } i > \lambda^{SP} \end{cases}. \tag{22}$$

Proof. See Appendix A. □

Figure 7 numerically illustrates the equilibrium. In Panel (a), the range of the price ratio is divided into three regions. Suppose the price ratio is too low, no manager would want to issue safe debt ($\lambda = 0$), and secondary market demand for the high-quality asset would be zero. If the price ratio is too high, all managers would attempt to issue safe debt ($\lambda = 1$), and secondary market supply for the high-quality asset would be zero. Only when the price ratio is in the medium region, a proper subset of intermediaries issue safe debt ($0 < \lambda < 1$), and secondary market clears.

Panel (b) presents the competitive allocation. In equilibrium, the market has an interior mix of intermediaries with two distinct types of capital structures: Managers with better securitization expertise ($i \leq \lambda^{CE}$) use safe debt financing, whereas other managers issue only equity ($i > \lambda^{CE}$). Compared with equity-financed intermediaries, safe debt-financed intermediaries originate more risky assets as collateral. Overall, intermediaries operated by managers with lower issuance costs on average issue more safe debt and hold larger portfolios.

Similar to the competitive allocation, the planner's choices divide managers into operating safe debt-financed intermediaries and equity-financed intermediaries. Cutoff λ^{SP} reflects the socially optimal concentration of safe asset production. As this cutoff is generally different from λ^{CE}, the planned allocation differs from competitive allocation in terms of both assets and liabilities, suggesting that the unique competitive equilibrium is inefficient.

By internalizing the price impact of intermediary balance sheet choices, the planner is able to implement a price ratio that is unsustainable in the competitive market. A higher price ratio relaxes collateral constraints for all intermediaries, thereby allowing the planner to efficiently organize investment and financing. The next proposition characterizes the inefficiency of the competitive equilibrium.

Proposition 3 (Constrained Inefficiency)**.** *The equilibrium is constrained inefficient: the market has an excessively large share of safe debt-financed intermediaries ($\lambda^{CE} > \lambda^{SP}$) but under-produces safe asset ($A^{CE} < A^{SP}$).*

Proof. See Appendix A. □

Given that managers are heterogenous, efficiency hinges on cross-sectional allocation of safe debt issuance and collateral origination. Unfortunately, individually optimal choices generate a two-sided misallocation, which results in an inefficient market structure and an under-production of safe assets.

On the asset side, similar to lemma 3, managers under-invest whenever they do not issue a large quantity of safe debt. Facing a decreasing returns to scale in investment, the planner optimally spreads origination among all managers. He does so by forcing managers with inferior securitization expertise to invest beyond their preferred quantities. However, managers' investment choices limit secondary market supply of the high-quality asset and cause a deficiency of aggregate collateral.

On the liability side, safe debt issuance by managers with less securitization expertise crowds out efficient issuance by expert managers. This occurs as the former group's promised trades reduce collateral that can be acquired by the latter group in bad times. 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 many intermediaries issue safe debt, and the sector produces fewer safe assets at a high average cost.

Figure 8 overlays the competitive allocation (same as panel (b) of Figure 7) and the planned allocation. The planner assigns only 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 originate more than their competitive levels: $x_i^{SP} > x_i^{CE}$.[41] The area of the shaded region measures aggregate under-investment in equilibrium, which equals the quantity of safe asset under-production.

5 Policy Intervention

The previous section shows that the market has excessively many intermediaries that use safe debt financing. Consider a policy that imposes an entry cost on asset managers who operate safe debt-financed intermediaries. By negatively affecting these mangers' payoff, this policy potentially deters entry into safe debt issuance and improves welfare. This section explores how such a policy impacts equilibrium outcomes.

Suppose that if intermediary i issues safe debt of any quantity $a_i > 0$, the manager incurs a cost $\zeta_i \in \mathbb{R}_+$ in the beginning of period $t = 0$.[42] For generality, the cost can be an arbitrary (weakly) increasing function of index $i \in \mathcal{I}$. This assumption 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 $t = 0$ optimization problem becomes discontinuous. The discontinuity at $a_i = 0$ is because issuing any safe debt incurs the manager the entry cost ζ_i. Conditional on a binary choice between $a_i = 0$ and $a_i > 0$, the objective function is the

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

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

same as (P0a). Given asset prices and the same collateral constraint (ICCa), *locally optimal* choices are characterized by the same conditions (6)–(8) as in the baseline model.

The policy distorts asset manages' safe debt issuance choices, which in turn affect their risky asset origination. If an intermediary issues only equity, the manager's payoff is

$$V^e = y^e c'^{-1}(y^e) - c(c'^{-1}(y^e)) - (1-p)\pi x_L\Big(\frac{q_h}{q_l} - 1\Big), \tag{23}$$

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

$$V_i^d = y_i^d c'^{-1}(y_i^d) - c(c'^{-1}(y_i^d)) - (1-p)\pi x_L\Big(\frac{q_h}{q_l} - 1\Big) - x_L\eta_i\Big(1 - \frac{q_l}{q_h}\Big) - \zeta_i, \tag{24}$$

where $y_i^d := y^e + \eta_i$ is the manager's marginal payoff from originating risky asset, which includes collateral value η_i. Note that V_i^d is strictly increasing in η_i, which itself decreases in manager index.[43] This implies that V_i^d is strictly larger for a smaller i. Since V^e is identical across i, others equal, only managers better at securitizing might issue safe debt.

To be consistent with the baseline model, 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 (17). Since the indifference is local (i.e., it is conditional on $a_i > 0$) and does not reflect global optimal choices, $\lambda \leq 1$ no longer has to hold; Instead, lemma 1 and equation (17) jointly imply that λ is now upper bounded by $\frac{\gamma}{2\xi}$, which is greater than one by assumption. As a function of λ, the new cutoff type $i(\lambda) \in (0,1)$ that is globally indifferent satisfies

$$V_{i(\lambda)}^d = V^e. \tag{25}$$

Given secondary market asset prices, and hence $\lambda \in (0, \frac{\gamma}{2\xi}]$, there will be a unique cutoff type $i(\lambda) < \lambda$ because $\zeta_i > 0$ and V_i^d is monotonic in i. Moreover, when the entry cost approaches zero, the new cutoff converges to λ: let $\bar{\zeta} = \max_{i\in\mathcal{I}} \zeta_i$, it holds that $\lim_{\bar{\zeta}\to 0+} i(\lambda) = \lambda$.

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

5.1 Equilibrium under an Entry Cost

Competitive equilibrium under the policy can be defined similarly as definition 1, except for that asset managers' $t = 0$ problem takes the entry cost into consideration. If an equilibrium exists, by proposition 1, the secondary market clearing condition requires

$$\frac{q_l}{q_h} \int_0^{i(\lambda)} x_{i,l} \, \mathrm{d}i = \int_{i(\lambda)}^1 \Delta x_{i,h} \, \mathrm{d}i. \tag{26}$$

The limiting property of $i(\lambda)$ indicates that as $\bar{\zeta}$ approaches zero, the corresponding aggregate excess demand function χ^{DE} converges to χ^{CE} of the baseline model.[44] By continuity of the competitive equilibrium in model parameters, an interior equilibrium exists when $\bar{\zeta}$ is relatively small. Let λ^{DE} and $i(\lambda^{DE})$ respectively denote the locally indifferent type and cutoff type in the new equilibrium. The following lemma characterizes the relationship among equilibrium cutoff types.

Lemma 4. *In equilibrium,* $i(\lambda^{DE}) < \lambda^{CE} < \lambda^{DE}$.

Proof. See Appendix A □

In addition to distorting intermediary balance sheets, the entry cost policy also affects equilibrium secondary market asset prices. Given the relationship between cutoff type λ and price ratio $\frac{q_l}{q_h}$ in equation (17), lemma 4 implies that the price ratio increases. Indeed, as fewer managers issue safe debt, there is less portfolio substitution in the negative-news stage and hence less asymmetric price pressure on the two risky assets.

So the policy moves equilibrium cutoff and asset prices towards the constrained efficient allocation. Does this imply that the policy corrects the inefficiency of competitive equilibrium? The next proposition provides a negative answer to this question. The result follows immediately from lemma 4 and risky asset origination as a function of λ in proposition 2.

[44]The aggregate excess demand functions are defined in the appendix.

Proposition 4 (Distorted Equilibrium)**.** *The entry cost reduces the fraction of safe debt-financed intermediaries, but nonetheless exacerbates the under-production of safe assets.*

By alleviating asset managers' excessive use of safe debt financing, the entry cost policy increases equilibrium price ratio, which relaxes the remaining safe debt-financed intermediaries' collateral constraints and allows them to issue more safe debt.

Unfortunately, this policy turns out worsening the original problem because it treats only the liability side of a two-sided misallocation. From managers' perspective, a higher price ratio is equivalent to a lower expected return from originating high-quality assets. This reduction in expected return has two effects on investment choices. At the intensive margin, equity-financed intermediaries, who do not internalize the social value of collateral, further under-invest. At the extensive margin, a larger fraction of asset managers give up issuing safe debt and hence choose the worsened investment level. These two effects jointly lead to a reduction in the aggregate 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 overlays the competitive allocation (same as panel (b) of Figure 7) and the policy-distorted allocation. While managers $i \in [0, i(\lambda^{DE})]$ do not change their investment choices, managers now operating equity-financed intermediaries ($i \in [i(\lambda^{DE}), 1]$) all lower their investment levels. This leads to an aggregate reduction in high-quality asset, 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 under-produces safe assets to an even greater extent because of a shortage of collateral.

5.2 Two-Sided Policy

The previous subsection shows that reducing excessive entry into safe debt issuance worsens the equilibrium by exacerbating the under-investment problem. Similarly frustrating is that a policy forcing equity-financed intermediaries to invest at the socially optimal level also worsens the equilibrium. This is because investing beyond individually optimal level reduces asset managers' payoff, and managers will issue safe debt to escape the scope of this policy.

To correct the two-sided misallocation, it is critical to design a policy that improves both sides of intermediary balance sheets. Specifically, the policymaker should simultaneously reduce entry into safe debt issuance and increase equity-financed intermediaries' investment choices.

If the policymaker's information set includes all model parameters, the implementation of an entry policy is feasible. It can be carried out as, for instance, a lump sum fee on any intermediary that issues safe debt, or a targeted quantity of tradable permits for safe debt issuance. In contrast, subsidizing risky investment could raise concerns over actions not explicitly considered in the model. For instance, a subsidy based on the quantity of origination can have a perverse effect if it incentivizes asset managers to lower screening standard and originate large quantities of low-quality assets.[45]

5.3 Credit Risk Retention Regulation

In this subsection, I take the theory's normative implications to shed light on a regulatory debate 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

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

requires "sponsors" of securitization transactions to retain at least 5% of un-hedged credit risk of collateral assets for any asset-backed securities. 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.[46] The final rule became effective for residential mortgage-backed securities (RMBS) in December 2015 and for other ABS, including CLOs, in December 2016.

Since the rule's initial proposal, its inclusion of CLO managers received considerable resistance from practitioners. The major complaint is that CLO managers do not have the capital to buy the securities issued by their CLOs, and the imposed financing cost might drive managers out of the CLO business. 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 accordingly not subject to the requirements of the Risk Retention Rule. Consequently, CLO managers became exempted from the rule in May 2018.

Although LSTA and asset managers asserted that the regulation has a devastating effect on the CLO business, I first investigate the realized impact.[47] My empirical investigation exploits the fact that virtually the same policy was imposed on the European CLO market before the US market. Figure 10 summarizes the timing of 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 market, but the time trends were similar. Potentially due to a quick introduction of the risk retention policy in the Europe in the end of 2010, the CLO market there recovered slowly relative to the US market. Since the finalization of the US risk retention policy in late 2014, there has been a salient drop

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

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

in entry in the US market.[48] This drop in entry rate reversed quickly after the policy gets revoked in early 2018.

This regulation's impact on CLO entry has important welfare implications. Proposition 4 has shown the equilibrium outcomes under the impact of entry cost imposed by such a regulation. By deterring CLO entry, the policy worsens the under-production of safe assets and therefore exacerbates the inefficiency of the leveraged loan market. Hence, my analysis points to an unintended consequence. As the debate over whether the risk retention rule should be reapplied to the US market continues, policymakers should take this consequence into consideration.

6 Maturity and Commitment

The existing banking literature focuses on a short-maturity mechanism, whereby intermediaries produce riskless debt by allowing creditors to enforce asset liquidation and debt repayment (e.g., Stein, 2012; Hanson et al., 2015). The model analyzed in previous sections deliberately abstracts away from this convention. In this section, I explore two extensions to understand conditions under which long-term contract with commitment to contingent portfolio substitution arises as the preferred safe debt contract.

6.1 Safe Debt Maturity

The assumed distributions of risky asset payoffs in the baseline model, as will become clear soon, mechanically discourage asset managers from using short-term safe debt. Moreover, the absence of net cash trades in the secondary market makes early repayment impossible

[48] Although the policy became effective in 2016, this response is likely due to the fact that CLO equity holders enjoy the option to refinance debt tranches after 2–3 years of non-call period, and the anticipated retention cost added difficulty to equity issuance.

in equilibrium. In this subsection, I relax these assumptions and analyze what drives asset managers' choices of debt maturity. To do so, I extend the model in two aspects. First, I allow risky assets to have general payoff distributions, and second, I introduce non-intermediary investors into the secondary market.

Asset payoff distributions are generalized as follows. Suppose $\tilde{R}_j$ is the payoff of risky asset $j \in \{h, l\}$, and the support of its distribution can be any compact subset of $\mathbb{R}_+$. A risky asset's fundamental values conditional on news at $t = 1$ are denoted by $R_j := \mathbb{E}[\tilde{R}_j|\text{positive news}]$ and $F_j := \mathbb{E}[\tilde{R}_j|\text{negative news}]$. In addition, let r_j and f_j be the lower bounds of the supports of the corresponding conditional distributions. For simplicity, I assume $r_j > F_j$ for $j \in \{h, l\}$. I also normalize $f_h > f_l = 0$, so the low-quality asset is indeed less valuable in securing safe debt.[49]

There is a costly technology that allows households to store their endowed consumption goods from date $t = 0$ to date $t = 1$. I interpret this storage technology as the formation of specialized capital for buying under-priced assets during market downturns, such as distressed debt strategy funds. Storing each unit of goods incurs a constant cost $\kappa > 0$. This linear participation cost structure implies that non-intermediary investors' demand for asset j in the secondary market is

$$z(q_j) = \begin{cases} +\infty, & (1-p)\left(\frac{F_j}{q_j} - 1\right) > \kappa \\ \forall z \in \mathbb{R}_+, & (1-p)\left(\frac{F_j}{q_j} - 1\right) = \kappa \\ 0, & (1-p)\left(\frac{F_j}{q_j} - 1\right) < \kappa \end{cases}. \tag{27}$$

The market clearing condition thus becomes

$$\int_{i \in \mathcal{I}} \Delta x_{i,j} \,\mathrm{d}i + \frac{z(q_j)}{q_j} = 0 \tag{28}$$

for $j \in \{h, l\}$. Since this capital is the only source of liquidity outside of the intermediary sector, it pins down the levels of secondary market asset prices in equilibrium.

[49] Accordingly, condition 2 is generalized to $c'(\bar{x}_l) < pR_h + (1-p)F_h$.

Under these assumptions, an asset manager can flexibly choose between short-term and long-term debt contracts as long as the debt is safe. 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 total asset value to be enough to ensure debt safety at the negative-news stage, either through portfolio substitution or early repayment. Clearly, which type of balance sheet adjustment allows for a larger safe debt capacity depends on the level of price q_h relative to the asset'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 debt. 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 asset prices as given. In the positive-news stage, debt rolls over, and no trade occurs. When negative news arrives at $t = 1$, the manager solves

$$v(x_{i,h}, x_{i,l}, a_i) = \max_{\Delta x_{i,h}, \Delta x_{i,l}, \Delta a_i} \sum\nolimits_j (x_{i,j} + \Delta x_{i,j})F_j - (a + \Delta a_i), \tag{29}$$

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

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

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

$$\Delta x_{i,l} f_h \frac{q_l}{q_h} + \Delta a_i\Big(1 - \frac{f_h}{q_h}\Big) \leq x_{i,h} f_h - a_i, \tag{30}$$

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 asset 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 ex-post desirable if and only if $q_h > f_h^+ := f_h + \frac{q_l}{F_l}(F_h - f_h)$. That is, the manager wants to repay debt early if and only if q_h is sufficiently higher than q_l. In this case, after the repayment, the manager can hold only low-quality asset and expect a high equity return. When $q_h \leq f_h^+$, 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.[50]

Intuitively, 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 asset prices. Since outside investors can potentially absorb liquidated assets, asset prices are eventually related to their funding cost. 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:*

(i) Long-term safe debt and equity financing coexist. There exists a unique $\lambda^{lt} \in (0, 1)$

[50] For instance, when short-term contract allows for more safe debt capacity and a manager chooses to do so (i.e., $a_i \leq x_{i,h}q_h + x_{i,l}q_l < a_i\frac{q_h}{f_h}$), the manager has to repay debt in the negative-news stage even if her desired action it rollover.

such that managers $[0, \lambda^{lt}]$ *issue long-term safe debt, and the rest issue only equity. Secondary market asset prices satisfy* $q_h \leq f_h + \frac{1}{\gamma}(1-p)(F_h - f_h)$, $q_l \geq \frac{(1-p)F_l}{1-p+\kappa}$, $\frac{q_l}{q_h} < \frac{F_l}{F_h}$, *and no risky asset is sold to outside investors.*

(ii) Short-term and long-term safe debt, and equity financing coexist. 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. Secondary market asset prices satisfy* $q_h = f_h + \frac{1}{\gamma - \xi_{\lambda^{st}}}(1-p)(F_h - f_h)$, $q_l = \frac{(1-p)F_l}{1-p+\kappa}$, *and* $\frac{q_l}{q_h} < \frac{F_l}{F_h}$. *A subset of low-quality assets is sold to outside investors.*

(iii) Short-term and long-term safe debt financing coexist. 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. Secondary market asset prices satisfy* $q_h = f_h + \frac{1}{\gamma - \xi_{\lambda^{st}}}(1-p)(F_h - f_h)$, $q_l = \frac{(1-p)F_l}{1-p+\kappa}$, *and* $\frac{q_l}{q_h} \in \left(\frac{(1-p)F_l}{(1-p)F_h + (\gamma - 2\xi)f_h}, \frac{F_l}{F_h}\right)$. *All low-quality assets are sold to outside investors.*

(iv) Universal short-term safe debt financing. All managers issue short-term safe debt. Secondary market asset prices are $q_j = \frac{(1-p)F_j}{1-p+\kappa}$, $j \in \{h, l\}$, *and all risky assets are sold to outside investors.*

Proof. See Appendix A. ∎

Type-i equilibrium arises when outsiders' funding cost is large with respect to the safety premium. In this equilibrium, the high-quality asset's price is low, hence the short-term contract either fails to maximize safe debt capacity, or the benefit of its capacity advantage is smaller than the cost of early liquidation. As a result, all safe debt-financed intermediaries use long-term contracts and substitute collateral in the secondary market. A subset of intermediaries issue only equity and profit from secondary market trades. The baseline model is a special case that satisfies the low-price condition, so it is without loss of generality to restrict attention to long-term safe debt contract.[51]

Type-ii and type-iii equilibria feature a "pecking order" in safe debt maturity choices. While short-term contract maximizes safe debt capacity, it is more costly to liquidate assets than to substitute collateral ex post. A greater safe debt capacity is more valuable for managers with better securitization expertise. In equilibrium, only managers with sufficiently low issuance costs use short-term contract to maximize capacity, and other intermediaries issue long-term safe debt or only equity. In the negative-news stage, the first group of intermediaries liquidate all risky assets, whereas the second and third (if any) groups substitute collateral. Outside investors absorb only the low-quality asset, which has a higher return. High-quality assets change hands among intermediaries.

Type-iv equilibrium arises when outsiders' funding cost is small with respect to the safety premium. In this equilibrium, risky assets do not experience a severe secondary market price discount, so the cost of early liquidation is smaller than the benefit of maximizing safe debt capacity. Hence, all intermediaries optimally issue short-term safe debt to enjoy cheap financing and liquidate their entire holdings of risky assets when negative news arrives. For the secondary market to clear, the two risky assets must offer the same expected return: $\frac{q_l}{q_h} = \frac{F_l}{F_h}$. Unlike equilibrium types i–iii, no intermediary's debt safety relies on collateral originated by others, and the constrained inefficiency associated with portfolio substitution does not arise in this equilibrium.

6.2 Information Frictions and Limited Commitment

So far, it has been assumed that asset managers can credibly commit to future actions contingent on news at $t = 1$. This assumption simplifies the analysis, but it is admittedly

[51]The payoff distribution in Section 3.1 dictates that $F_h = f_h = 1$, so mechanically, $q_h \leq f_h$. 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.

unrealistic for two reasons. First, asset managers have access to non-public information and thus can better assess asset quality than investors do. Second, managers still cannot perfectly observe the quality of a risky asset. Although there exist publicly verifiable proxies associated with an asset's quality (e.g., credit ratings), contracting based on these proxies as if they accurately measure asset quality is unlikely to force managers 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 asset types to be imperfectly contractible: A debt contract that requires a quantity $m_i \in \mathbb{R}_+$ of high-quality asset can only enforce

$$\hat{x}_{i,h} + \Delta x_{i,h} + \rho(x_{i,l} + \Delta x_{i,l}) \geq m_i. \tag{31}$$

The left hand side of (31) can be interpreted as the quantity of pre-trade qualified risky assets that will continue to satisfy the contract's requirement after secondary market trades. From the manager's perspective, every unit of high-quality asset will continue to be qualified with certainty, whereas each unit of low-quality asset 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 asset quality proxies. The larger ρ is, the more low-quality asset 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 is imperfect. In particular, a manager's perceived quantity of high-quality asset, $\hat{x}_{i,h}$, 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 asset to high-quality asset. This risk-shifting incentive and imperfect information imply that the contract in Section 3 inevitably fails to ensure debt safety. Specifically, if the contract specifies $m_i = a_i$, the manager would "reach for yield" by choosing a post-trade portfolio with $x_{i,h} +$

$\Delta x_{i,h} < \hat{x}_{i,h} + \Delta x_{i,h} \leq a_i$ because low-quality asset has a higher expected return ($q_l/q_h < \pi$). This contractual failure implies that the portfolio's payoff in state $s = d$ is insufficient to pay back debt, and the debt defaults with a positive probability.[52]

The debt contract can still rely on verifiable asset quality proxies to address the informational and agency frictions. An arrangement that potentially restores debt safety is over-collateralization. This provision requires the quantity of qualified risky assets to be no less than safe debt face value plus 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 asset into qualified holdings at the cost of $\frac{q_l}{q_h}$ units of actual high-quality asset. Meanwhile, this unit of low-quality asset only fulfills ρ units towards the requirement. When ρ is relatively small, mixing in low-quality asset 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 asset that she can possibly hold without violating the over-collateralization requirement. Hence, by setting a sufficiently large a_i^{oc}, the contract forces the manager to include enough high-quality asset in the adjusted portfolio. In contrast, when ρ is large, the left hand side of (OC) would be increasing in $\Delta x_{i,l}$, relaxing this inequality 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 contract implements debt safety if and only if the over-collateralization requirement a_i^{oc} satisfies*

$$\rho\Big((x_{i,h} - a_i)\frac{q_h}{q_l} + x_{i,l}\Big) + \bar{\epsilon} \leq a_i^{oc} \leq \Big((x_{i,h} - a_i)\frac{q_h}{q_l} + x_{i,l}\Big)\frac{q_l}{q_h}. \tag{32}$$

Proof. See Appendix A. □

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

This result indicates that perfect contractibility is not a necessary condition for secondary market trading to increase safe debt capacity. As long as the proxies for asset quality allow the contract to sufficiently constrain the manager's portfolio choices, promised trades can be implemented with over-collateralization.[53] The secondary market price asset 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 (32) to be feasibly satisfied.

7 Concluding Remarks

The rise of shadow banking, particularly securitization, is largely attributable to the demand for safe assets. Nonbank financial intermediaries attempted to produce safe assets in the form of collateralized long-term debt securities, but many of such assets failed miserably during the financial crisis. They failed because the quality of their static collateral portfolios deteriorated after adverse systemic shocks. This paper analyzes the idea of using dynamic collateral portfolios to address this challenge. The mechanism is best exemplified by CLOs, an increasingly large group of investment vehicles that have been producing safe assets for decades and have not ever failed.

At the core of this mechanism is a commitment to dynamically maintaining collateral quality thorough secondary market trades. By making this commitment, a CLO manager increases its safe debt capacity but bears the cost of contingent quality-improving trades. This paper develops an equilibrium model of safe asset production, in which CLOs and equity-financed investment funds endogenously coexist and trade to substitute portfolios in bad times. The empirical findings and analytical insights in this paper provide an equilibrium view of the leveraged loan market and useful policy implications.

[53] If $x_{i,l}$ is unobservable, the lower bound of a_i^{oc} can be implemented with $\rho(x_i - a_i)\frac{q_h}{q_l} + \bar{\epsilon}$ instead.

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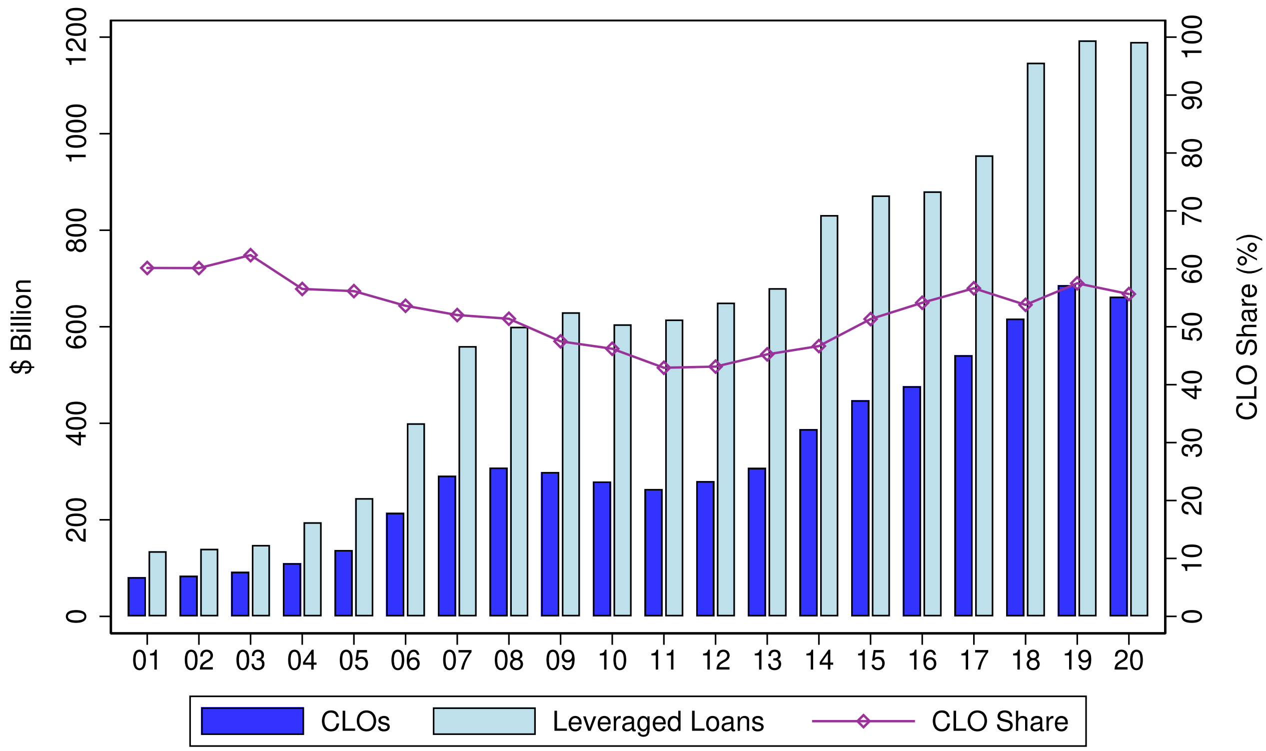


Figure 1: **Leveraged loans and CLOs outstanding, 2001–2020.**
This figure plots annual aggregate par values outstanding for leveraged loans (institutional term loan facilities) and CLOs in the US market. Data source: SIFMA.

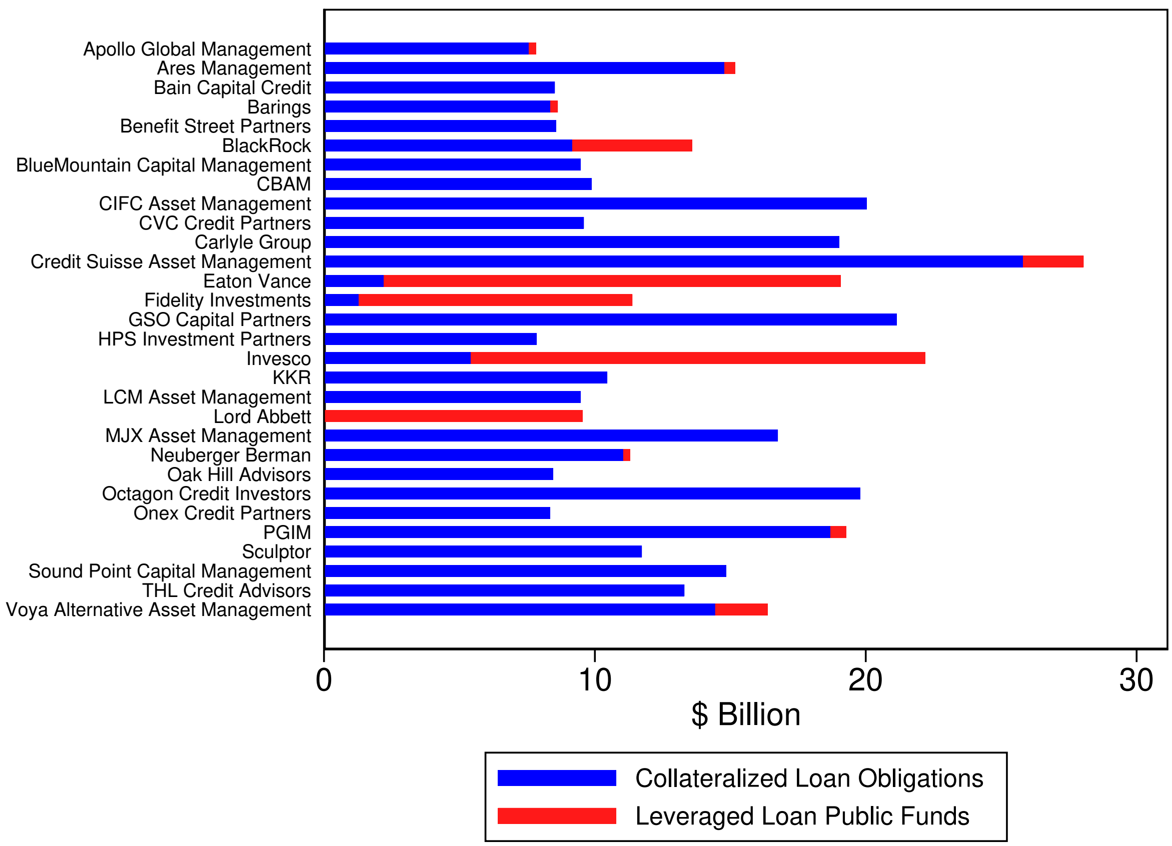
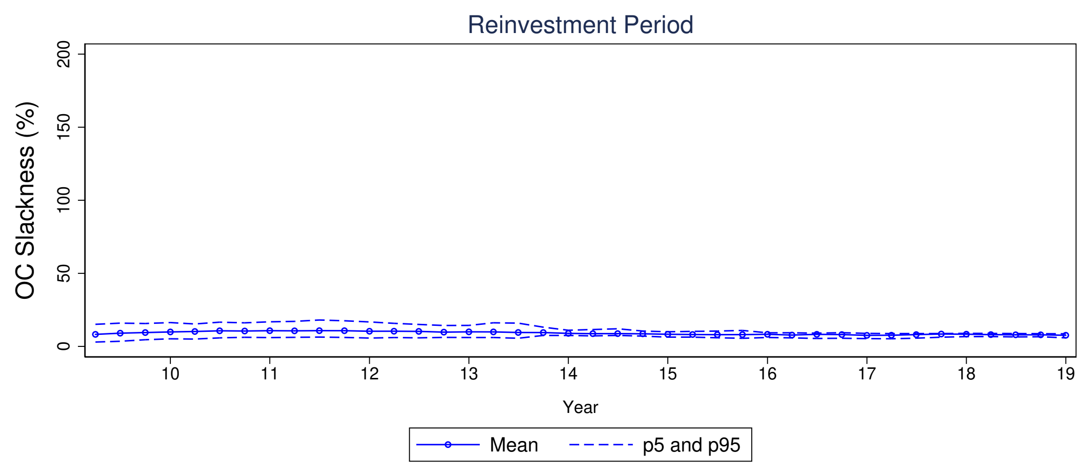
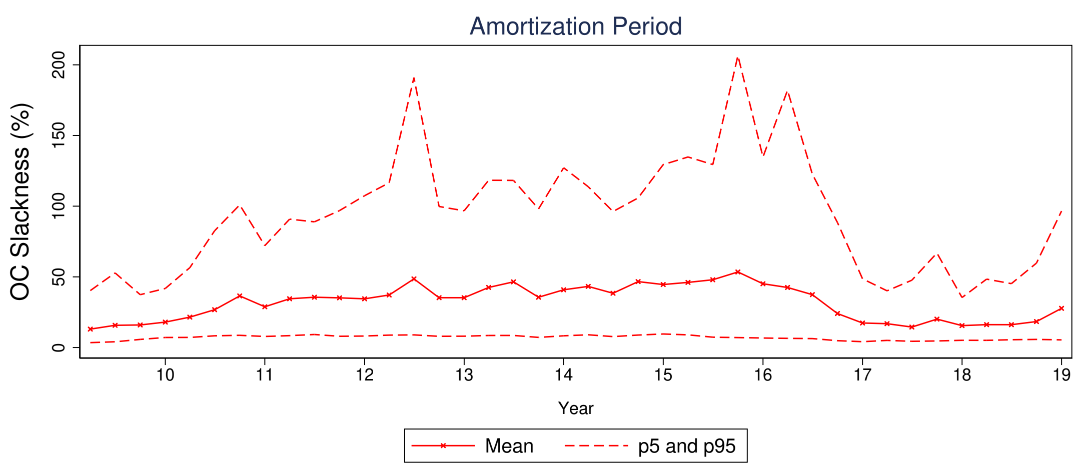


Figure 2: **Asset managers and their choices of investment vehicles.**
This figure presents the size of assets under management for US CLOs and leveraged loan funds (open-end and closed-end mutual funds and exchange-traded funds) operated by the 30 largest asset managers at the end of 2019. Data come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

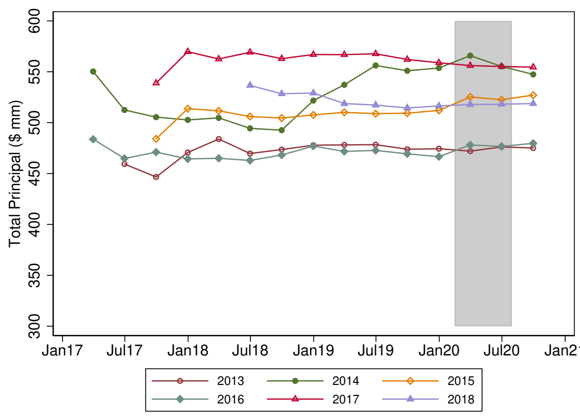


(a) CLOs in Reinvestment Period

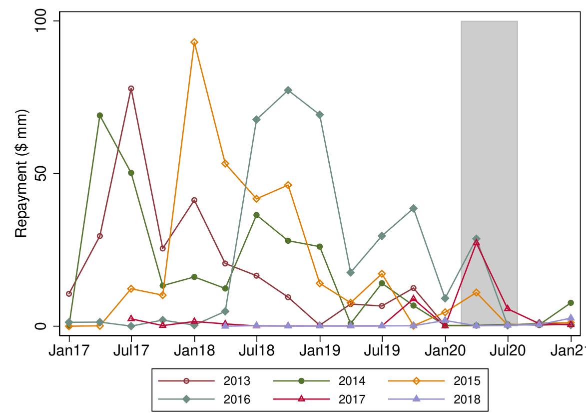


(b) CLOs in Amortization Period

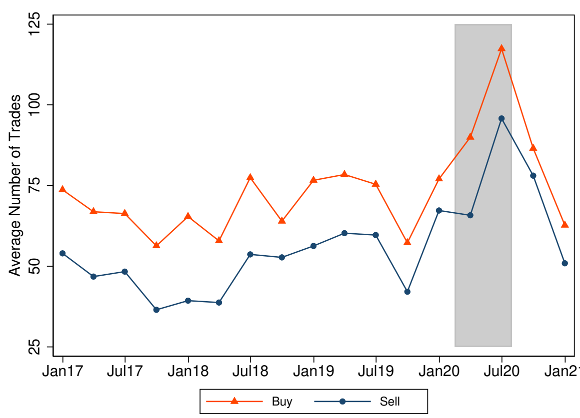
Figure 3: **Slackness of senior tranche over-collateralization constraint.**
This figure presents quarterly time series of cross-sectional dispersion in the slackness of CLO senior tranche over-collateralization (OC) constraints between 2010–2019. The slackness is defined as extra OC score scaled by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



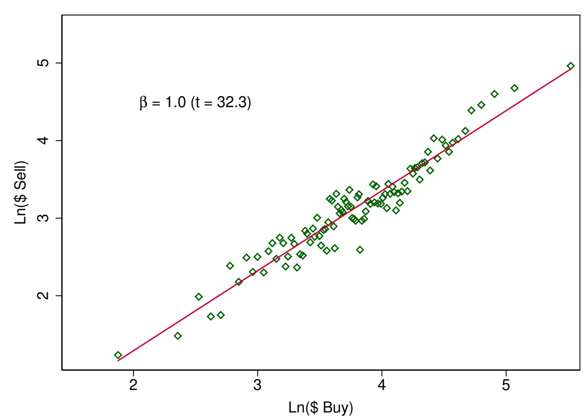
(a) Portfolio Total Loan Holdings



(b) Accelerated Debt Repayment

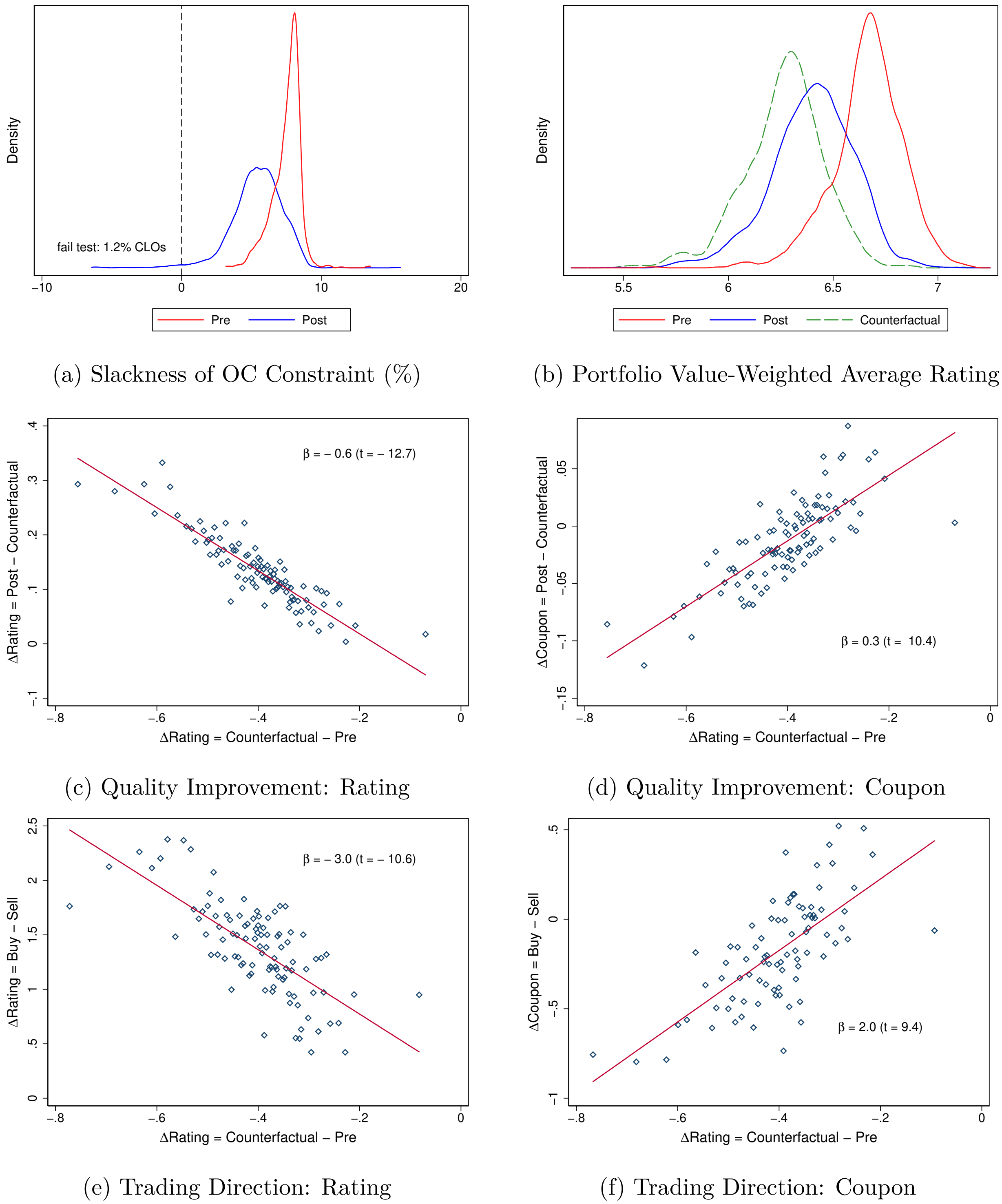


(c) Quarterly Loan Trades



(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

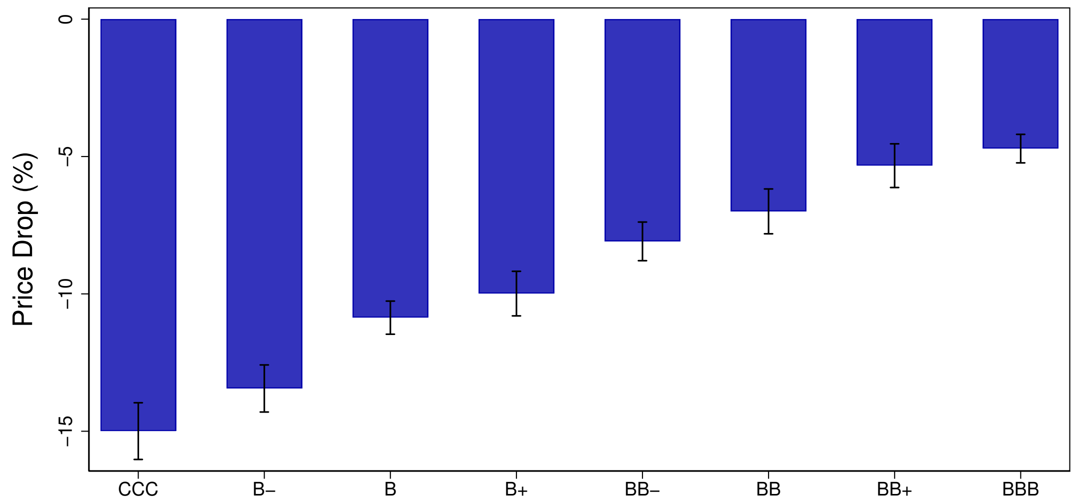
(c) Quality Improvement: Rating

(d) Quality Improvement: Coupon

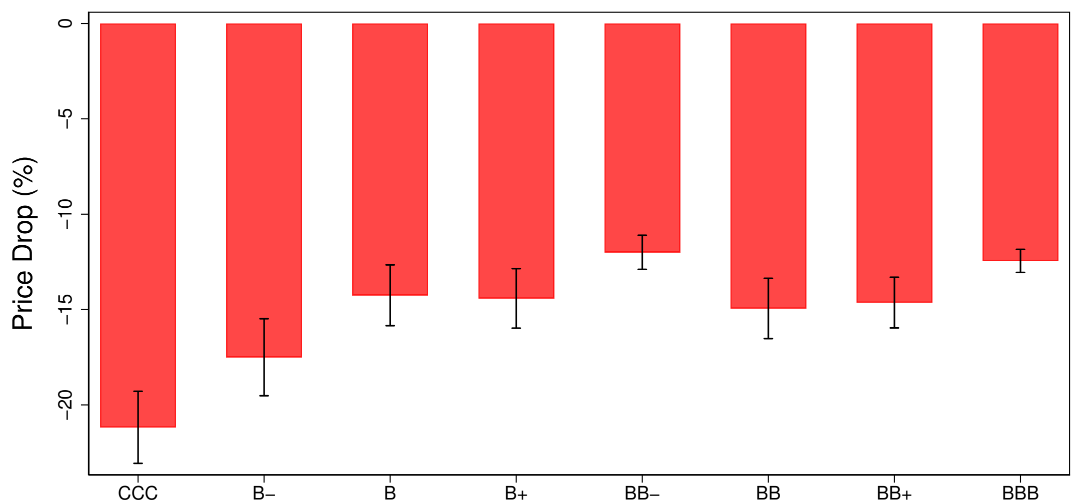
(e) Trading Direction: Rating

(f) Trading Direction: Coupon

Figure 5: **Portfolio substitution improves portfolio quality.**
This figure shows the effect of portfolio substitution on CLOs' portfolio 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.

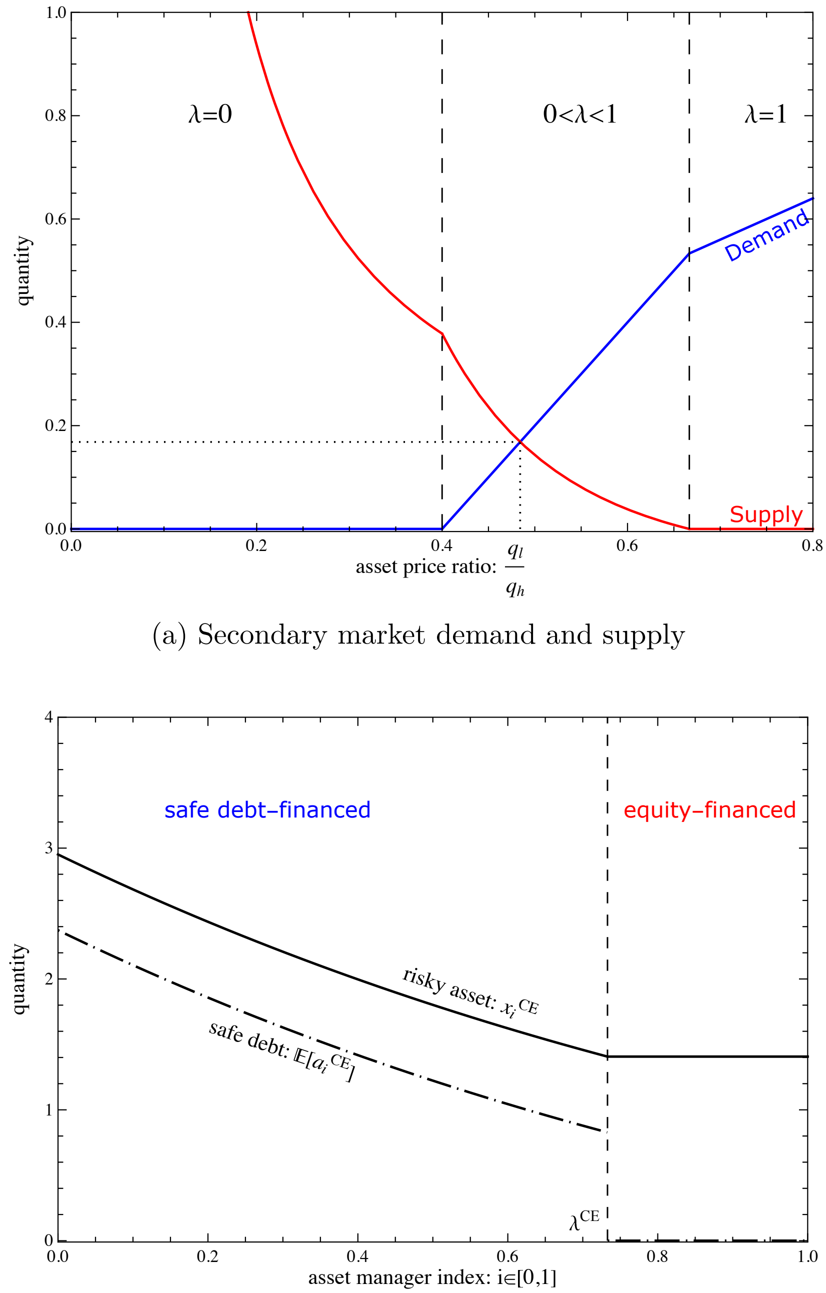


(a) Leveraged Loans



(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.



(a) Secondary market demand and supply

(b) Cross section of balance sheet choices

Figure 7: **Competitive equilibrium.**
This figure numerically illustrates the competitive equilibrium. Panel (7a) plots aggregate secondary market demand and supply for high-quality collateral as functions of the asset price ratio. Panel (7b) plots the cross section of asset and liability choices in competitive equilibrium, where x_i^{CE} and $\mathbb{E}[a_i^{CE}]$ denote equilibrium quantities of risky asset origination and expected safe debt issuance by manager i, respectively. Functional form and parameter values: $c(x) = x^{1.2}$, $p = 0.95$, $R = 1.2$, $\pi = 0.8$, $\gamma = 0.3$, $\xi = 0.14$, $x_L = 0.8$.

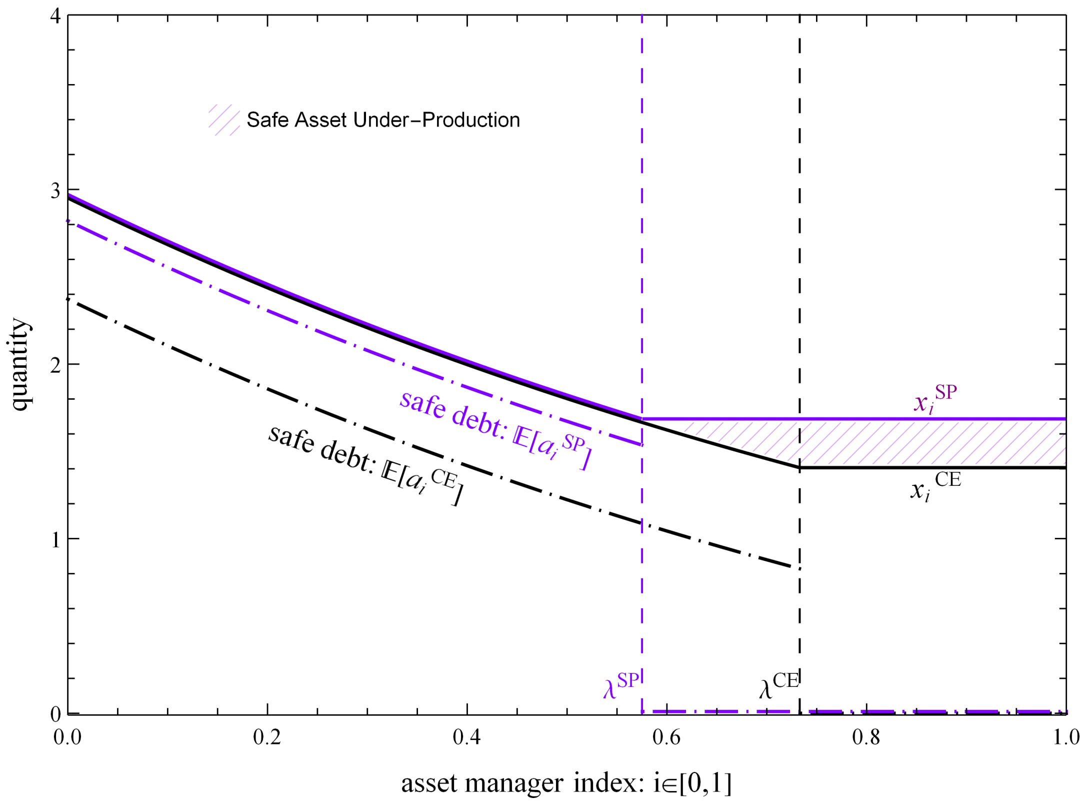


Figure 8: **Constrained inefficiency of the equilibrium.**
This figure numerically illustrates the differences between competitive allocation and social planner's allocation. Superscripts CE and SP indicate the competitive and planned allocations, and x_i and $\mathbb{E}[a_i]$ denote the quantities of risky asset origination and expected safe debt issuance by manager i, respectively. The area of the shaded region represents the quantity of under-production of safe assets in competitive equilibrium. Functional form and parameter values are the same as in Figure 7.

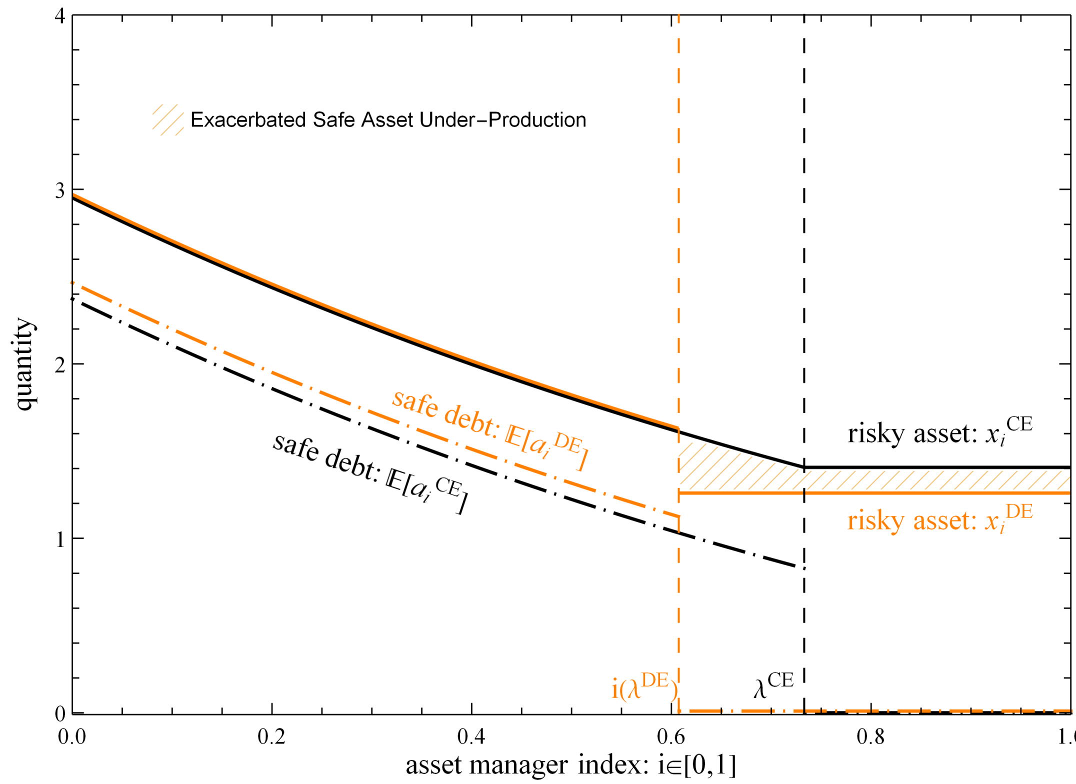


Figure 9: **Equilibrium distorted by the entry cost policy.**
This figure numerically illustrates competitive allocation when an entry cost is imposed on safe debt-financed intermediaries. Superscripts CE and DE indicate the original and distorted competitive allocations, and x_i and $\mathbb{E}[a_i]$ denote the quantities of risky asset origination and expected safe debt issuance by manager i, respectively. The area of the shaded region represents the quantity of incremental under-production 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.

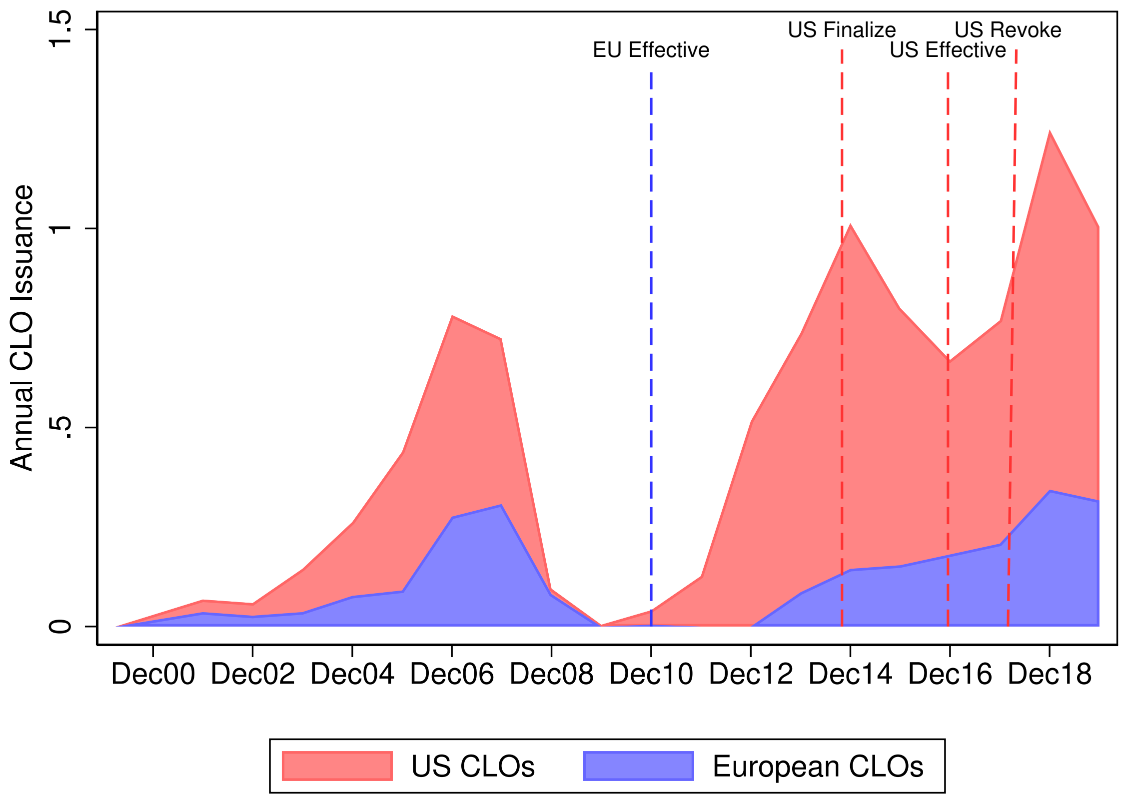


Figure 10: **Risk retention and CLO entry in the US and European markets.** This figure plots the timing of regulatory events and annual average number of an asset manager's CLO deals issued in the US and European markets. The Capital Requirements Directive II introduced in Europe requires 5% risk retention 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.

Appendix

A Proofs

Proof of Lemma 1. 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 asset's market clearing condition.

Proof of Lemma 2. 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 (16) 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 (16) is an equilibrium. Apply similar arguments to the planner's Kuhn-Tucker conditions (13)-(15), 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 $\{a_i : a_i \leq x_{i,h} + x_{i,l}\pi\}_{i\in\mathcal{I}}$ 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. If a competitive equilibrium exists, the cutoff type's indifference condition (17) 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 condition 1. The two groups of intermediaries' primary market investment choices follow from substituting (9) and (A1) into (6), respectively. Given optimal secondary market trades in proposition 1, the market clearing condition 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 expressed 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 condition 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.

Similarly, 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 (14) 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 investment choices follow from substituting $\eta_i^{SP} = \max\{\xi_\lambda - \xi_i, 0\}$ and $\psi^{SP} = \gamma - \xi_\lambda$ into (13). 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.

Full Analysis of the Two-Type Case (Proof of Lemma 3). In both competitive and planned 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 (13)–(15) and the market clearing condition. Figure A.7 summarizes all these results. There are four endogenous cutoffs, $0 < \underline{\alpha}^{SP} < \underline{\alpha}^{CE} < \bar{\alpha}^{SP} < \bar{\alpha}^{CE} < 1$, that divide $(0,1)$ into five mutually exclusive regions. Prices and allocations are different in each region. 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 $(\underline{a}_i^{CE}, \bar{a}_i^{CE}) = (x_{i,h} + x_{i,l}\frac{q_l}{q_h}, 0)$. By proposition 1, secondary market demand and supply for h are $\alpha x_L \frac{q_l}{q_h}$ and $(1-\alpha)(\bar{x} - x_L)$. Market clearing requires $\alpha \in (\underline{\alpha}^{CE}, \bar{\alpha}^{CE})$, where $\underline{\alpha}^{CE} := (\bar{x} - x_L)\Big(\bar{x} - (1 - \frac{(1-p)\pi}{1-p+\gamma-\bar{\xi}}x_L)\Big)^{-1}$ and $\bar{\alpha}^{CE} := (\underline{x} - x_L)\Big(\underline{x} - (1 - \frac{(1-p)\pi}{1-p+\gamma-\underline{\xi}}x_L)\Big)^{-1}$. For the planner, both types 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 $\alpha \le \underline{\alpha}^{CE}$. 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 $\alpha \le \underline{\alpha}^{SP}$.

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 $\alpha \geq \bar{\alpha}^{CE}$, investment choices are identical in competitive and planned allocations, so $A^{CE} = A^{SP}$ by equation (16).[54] The result that $\bar{x}^{CE} < \bar{x}^{SP}$ and $A^{CE} < A^{SP}$ when $\alpha \in (\underline{\alpha}^{SP}, \underline{\alpha}^{CE})$ follows from the following observations. When $\underline{\alpha}^{SP} < \alpha \leq \underline{\alpha}^{CE}$, $\psi^{SP} > \gamma - \bar{\xi}$ implies $\bar{x}^{CE} < \bar{x}^{SP}$; When $\underline{\alpha}^{CE} < \alpha \leq \bar{\alpha}^{SP}$, $\underline{a}_i^{CE} < \underline{a}_i^{SP}$ and $\bar{a}_i^{CE} = \bar{a}_i^{SP}$; When $\bar{\alpha}^{SP} < \alpha \leq \bar{\alpha}^{SP}$, $(1-p)\pi\frac{q_h}{q_l} < 1 - p + \gamma - \underline{\xi}$ implies $\bar{x}^{CE} < \bar{x}^{SP}$.

Proof of Proposition 3. 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

$$A^{SP} - A^{CE} = X^{SP} - X^{CE} = \int_{\lambda^{SP}}^1 (x_i^{SP} - x_i^{CE})\,\mathrm{d}i > 0 \tag{A6}$$

because $x_i^{SP} > x_i^{CE}$ for any $i \in (\lambda^{SP}, 1]$ by equations (18) and (21).

Proof of Lemma 4. The proof is by contradiction and consists of two steps. Both steps are constructed using the cutoff type condition (17), the market clearing condition (A2), and individually optimal risky asset origination choices (18) in proposition 2. The aggregate excess demand equation in policy-distorted market is

$$\chi^{DE}(\lambda) = \frac{q_l}{q_h}\int_0^{i(\lambda)} x_{i,l}\,\mathrm{d}i - \int_{i(\lambda)}^1 (x_i - x_{i,l})\,\mathrm{d}i. \tag{A7}$$

For expositional convenience, I use superscript CE to label variables in competitive equilib-

[54] The intuition for this result is similar to that of lemma 2: when constraints are slack for both individual managers and the planner, the pecuniary externality does not affect the efficiency of allocation.

rium, and I use DE to label variables in the distorted equilibrium under consideration.

Step 1: Suppose $\lambda^{DE} < \lambda^{CE}$, and hence $i(\lambda^{DE}) < \lambda^{DE} < \lambda^{CE}$. By equation (17), this implies $(\frac{q_l}{q_h})^{DE} < (\frac{q_l}{q_h})^{CE}$, and hence

$$\left(\frac{q_l}{q_h}\right)^{DE} \int_0^{i(\lambda^{DE})} x_{i,l}\,\mathrm{d}i < \left(\frac{q_l}{q_h}\right)^{DE} \int_0^{\lambda^{CE}} x_{i,l}\,\mathrm{d}i < \left(\frac{q_l}{q_h}\right)^{CE} \int_0^{\lambda^{CE}} x_{i,l}\,\mathrm{d}i. \tag{A8}$$

For equity-financed intermediaries, by equation (18), the hypothesized inequality also implies $x_i^{DE} > x_i^{CE}$, which further implies

$$\int_{i(\lambda^{CE})}^{1} x_i^{DE}\,\mathrm{d}i > \int_{\lambda^{CE}}^{1} x_i^{DE}\,\mathrm{d}i > \int_{\lambda^{CE}}^{1} x_i^{CE}\,\mathrm{d}i. \tag{A9}$$

Given equation (A2),

$$\left(\frac{q_l}{q_h}\right)^{CE} \int_0^{\lambda^{CE}} x_{i,l}\,\mathrm{d}i = \int_{\lambda^{CE}}^{1} (x_i^{CE} - x_{i,l})\,\mathrm{d}i, \tag{A10}$$

so inequalities (A8) and (A9) jointly imply

$$\left(\frac{q_l}{q_h}\right)^{DE} \int_0^{i(\lambda^{DE})} x_{i,l}\,\mathrm{d}i < \int_{i(\lambda^{CE})}^{1} (x_i^{DE} - x_{i,l})\,\mathrm{d}i. \tag{A11}$$

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

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

$$\left(\frac{q_l}{q_h}\right)^{DE} \int_0^{i(\lambda^{DE})} x_{i,l}\,\mathrm{d}i > \int_{i(\lambda^{CE})}^{1} (x_i^{DE} - x_{i,l})\,\mathrm{d}i, \tag{A12}$$

which is a contradiction too. Hence, the regulation-distorted competitive equilibrium satisfies $i(\lambda^{DE}) < \lambda^{CE} < \lambda^{DE}$.

Proof of Proposition 5. The proof builds on the observation that $\Delta a_i = -a_i$ is ex-post desirable if and only if $q_h > f_h^+ := f_h + \frac{q_l}{F_l}(F_h - f_h)$. To see that $q_h > f_h^+$ is sufficient, note that it implies $\frac{q_h}{F_h} > \frac{q_l}{F_l} + \frac{f_h}{F_h}\left(1 - \frac{q_l}{F_l}\right) \geq \frac{q_l}{F_l}$, so constraint (30) binds: the objective in problem (P1') then reduces to $\Delta a_i \frac{F_l(f_h^+ - q_h)}{f_h q_l}$, which strictly decreases in Δa_i. It can be easily seen from above that $q_h > f_h^+$ 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.

Competitive equilibria with safe debt maturity choices can be found 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 will use long-term contract. Similar to the baseline model, the competitive 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 conditions imply that no risky asset is sold to outsider investors. 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: $q_h \in (f_h, f_h^+]$. In this case, short-term contract maximizes ex-ante safe debt capacity ($a_i \frac{q_h}{q_l} > a_i$), but $\Delta a_i = 0$ is ex-post desirable. An analog of lemma 1 holds: $\frac{q_l}{q_h} \leq \frac{F_l}{F_h}$, otherwise there is either zero demand for low-quality asset or infinite demand for high-quality asset.[55] Hence, constraint (30) 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 originating risky asset is $y_i^e := pR_h + (1-p) F_l \frac{q_h}{q_l}$, and her payoff is

$$V_i^e = y_i^e c'^{-1}(y_i^e) - c(c'^{-1}(y_i^e)) - x_{i,l}\Big(p(R_h - R_l) + (y_i^e - pR_h)\Big(1 - \frac{q_l}{q_h}\Big)\Big). \tag{A13}$$

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

(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 $\eta_i^{lt} > 0$, her marginal payoff from originating risky asset is $y_i^{lt} = pR_h + (1-p)F_h + (\gamma - \xi_i)f_h$, and her payoff is

$$V_i^{lt} = y_i^{lt} c'^{-1}(y_i^{lt}) - c(c'^{-1}(y_i^{lt})) - x_{i,l}\Big(p(R_h - R_l) + (y_i^{lt} - pR_h)\Big(1 - \frac{q_l}{q_h}\Big)\Big). \quad \text{(A14)}$$

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

$$V_i^{st} = y_i^{st} c'^{-1}(y_i^{st}) - c(c'^{-1}(y_i^{st})) - x_{i,l}\Big(p(R_h - R_l) + (y_i^{st} - pR_h)\Big(1 - \frac{q_l}{q_h}\Big)\Big). \quad \text{(A15)}$$

The following observations indicate a pecking order among these liability types. First, $q_h \in (f_h, f_h^+]$ implies $\frac{F_h - f_h}{q_h - f_h} - (\frac{q_h F_l}{q_l f_h} - \frac{F_h}{f_h}) = -\frac{q_h(q_h - f_h^+)}{(q_h - f_h)q_l f_h} \geq 0$, 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: $\frac{\partial V_i}{\partial y_i} = c'^{-1}(y_i) - x_{i,l}(1 - \frac{q_l}{q_h}) > c'^{-1}(pR_h + (1-p)F_h) - x_{i,l} > 0$. 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 each 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 (28) indicates that in equilibrium, outside investors only buy the asset that has a (weakly) higher expected return. Possible 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 asset 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 asset is sold to outside investors.
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 asset 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 secondary market, long-term safe debt-financed intermediaries buy all high-quality assets sold by short-term safe debt-financed as equity-financed intermediaries. Low-quality assets are bought by equity-financed intermediaries and outside investors.
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 asset 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 secondary market, long-term safe debt-financed intermediaries buy all high-quality assets sold by short-term safe debt-financed intermediaries. All low-quality assets are bought by outside investors.
4. $\eta_i^{st} > 0$ for all i. Equilibrium asset prices are $q_j = \frac{(1-p)F_j}{1-p+\kappa}$, $j = h, l$. In secondary market, all risky assets are sold to outside investors.

Case 3: $q_h \in (f_h^+, F_h]$. 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 $q_h > f_h^+$ 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 outside investors buy asset h, their demand for asset l, which has a higher return, will be infinity. This contradicts with market clearing condition (28). So this case cannot exist in equilibrium.

Proof of Proposition 6. By lemma 1, the risk-neutral manager's objective in the negative-news stage 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 asset l given constraint (OC) is $\Delta x_{i,l} = (\frac{q_l}{q_h} - \rho)^{-1}(\hat{x}_{i,h} + \rho x_{i,l} - a_i - a_i^{oc})$. Suppose 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 asset h is always satisfied: $\Delta x_{i,h} = (1 - \rho\frac{q_h}{q_l})^{-1}(a_i + a_i^{oc} - \hat{x}_{i,h} - \rho x_{i,l}) \geq a_i - x_{i,h} + (1 - \rho\frac{q_h}{q_l})^{-1}(\bar{\epsilon} - \hat{\epsilon}_i) \geq -x_{i,h}$. 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 asset to low-quality asset without violating constraint (OC).

B Data and Sample Construction

B.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 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.[56] 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.

B.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

[56] 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.

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.[57] 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

[57] 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.

and aggregate balance amount to the deal ID–report date–borrower–maturity date level.[58] 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 current USD-EUR exchange rate.

B.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

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

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.[59] 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.[60] 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).

C Supplementary Results, Figures, and Tables

C.1 CLO Issuance

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

C.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 asset portfolio. It is trivial that assets 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

[59]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.

[60]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.

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

$$Quality_{it} = \beta AAA\%_i + \Gamma' Control_{it} + \delta_t + \epsilon_{it}, \tag{C16}$$

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.[61] The point estimate remains similar, suggesting that the result is not driven by unobserved shocks during the quarter of CLO issuance.

Columns (4)–(6) replace the dependent variable with portfolio value-weighted average coupon rate, which measures loan quality based on market risk pricing rather than rating agencies' models. Since leveraged loan coupons are quarterly updated based on a floating benchmark rate (typically 3-month LIBOR), in the cross section, a higher coupon implies a riskier portfolio. For both measures, an interquartile variation in $AAA\%$ is associated with roughly 0.5 standard deviation higher collateral quality, suggesting a strong positive relationship between portfolio quality and safe debt outstanding.[62]

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

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

C.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

$$Entry_{imt} = \beta_0 + \beta_1 USmkt_{im} \times CRR_t + \beta_2 USmkt_{im} + \beta_3 CRR_t + \Gamma' Control_{m,t-1} + \epsilon_{imt}, \quad \text{(C17)}$$

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.[63]

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 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

[63] 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.

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.

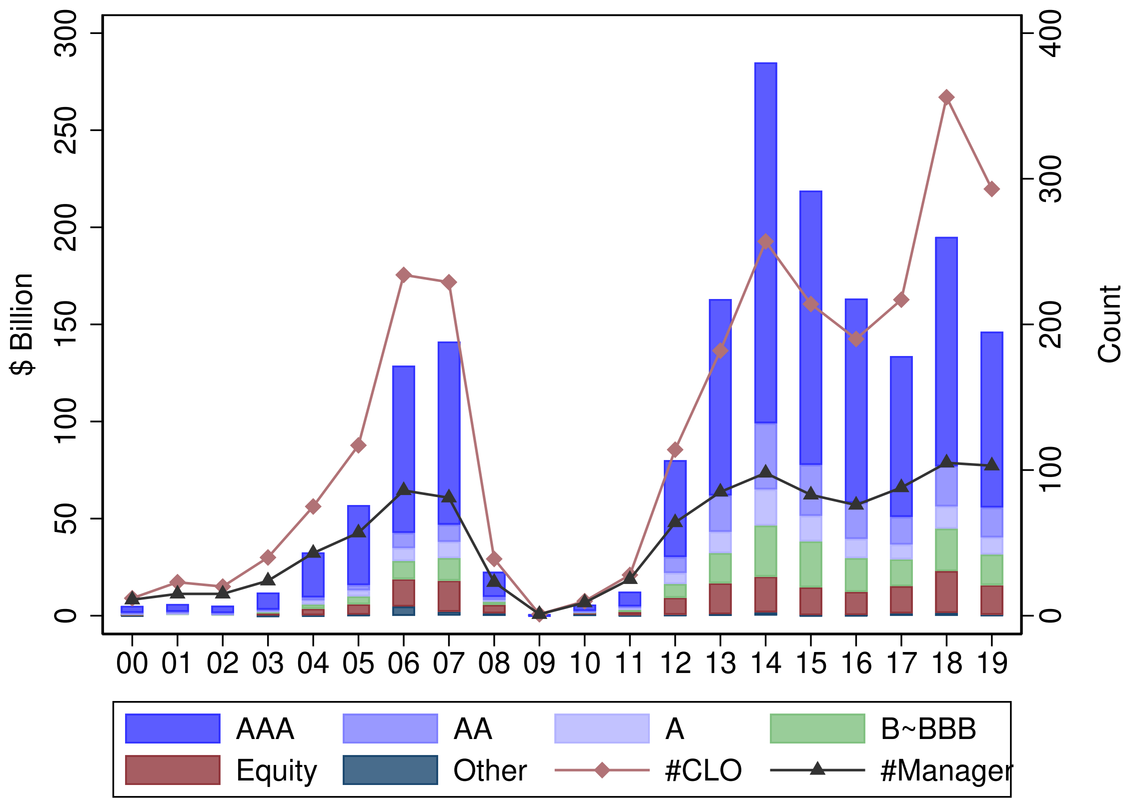


Figure A.1: **Annual CLO issuance, 2000–2019.**
This figure plots annual issuance amount and the numbers of deals and asset managers of open-market CLOs issued in the US and Europe. The issuance amount is decomposed by CLO liability tranches based on initial credit ratings, and tranche size denominated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

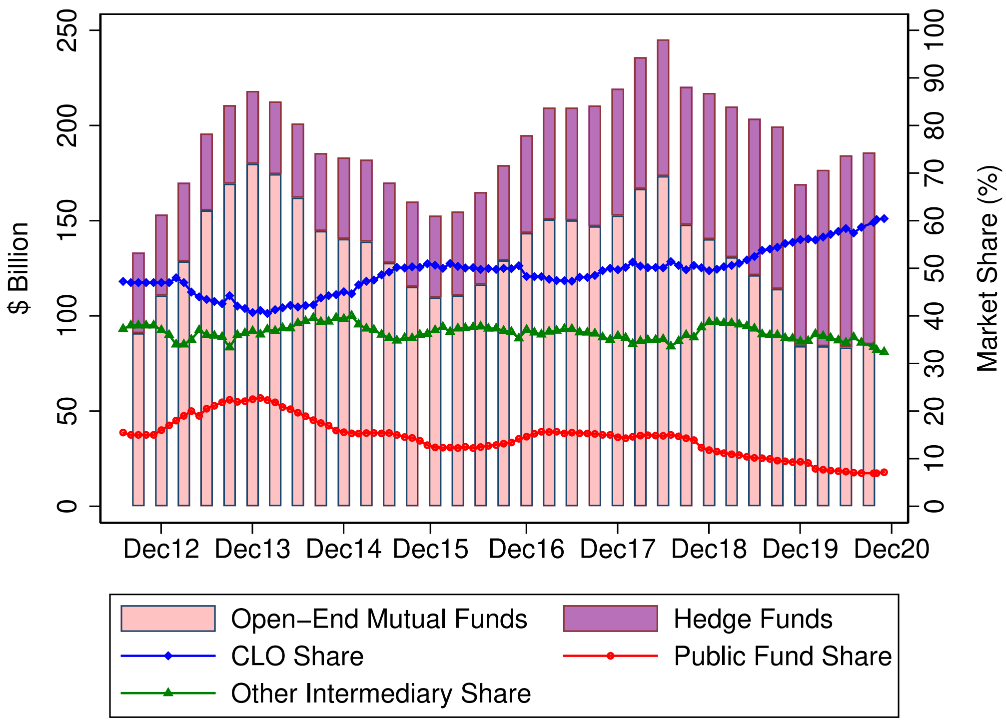


Figure A.2: **Intermediaries in the leveraged loan market, 2012–2020.**
This figure provides more detailed information on the composition of intermediaries in the leveraged loan market. The stacked bars plot total values of leveraged loans held by open-end mutual funds and hedge funds (left axis). The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

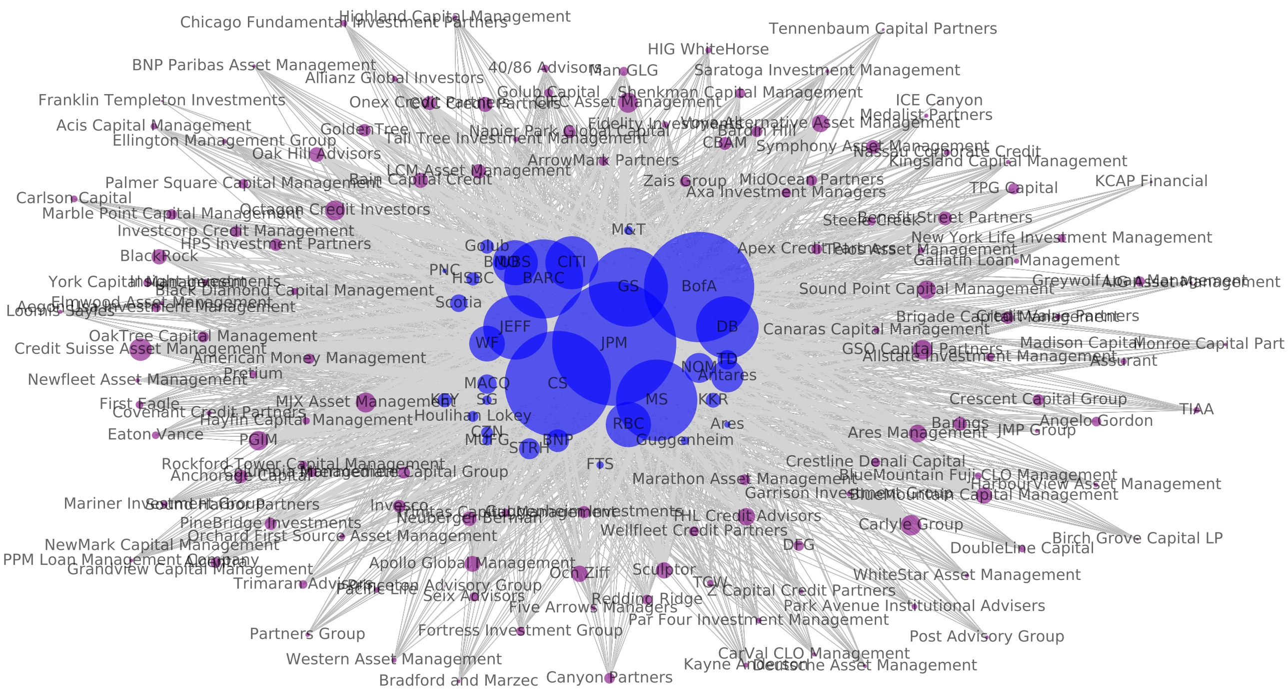
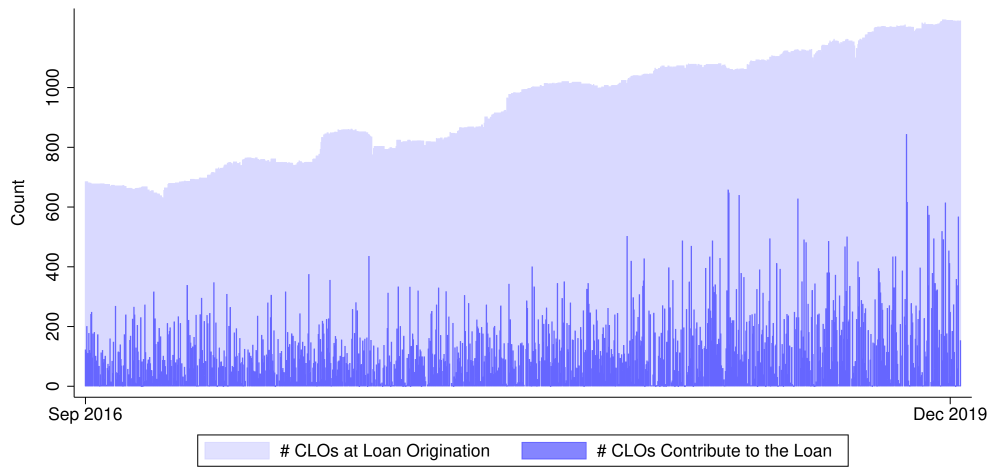
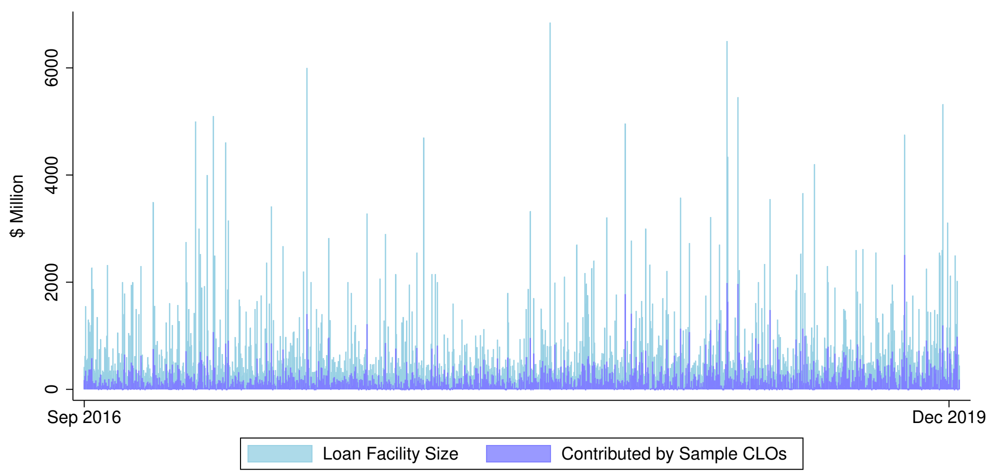


Figure A.3: **Leveraged loan underwriters and CLO managers.**
This figure plots underwriter banks ("lead arranger") and CLO managers between 2016–2019. The size of a blue circle is proportional to the total amount of loans arranged by an underwriter, and the size of a purple circle is proportional to 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.4: **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.

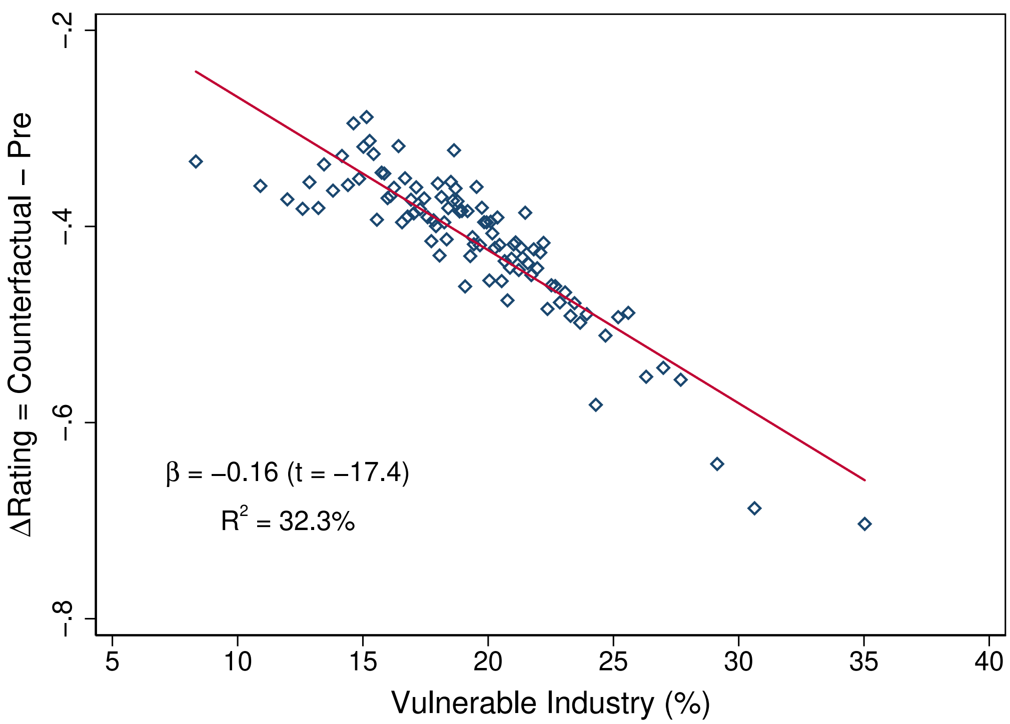


Figure A.5: **Vulnerable industry exposure and counterfactual collateral quality deterioration.**
This figure is a scatter plot that groups CLOs into 100 bins by portfolio weight in industries vulnerable to the COVID-19 pandemic before February 15, 2020 and depict the average counterfactual portfolio 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.

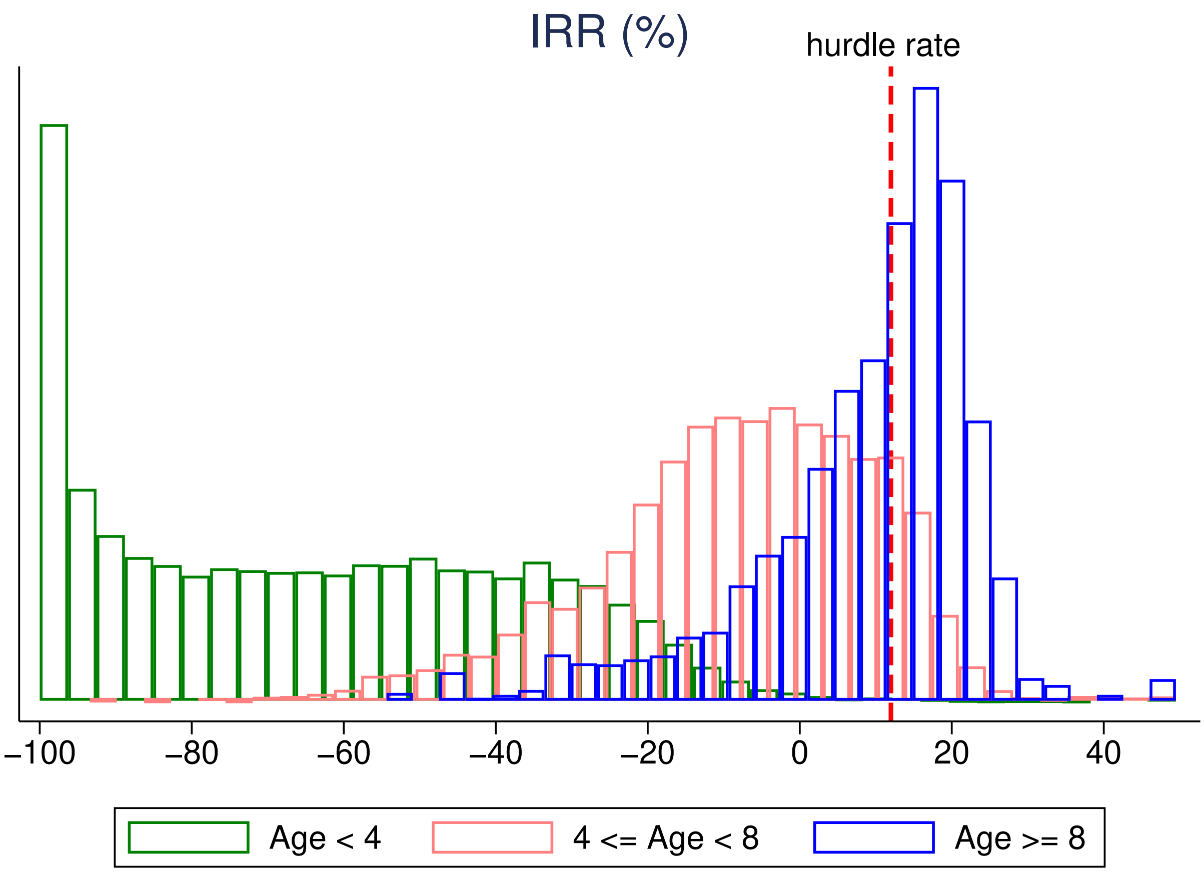


Figure A.6: **CLO equity IRR.**
This figure plots empirical distributions of US CLO equity tranche internal rate of return (IRR) by the deal's age. The vertical dashed line indicates the typical hurdle rate, 12%, maintaining a deal's IRR above which allows the asset manager to receive 20% of incentive fee from equity dividends.

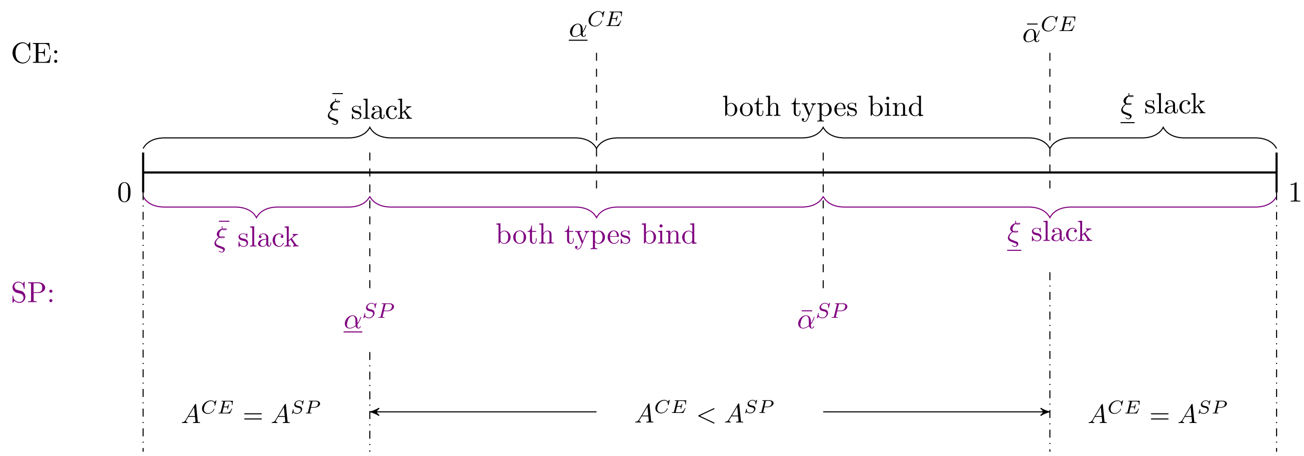
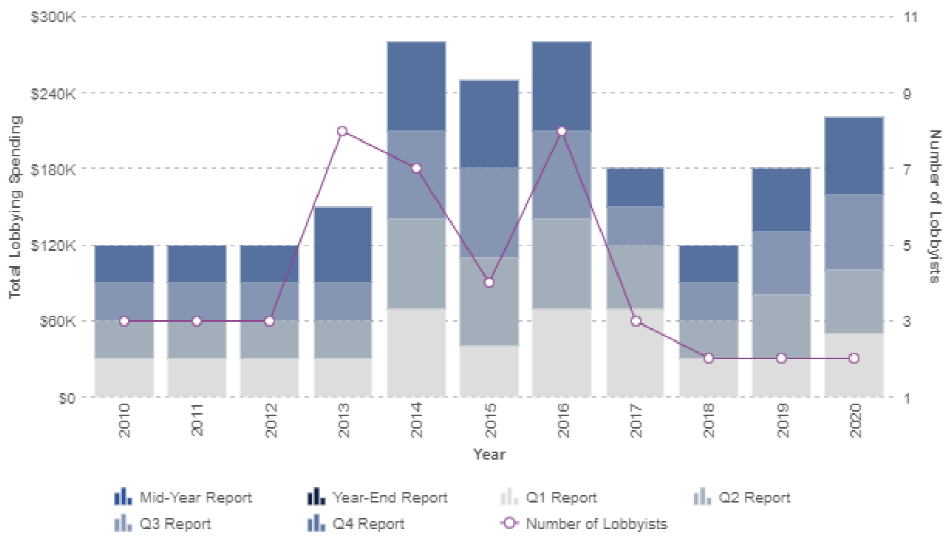
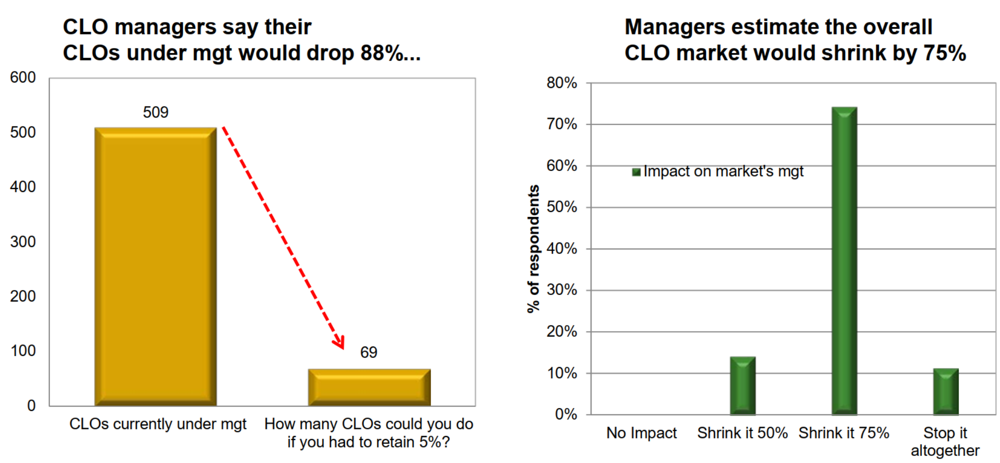


Figure A.7: **Two-type case: competitive and planned allocations.**
This figure illustrates how the competitive and planned allocations in the two-type case depend on α, the fraction of low-cost manager type.



(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 B.

	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