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

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Abstract

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

JEL classifications: G11, G23, G28

Keywords: safe asset, collateral management, pecuniary externality, leveraged loan, collateralized loan obligation, credit risk retention

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Introduction

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

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

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

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

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

This paper provides the first theoretical analysis of safe asset production by CLOs. Specifically, I develop an equilibrium model of the leveraged loan market to study the supply of safe assets and the dynamic trading of underlying loans. The model's main insight is that when managers can promise to maintain collateral quality in downturns, intermediaries with two distinct types of liabilities endogenously coexist, and the market produces more safe assets beyond static securitization (Proposition 1). I then show that the competitive equilibrium may not be socially optimal (Proposition 2) and that a recent policy can exacerbate the inefficiency (Proposition 3).

I consider a three-period model in which investors get a non-pecuniary benefit from holding safe assets. The challenge faced by intermediaries trying to issue a large quantity of safe debt is that risky loans are scarce (due to diminishing returns) and may deteriorate after origination (due to aggregate shocks). Deteriorated loans are riskier and might pay off poorly, but which loans will deteriorate is unknown ex ante. After deterioration, a mismatch between assets and liabilities arises: good loans are better collateral but may be held by intermediaries with no commensurate safe debt outstanding. This mismatch generates secondary market trading, through which intermediaries reallocate loans among themselves.

My framework rationalizes the observed market structure as an equilibrium outcome. In the model, two groups of intermediaries emerge and coexist. The first group, which resembles CLOs, maximizes safe debt capacity by promising to maintain collateral quality. The second group, like mutual funds and hedge funds, chooses not to issue any safe debt. In bad times, the first group sells deteriorated loans to, and buys less risky loans from, the second group. These trades cause the price of bad loans to decrease relative to the price of good loans, making it profitable to trade against the CLOs. Anticipating the profits, the second group willingly gives up issuing safe debt and provides collateral in the secondary market.

Secondary market trades in my model are broadly consistent with empirical observations. I document that CLOs' collateral substitution in the COVID-19 crisis substantially improved their portfolio quality. Tracking the dynamics of loan ownership, Giannetti and Meisenzahl (2021) show that mutual funds and hedge funds buy deteriorated loans sold by CLOs. Simultaneous trades initiated by many CLOs also exert pressures on loan prices (Elkamhi and Nozawa, 2022), which creates profit opportunities for the counterparties.

How does secondary market trading increase safe asset supply in an economy with only aggregate uncertainty? Intuitively, safe debt cannot exceed the worst-possible loan payoffs, so reallocating loans before the payoffs realize is valuable only if intermediaries have heterogeneous securitization technology. Collateral providers, who lack superior technology to securitize loans, lend more than in static securitization and profit from the secondary market; Meanwhile, the increased lending provides more collateral and allows safe debt issuers, who face lower costs of securitization, to produce a greater supply of safe assets.

This market structure suffers from an inherent inefficiency precisely when loan trading is socially valuable. The source of inefficiency is a pecuniary externality: intermediaries ignore the equilibrium effects of their lending and financing choices on loan prices, which tighten safe debt issuers' binding collateral constraints. On the asset side, there is underinvestment because the private profits of lending are lower than the social benefits of collateral. On the liability side, issuing safe debt is privately optimal for intermediaries with mediocre securitization technology, but doing so reduces collateral available to others. These two forces jointly depress the marginal rate of collateral substitution commonly faced by all safe debt issuers. As a result, there is excessive entry into safe asset production, but the market underproduces safe assets relative to a constrained planner's allocation.

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

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

The framework presented in this paper contributes to a fast-growing body of empirical literature on leveraged loans and CLOs. Research on CLOs' asset portfolios generally takes the contracts as given and documents that managers strategically trade loans that are marked-to-market (Elkamhi and Nozawa, 2022; Kundu, 2021) or have higher prices (Loumioti and Vasvari, 2019; Nicolai, 2020). Research on the liability side has studied the realized returns (Cordell, Roberts, and Schwert, 2021), secondary market transactions (Foley-Fisher, Gorton, and Verani, 2020), and credit ratings (Griffin and Nickerson, 2020) of CLO securities. However, there is limited understanding on how intermediary liabilities are shaped by the CLO contracts and the resulting loan trades. My paper provides an equilibrium view of safe asset production that explains the dynamics of CLO balance sheets and the structure of the leveraged loan market.

More broadly, this paper's analysis of nonbank intermediaries offers a new perspective on modern financial intermediation. Seminal work by Diamond and Dybvig (1983) and Gorton and Pennacchi (1990) find that by creating safe and liquid claims, intermediaries facilitate efficient allocation under information frictions. Subsequent research further develops the insight that safety creation drives intermediary asset choices.[2] DeAngelo and Stulz (2015) analyze bank capital structure and risk management when safe debt commands a premium. Dang et al. (2017) show that by discouraging information acquisition, holding opaque assets helps banks make their deposits safe. Diamond (2020) models safe asset production in an endowment economy in which intermediary balance sheets are jointly determined with the liabilities of non-financial firms. In the existing literature, there is no role for dynamic asset portfolios in the production of safe liabilities. My innovation is to analyze how secondary market trading allows intermediaries to create safe assets 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.

My normative analysis builds on the theoretical literature on pecuniary externalities associated with price-dependent borrowing constraints, which Dávila and Korinek (2018) classify as "collateral externalities". In Gromb and Vayanos (2002), competitive arbitragers trading in segmented markets face collateral constraints, through which asset prices prevent efficient risk taking. Stein (2012) analyzes banks that issue short-term safe debt backed by a promise to liquidate loans. Since banks fail to internalize that lower loan prices crowd out nonbanks' real investments, the market overproduces safe assets. Neuhann (2019) considers loan buyers who do not internalize that higher prices relax bank collateral constraints and reduce the incentives to screen loans. My model differs in that intermediaries with identical lending technology trade loans among themselves after choosing different liabilities. As the

[2] One strand of the literature posits that an excessive production of private safe assets can lead to financial fragility due to fire sales (Stein, 2012; Greenwood, Hanson, and Stein, 2015) or neglected risks (Gennaioli, Shleifer, and Vishny, 2012, 2013).

prices and constraints depend on the balance sheets of all counterparties, the equilibrium features safe asset underproduction and presents new policy implications.

The remainder of this paper is organized as follows. Section 1 presents institutional background and empirical facts. Section 2 introduces the model, and Section 3 characterizes the equilibrium. Section 4 analyzes the equilibrium's welfare properties and the effects of policy interventions, and Section 5 concludes.

1 Institutional Background and Empirical Facts

Leveraged loans are private debt extended to corporations that have a high existing leverage.[3] These loans are originated through syndication deals, where underwriters organize select groups of lenders to privately contract with the borrowers. Following Federal Reserve Board (2021), this paper restricts attention to "institutional leveraged loans", which are term loans and mostly held by nonbanks.[4] CLOs are the largest group of nonbank intermediaries that hold leveraged loans. As Figure 1 shows, US leveraged loans quickly grew from $130 billion to $1.2 trillion between 2001—2020, and CLOs consistently held roughly half of these loans. The vast majority of CLOs are "open-market CLOs", which are operated by asset managers that are independent from the underwriter banks.

Unlike other asset-backed securities (ABS) that are backed by static collateral, CLOs allow their managers to buy and sell the underlying loans during a predetermined reinvestment period. A CLO lasts around 10 years, and the reinvestment period is usually the first 5 years. After this period, the CLO enters its amortization period and repays debt principals over

[3]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.

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

time.[5] The manager's compensation consists of fixed fees, which are based on tranche size, and incentive fees, which are based on equity performance.

Safe Asset Production. Since no asset is literally risk free, the definitions of safe assets are diverse and sometimes vague. Existing definitions often involve the convenience services provided by low-risk debt instruments. In the context of this paper, such services are reflected in that highly-rated CLO securities help regulated financial institutions satisfy risk-based capital requirements (Benmelech and Dlugosz, 2009). While leveraged loans have speculative-grade ratings, CLOs' senior debt tranches (about 65% of liabilities) are rated AAA and have never defaulted in history. The safety of senior tranches relies on several factors. First, the underlying portfolios are diversified, typically consisting of 100–300 loan shares. Second, the default recovery rates of leveraged loans have been moderately high.[6] Third, CLO contracts include covenants that protect debtholders, which I will introduce in detail later.

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

Covenants and Collateral Constraints. The overall large size of leveraged loans creates an economy of scale in information production. As most of the loans are individually rated

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

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

by third parties, long-term contracts enforced based on the ratings allow CLO managers to commit to maintaining collateral quality. This commitment is implemented with regular (e.g., monthly) collateral tests that are linked to the manager's compensation. The most important test is the over-collateralization (OC) test, which calculates a ratio of quality-adjusted total par of loan holdings to the face value of the debt tranche.[7] When the OC test fails, the covenants require the manager to either trade loans or accelerate debt repayment to bring the ratio above a predetermined threshold.

Dynamics of CLO Balance Sheets. Collateral constraints imposed by the contracts play a crucial role in governing the dynamics of the CLO balance sheet. In Section IA.2 of the Internet Appendix, I provide detailed evidence for the following facts. First, the collateral constraints are persistently binding, which implies that CLO managers fully use their safe debt capacity. Second, in response to systematic loan deterioration caused by the COVID-19 crisis, CLOs substitute collateral by trading in the secondary market. Third, collateral substitution offsets a major fraction of loan deterioration, thus improving CLOs' portfolio quality relative to counterfactual portfolios.[8] Finally, these trades appear to exert asymmetric price pressure on loans of different quality.

2 An Equilibrium Model of Securitized Lending

This section presents an equilibrium model of securitized lending in which asset managers can credibly promise to maintain collateral quality through secondary market trading. The setup focuses on long-term contracts under full commitment and relegates the analysis of maturity choice and contractual frictions to Section IA.3 of the Internet Appendix. All proofs and derivations are in the Appendix.

[7]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.

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

2.1 Environment

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

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

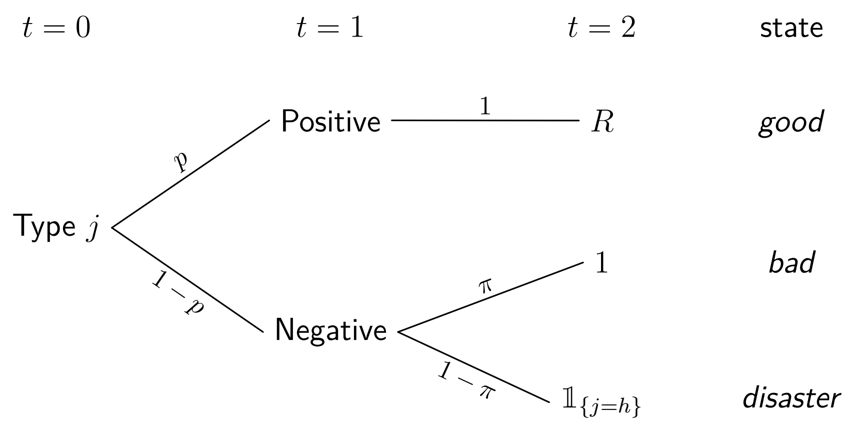
$$U = \mathbb{E}_0\Big[\sum_{t=0}^{2} C_t\Big] + \gamma A, \tag{1}$$

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

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

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

Investment Technology. Investors cannot lend directly. Asset managers have identical and independent access to two types of scalable investment projects $j \in \{h, l\}$. Every unit of capital in projects generates a gross payoff R_j^ω that depends on state $\omega \in \Omega = \{g, b, d\}$ at $t = 2$. In period $t = 1$, a piece of public news s arrives, which can be either positive ("+") or negative ("−") with probabilities p and $1 - p$, respectively. If s is positive, state g ("good") will realize with certainty, and both types of projects will pay $R_j^g = R > 1$ units of consumption goods. If s is negative, then $t = 2$ state remains uncertain. With probability $\pi \in (0, 1)$, state b ("bad") will realize, and the two types both pay $R_j^b = 1$. With probability $1 - \pi$, state d ("disaster") realizes. Whereas type h still pays $R_h^d = 1$ in this state, type l pays $R_l^d = 0$. The existence of a strictly positive worst-possible loan payoff at $t = 2$ makes issuing long-term safe debt possible.[9]



Converting consumption goods into x units of capital incurs $c(x)$, where c is twice differentiable and satisfies $c(0) = 0$, $c'(\cdot) > 0$, and $c''(\cdot) < 0$. To simplify the analysis, I assume that project payoffs are fully pledgeable, and asset managers enjoy full bargaining power. By lending to projects, an intermediary originates risky loans.[10] Depending on project

[9]This payoff distribution is stronger than necessary but helps keep the model transparent. Subsection IA.3.1 considers a setting with generalized conditional payoff distributions.

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

types, I refer to the loans as h (high-quality, or "good") and l (low-quality, or "bad") loans, respectively.

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

To finance the investment cost $c(x_i)$, the intermediary issues safe debt with face value $a_i \geq 0$ and external equity shares. Since only safe debt provides convenience services, here equity can be interpreted as any risky liability, such as junior debt. Intermediaries hold no asset other than loans because consumption goods are non-storable, cross-holdings of claims are unprofitable, and bilateral contracts between managers are not enforceable.

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

The Intermediary's Optimization Problem. Asset managers make sequential choices to maximize their own payoffs. I describe their optimization problem backwardly and only consider repayment in the final period. The option of early debt repayment, as I show in Section IA.3 of the Internet Appendix, can be ignored without loss of generality under the setup in this section.

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

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

These trades are subject to a budget constraint

$$\sum\nolimits_j (x_{i,j} + \Delta x^s_{i,j}) q^s_j \leq \sum\nolimits_j x_{i,j} q^s_j, \tag{BC}$$

a maintenance collateral constraint

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

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

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

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

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

$$a_i \le \left(\sum_j x_{i,j} q_j^s\right) \max_j \min_{\omega \in \Omega^s} \frac{R_j^\omega}{q_j^s}, \ \forall s \tag{ICC}$$

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

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

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

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

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

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

2.2 Equilibrium Definition

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

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

$$\int_i \Delta x_{i,j}^s \, \mathrm{d}i = 0 \quad \text{for } j \in \{h, l\}, s \in \{+, -\}. \tag{2}$$

2.3 Discussion of Model Setup

My model builds on two main assumptions. First, investors get utility from safe assets, which is standard in the literature (e.g., Krishnamurthy and Vissing-Jorgensen, 2012; Stein, 2012; Diamond, 2020). Because of this preference, safe debt can be priced at a premium, and an intermediary's capital structure is relevant to its value, breaking the Modigliani and Miller (1958) theorem. Empirically, CLO debt tranches are overpriced on a risk-adjusted basis relative to leveraged loans, which helps the equity tranches earn high returns (Cordell, Roberts, and Schwert, 2021). Second, investment exhibits decreasing returns to scale, so intermediaries face a scarcity of risky loans. This is consistent with the large number of CLOs and managers and the relatively small size of their loan portfolios.

The securitization technology that allows managers to commit to satisfying the collateral constraints is crucial for debt safety. In practice, CLOs only hold fairly standardized corporate loans, so that long-term contracts can effectively discipline the manager's portfolio choices. With simple collateral, CLOs are vastly different from collateralized debt obligations (CDOs), which held enormous complex derivatives such as credit default swaps (Cordell, Huang, and Williams, 2011). Consistent with these facts, intermediaries in the model cannot use state-contingent bilateral contracts.

Another assumption is that asset managers may face heterogeneous safe debt issuance costs. A lower cost can be interpreted as a technological advantage that arises from the manager's other businesses. For example, it is plausibly less costly for KKR than Fidelity to securitize loans and raise funding from global private markets. The issuance cost is assumed to be exogenous and proportional to safe debt for tractability. Alternative assumptions, such as a cost associated with issuing levered equity, yield qualitatively similar results.

3 Equilibrium

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

3.1 Benchmark: Static Securitization

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

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

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

3.2 Secondary Market Trades

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

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

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

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

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

Lemma 2. *In the negative-news stage, the ratio of secondary market loan prices is lower than the ratio of fundamental values:* $\frac{q_l}{q_h} \leq \pi$.[11]

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

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

$$\Delta x_{i,h} = a_i - x_{i,h}, \;\; \Delta x_{i,l} = -\frac{(a_i - x_{i,h})q_h}{q_l} \tag{3}$$

for any given $x_{i,h}$ and a_i. These trades reallocate risky loans among intermediaries. A

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

manager with $a_i > x_{i,h}$ optimally sells just enough bad loans to increase the holding of good loans to keep debt safe. By contrast, a manager with $a_i < x_{i,h}$ sells its extra good loans and buys bad loans to profit from the deviation of loan prices from fundamentals.

3.3 Balance Sheet Choices

This subsection characterizes the manager's optimal lending and financing choices at $t = 0$ for given loan prices. The analysis in the previous subsection shows that equity holders' continuation value v in the positive- and negative-news stages are $x_i R - a_i$ and $\pi\Big(x_{i,l} + (x_{i,h} - a_i)\frac{q_h}{q_l}\Big)$, respectively. By no arbitrage, $0 < q_l < q_h$, so initial collateral constraint (ICC) is equivalent to

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

Substitute v into (P0), the manager's lending and financing problem becomes[12]

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

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

$$pR + (1-p)\pi\frac{q_h}{q_l} - c'(x_i) + \eta_i = 0, \tag{4}$$

$$\gamma - \xi_i - (1-p)\Big(\pi\frac{q_h}{q_l} - 1\Big) - \eta_i + \mu_i = 0, \tag{5}$$

and

$$\eta_i \geq 0, \eta_i\Big(a_i - \Big(x_{i,h} + x_{i,l}\frac{q_l}{q_h}\Big)\Big) = 0, \mu_i \geq 0, \mu_i a_i = 0. \tag{6}$$

Equation (5) states that a manager's financing choice is based on a tradeoff between

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

ex-ante funding benefit of safe debt, $\gamma - \xi_i$, and expected losses from loan trades in bad times, $(1-p)\left(\pi \frac{q_h}{q_l} - 1\right)$. It follows that two cases are possible. In the first case, the benefit is less than the cost, hence no safe debt would be issued ($\mu_i > 0$), and the collateral constraint would be slack ($\eta_i = 0$). Accordingly, the lending choice in (4) is simply based on a tradeoff between the expected payoff and the marginal cost of investment.

In the second case, the funding benefit exceeds the losses from trading, and collateral constraint (ICCa) binds. On the liability side, the manager fully uses safe debt capacity in (ICCa) to exploit cheap financing. On the asset side, as characterized by Equation (4), lending exceeds what the payoff–cost tradeoff suggests. The additional investment, captured by $\eta_i = \gamma - \xi_i - (1-p)(\pi \frac{q_h}{q_l} - 1) > 0$, reflects the collateral value of loans. As η_i decreases in ξ_i, a manager with better securitization technology lends more and issues more safe debt.

3.4 Equilibrium Market Structure and Safe Asset Supply

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

The market-clearing condition (2) and optimal trades in (3) imply an equilibrium relationship that is consistent with Walras law:

$$\int_i a_i \, \mathrm{d}i = \int_i x_{i,h} \, \mathrm{d}i. \tag{7}$$

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

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

3.4.1 Equilibrium without Heterogeneity

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

Lemma 3. *If managers are homogeneous,* $\frac{q_l}{q_h} = \frac{(1-p)\pi}{1-p+\gamma-\xi^*}$, $x_i = c'^{-1}(pR + 1 - p + \gamma - \xi^*)$, *and any* $\left\{a_i : a_i \leq x_{i,h} + x_{i,l}\frac{q_l}{q_h}\right\}_{i\in\mathcal{I}}$ *that satisfies Equation (7) is an equilibrium. The supply of safe assets is the same as in static securitization.*

The intuition of this result follows from the tradeoff captured in Equation (5). When mangers are homogenous, secondary market prices must adjust until everyone is indifferent about financing choices. That is, the benefit of issuing one more unit of safe debt equals the profit of selling one more unit of collateral to others. This indifference condition implies that lending choices, and hence by Equation (7), the supply of safe assets, coincide with the setting where nobody sells collateral to others, namely, the static benchmark.

3.4.2 Equilibrium with Heterogeneity in Securitization Technology

For various reasons, asset managers may face a technological difference in securitization. My analysis of the equilibrium under this heterogeneity is based on a setting where every manager has a different type. This setting allows for a clean characterization that incorporates intuition from settings with discrete manager types, for which I provide an analysis in Subsection IA.4.1 of the Internet Appendix.

Without loss of generality, let manager i's variable safe debt issuance cost be $\xi_i = 2\xi i$ for constant $\xi \in (0, \gamma/2)$. Managers are thus ranked by issuance cost. Intuitively, a manager with a higher issuance cost benefits less from safe debt and is more willing to issue only equity, and Equation (5) indicates that the constraints on safe debt choices will bind for almost everyone. Hence, financing choices at the extensive margin can be summarized by a cutoff $\lambda \in [0, 1]$: managers $i \leq \lambda$ issue safe debt, and managers $i > \lambda$ issue only equity. By construction, the cutoff type is indifferent between issuing safe debt and providing collateral to others:

$$\gamma - \xi_\lambda = (1-p)\Big(\pi \frac{q_h}{q_l} - 1\Big). \tag{8}$$

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

Proposition 1 (Competitive Equilibrium)**.** *There exists a unique equilibrium.*[13] *In equilibrium, there is an interior cutoff $\lambda^{CE} \in (0, 1)$ such that (i) managers below the cutoff fully use safe debt capacity and promise to maintain collateral quality, and (ii) managers above the cutoff do not issue any safe debt. Specifically,*

$$x_i^{CE} = \begin{cases} c'^{-1}\Big(pR + 1 - p + \gamma - \xi_i\Big), & \textit{if } i \leq \lambda^{CE} \\ c'^{-1}\Big(pR + 1 - p + \gamma - \xi_{\lambda^{CE}}\Big), & \textit{if } i > \lambda^{CE} \end{cases}, \tag{9}$$

$$a_i^{CE} = \begin{cases} x_i^{CE} - x_{i,l} + x_{i,l}\frac{q_l}{q_h}, & \textit{if } i \leq \lambda^{CE} \\ 0, & \textit{if } i > \lambda^{CE} \end{cases}, \tag{10}$$

[13] The uniqueness is with respect to balance sheet quantities and price ratio. The levels of loan prices are not uniquely identified. Subsection IA.3.1 of the Internet Appendix generalizes the setting to allow for identified price levels.

and

$$\frac{q_l}{q_h} = \frac{(1-p)\pi}{1-p+\gamma-\xi_{\lambda^{CE}}} \tag{11}$$

Proposition 1 characterizes intermediary balance sheets and the market structure. In equilibrium, two distinct groups of intermediaries, like CLOs and mutual funds, endogenously coexist. The first group optimally exhausts safe debt capacity, which they maximize by promising to replace the entirety of deteriorated loans after negative news.[14] This promise allows the managers to enjoy high payoffs after positive news.

By contrast, managers in the second group completely give up issuing safe debt. They do so because market-clearing loan prices deviate from fundamental values (i.e., $q_l/q_h < \pi$), which makes providing collateral in the secondary market more attractive to them. As the profit of collateral provision does not depend on the manager's safe debt issuance cost, intermediaries in this group have identical lending choices.

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

An immediate corollary of Proposition 1 is that the market produces more safe assets than the static benchmark. Consistent with Equation (7), this greater safe asset supply is accompanied by a larger quantity of high-quality loans. The collateral providers, despite having no need for collateral, lend more than they would in static securitization: Equation (9) shows that $x_i^{CE} > x_i^{STA}$ for every $i > \lambda^{CE}$. They do so because the anticipated profits from secondary market trading increase the marginal return from loan origination. Moreover, as safe debt is issued by managers with relatively better securitization technology, the market also has a lower average cost of safe asset production than the static benchmark.

Figure 3 provides a numerical illustration of the equilibrium and compares the market structure with and without a secondary market. Unlike that everyone issues safe debt in

[14] To see this, substitute the safe debt choice (10) into optimal trades in (3).

static securitization, the market has an interior mix of intermediaries with distinct liabilities. Managers with better securitization technology issue safe debt and have larger balance sheets. Their increased safe debt capacity from dynamic collateral management can be seen in the wedge between $\mathbb{E}[a_i^{CE}]$ and $\mathbb{E}[a_i^{STA}]$. From an equilibrium perspective, this increase comes from the lending choices of the the other side of the market, which is reflected by the wedge between x_i^{CE} and x_i^{STA}.

3.5 Model Extensions

My model's focus on long-term debt leaves the question open as to why CLOs do not issue short-term debt, which can be made safe by liquidating loans and repaying debtholders in bad times. To address this question, I analyze two extensions in Section IA.3 of the Internet Appendix. First, I allow debt maturity choices and loan trades to be jointly determined with secondary market purchases by outside investors.[15] Intuitively, long-term contracts help CLOs maximize and maintain cheap leverage when it is costly for outsiders to participate and buy liquidated loans. Second, I discuss contractual frictions, under which managers strategically respond to collateral constraints. I show that requiring over-collateralization can constrain managers from reaching for yield. However, the informativeness of verifiable proxies for loan quality is crucial to the safety of long-term debt backed by dynamic portfolios.

4 Welfare and Policy Implications

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

[15] Outsiders (e.g., distressed debt funds) differ from intermediaries in that they only invest in liquidated assets in the secondary market and do not participate in loan origination.

4.1 Social Planner's Problem

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

The market-clearing condition (2) imposes an additional constraint on the planner. As shown in the previous section, in the negative-news stage, binding constraints trigger loan trades given in Equation (3). The secondary market clears if and only if $\int_i (a_i - x_{i,h})\,\mathrm{d}i \le 0$, which gives rise to an aggregate collateral constraint.[16]

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

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

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

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

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

The aggregate collateral constraint (ACC) binds at the optimum: otherwise, there would be some i such that $a_i \in [0, x_{i,h})$, and since $\gamma > \xi_i$, increasing a_i would improve the objective, a contradiction to optimality. This implies that Equation (7) holds in the planned economy as well. Moreover, the slackness of individual collateral constraint (ICC) strictly increases in

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

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

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

$$pR + 1 - p - c'(x_i) + \psi^{SP} + \eta_i^{SP} = 0, \tag{12}$$

$$\gamma - \xi_i - \psi^{SP} - \eta_i^{SP} + \mu_i^{SP} = 0, \tag{13}$$

and

$$\eta_i^{SP} \geq 0, \eta_i^{SP}(a_i - x_{i,h} - x_{i,l}\pi) = 0, \mu_i^{SP} \geq 0, \mu_i^{SP} a_i = 0. \tag{14}$$

The planner internalizes the externalities of intermediary balance sheets. His choice of lending, as characterized by (12), accounts for both individual (η_i^{SP}) and social (ψ^{SP}) collateral values. The social collateral value captures that an intermediary's lending increases collateral available to others because loans can be reallocated through trades. For financing choices characterized by (13), the planner trades off between the net benefit from producing safe asset and the reduction in aggregate safe debt capacity. This social cost differs from a manager's private cost, which is calculated given the loan prices.

4.1.1 Welfare without Heterogeneity

Before the main welfare analysis, I revisit the knife-edge case in Lemma 3.

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

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

4.1.2 Welfare with Heterogeneity in Securitization Technology

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

Proposition 2 (Welfare Properties). *The planner's choices lead to price ratio* $\frac{q_l}{q_h} = \pi$*, social collateral value* $\psi^{SP} = \gamma - \xi_{\lambda^{SP}}$*, and a unique cutoff* $\lambda^{SP} \in (0, 1)$ *such that (i) managers below the cutoff fully uses safe debt capacity and promise to maintain collateral quality, and (ii) managers above the cutoff do not issue any safe debt. Secondary market trading improves welfare relative to static securitization, but the equilibrium is constrained inefficient. In particular, there is excessive entry into safe asset production, collateral providers underinvest, and the market underproduces safe assets:* $\lambda^{CE} > \lambda^{SP}$*,* $x_i^{CE} < x_i^{SP}$ *for* $i \in [\lambda^{SP}, 1]$*,* $A^{CE} < A^{SP}$*.*

Similar to the competitive market, the planner divides intermediaries into two distinct groups with different liabilities. Hence, cutoff λ^{SP} reflects the socially optimal entry into safe asset production. The social value per unit of high-quality loans, ψ^{SP}, equals the net benefit of safe asset production by the manager at the cutoff.

Because managers can always choose static securitization, they are better off with secondary market trading by revealed preference. As investors break even, this implies a welfare improvement that arises from specialization. The collateral providers, who lack superior technology to securitize loans and have smaller balance sheets, specialize in supplying collateral to others. Given diminishing returns to scale, their increased lending is relatively more productive. Meanwhile, the increased collateral allows the safe debt issuers, who have better securitization technology, to produce a greater supply of safe assets.

Despite these benefits, the equilibrium is socially suboptimal. Figure 4 illustrates the differences between the competitive and planner's allocations. The planner assigns managers $i \in [0, \lambda^{CE}]$ to issue safe debt, and each of them on average issues more than their competitive quantities: $\mathbb{E}[a_i^{SP}] > \mathbb{E}[a_i^{CE}]$. Meanwhile, the planner forces the rest of intermediaries, which are equity financed, to lend more than their competitive levels: $x_i^{SP} > x_i^{CE}$. The area of the shaded region measures aggregate underinvestment, which, by Equation (7), equals the underproduction of safe assets.

4.2 Source of Inefficiency

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

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

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

Corollary 2.1. *Equity-financed intermediaries' private profit from providing collateral in the secondary market is lower than the social value of collateral:* $(1-p)(\pi\frac{q_h}{q_l}-1) < \psi^{SP}$.

On the asset side, there is an underinvestment among managers with inferior securitization technology.[17] The planner forces these managers to lend beyond their privately-optimal quantities, which allows other managers, who have superior technology, to issue more safe debt. In the competitive market, the collateral providers do not fully internalize the social value of collateral, and their lending choices limit the secondary market supply of high-quality loans and cause the underproduction of safe assets.

Corollary 2.2. *For managers with mediocre securitization technology, the private benefit of issuing safe debt is lower than the social value of collateral:* $\gamma - \xi_i < \psi^{SP}$ *for* $i \in (\lambda^{SP}, \lambda^{CE})$.

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

4.3 Policy Intervention

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

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

Suppose the policy incurs a cost $\zeta_i \in \mathbb{R}_+$ in the beginning of period $t = 0$ if manager i issues safe debt of any quantity $a_i > 0$.[18] For generality, the cost can be an arbitrary (weakly) increasing function of index $i \in \mathcal{I}$. This allows for any monotonic heterogeneity in the policy's impact: it's possible that a less resourceful manager (i.e., having a higher safe debt issuance cost ξ_i) also faces a higher policy-induced entry cost.

Under this policy, the manager's optimization problem in period $t = 0$ exhibits a discontinuity at $a_i = 0$. Given a binary choice between $a_i = 0$ and $a_i > 0$, I call the solution to (P0a) as *locally optimal* choices. These choices are characterized by the same conditions (4)–(6).

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

$$V_i^e = y_i^e c'^{-1}(y_i^e) - c(c'^{-1}(y_i^e)) - (1-p)\pi x_L\left(\frac{q_h}{q_l} - 1\right), \tag{15}$$

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

$$V_i^d = y_i^d c'^{-1}(y_i^d) - c(c'^{-1}(y_i^d)) - (1-p)\pi x_L\left(\frac{q_h}{q_l} - 1\right) - x_L\eta_i\left(1 - \frac{q_l}{q_h}\right) - \zeta_i, \tag{16}$$

where $y_i^d := y_i^e + \eta_i$ is the manager's marginal payoff from lending, which includes collateral value η_i. Note that V_i^d is strictly increasing in η_i, which itself decreases in index i.[19] This implies that V_i^d is strictly larger for a smaller i. Since V_i^e is identical across i, others equal, only managers better at securitization issue safe debt.

Similar to previous sections, I use λ to denote the manager type that is *locally indifferent* between issuing safe debt and issuing only equity, so this type satisfies Equation (8). Since the indifference is local (i.e., it is conditional on $a_i > 0$) and does not reflect globally optimal choices, $\lambda \leq 1$ no longer has to hold; Instead, Lemma 2 and Equation (8) imply that λ is

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

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

now upper bounded by $\frac{\gamma}{2\xi} > 1$. I denote the new cutoff type $\iota : [0, \frac{\gamma}{2\xi}] \mapsto [0, 1]$ as a function of λ. This type satisfies a global indifference condition

$$V^d_{\iota(\lambda)} = V^e_i. \tag{17}$$

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

4.3.1 Equilibrium under an Entry Cost

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

Proposition 3 (Equilibrium under an Entry Cost Policy)**.** *The entry cost policy reduces the fraction of safe debt issuers, allows the remaining issuers to issue more safe debt, but worsens the underproduction of safe assets:* $\iota(\lambda^{ECP}) < \lambda^{CE}$, $\mathbb{E}[a_i^{ECP}] > \mathbb{E}[a_i^{CE}]$ *for* $i \in [0, \iota(\lambda^{ECP})]$, $A^{ECP} < A^{CE}$.

Proposition 3 demonstrates that, while the policy corrects the excessive entry into safe asset production, it may exacerbate the welfare loss through equilibrium effects. Since the entry cost deters managers from issuing safe debt, there is less pressure on secondary market prices. One the one hand, a higher price ratio relaxes the remaining issuers' collateral constraints and allows them to issue more safe debt. On the other hand, providing collateral in the secondary market becomes less profitable, which discourages the collateral providers' investment. As a larger fraction of managers become collateral providers and choose the decreased investment level, the policy leads to a reduction in collateral. In aggregate, the aforementioned increase in safe debt issuance is overwhelmed by the decrease in collateral, and the market ends up producing even fewer safe assets after the policy intervention.

Figure 5 compares the competitive allocation (same as Figure 3) and the policy-distorted allocation. While managers $i \in [0, \iota(\lambda^{ECP})]$ do not change their lending choices, managers currently operating equity-financed intermediaries ($i \in [\iota(\lambda^{ECP}), 1]$) all lower their investment levels. This leads to a reduction in aggregate high-quality loans, the quantity of which equals the area of the shaded region. Despite that every safe-debt financed intermediary on average issues more than before ($\mathbb{E}[a_i^{ECP}] > \mathbb{E}[a_i^{CE}]$), the market underproduces safe assets to an even greater extent because of a shortage of collateral.

4.3.2 Credit Risk Retention Regulation

The above analysis sheds light on a controversial regulation in the leveraged loan market. The regulation, generally referred to as Credit Risk Retention Rule, was initially proposed by 6 federal agencies (collectively, "regulators") in 2011 to implement the credit risk retention requirements of the Dodd-Frank Act. The rule requires "sponsors" of securitization transactions to retain at least 5% of un-hedged credit risk of collateral assets for any ABS. Sponsors can choose to retain 5% of each class of securities ("vertical retention"), a part of the first-loss interest that has a fair value of 5% of all ABS interests ("horizontal retention"), or any convex combination of the two.[20] The final rule became effective for residential mortgage-backed securities (RMBS) in December 2015 and for other ABS, including CLOs, in December 2016.

The rule's inclusion of CLOs received considerable resistance from practitioners. The major complaint is that the rule imposes substantial operational and capital costs on asset managers and might drive them 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

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

the D.C. Circuit concluded that managers of open-market CLOs are not "sponsors" under the Dodd-Frank Act and are not subject to the requirements of the Risk Retention Rule. Consequently, CLO managers became exempted from the rule in May 2018.

Section IA.5.2 of the Internet Appendix empirically investigates the regulation's effect, which the LSTA and CLO managers claimed to be devastating. Figure 6 shows the timing of the regulatory events and annual average CLO entry rate in the US and European markets between 2000–2019. Before the crisis, an average manager issued more CLOs in the US, but the time trends were similar. Perhaps due to a quick introduction of the policy in the end of 2010, the European CLO market recovered slowly compared to the US market. Since the finalization of the US risk retention policy in late 2014, there has been a salient drop in CLO entry in the US.[21] This drop reversed quickly after the policy got revoked in early 2018.

This regulation's impact on CLO entry has important welfare implications. Proposition 3 has shown the equilibrium outcomes under an entry cost imposed by such a regulation. By deterring CLO entry, the policy potentially worsens the underproduction of safe assets and exacerbates the inherent inefficiency of the leveraged loan market. Therefore, my analysis points to an unintended consequence. As the debate over whether the risk retention rule should be reapplied to the US market continues, policymakers should take this consequence into consideration.

5 Conclusion

Securitization is the transformation of risky loans into tranches with different cash flow priorities. Facing the demand for safe assets, the private sector has created large quantities senior tranches, but many of these securities defaulted in or after the 2008–2009 financial

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

crisis. They failed because the quality of their underlying loans deteriorated and subsequently generated insufficient cash flows for repayment.

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

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

References

Benmelech, E. and J. Dlugosz (2009). The alchemy of CDO credit ratings. *Journal of Monetary Economics 56*(5), 617–634.

Cordell, L., Y. Huang, and M. Williams (2011). Collateral damage: Sizing and assessing the subprime cdo crisis.

Cordell, L., M. R. Roberts, and M. Schwert (2021). Clo performance. Technical report, National Bureau of Economic Research.

Dang, T. V., G. Gorton, B. Holmström, and G. Ordonez (2017). Banks as secret keepers. *American Economic Review 107*(4), 1005–29.

Dávila, E. and A. Korinek (2018). Pecuniary externalities in economies with financial frictions. *The Review of Economic Studies 85*(1), 352–395.

DeAngelo, H. and R. M. Stulz (2015). Liquid-claim production, risk management, and bank capital structure: Why high leverage is optimal for banks. *Journal of financial economics 116*(2), 219–236.

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

Diamond, W. (2020). Safety transformation and the structure of the financial system. *The Journal of Finance 75*(6), 2973–3012.

Egan, M., S. Lewellen, and A. Sunderam (2021). The cross section of bank value. *The Review of Financial Studies.*

Elkamhi, R. and Y. Nozawa (2022). Fire-sale risk in the leveraged loan market. *Rotman School of Management Working Paper* (3635086).

Federal Reserve Board (2021). Financial stability report. Technical report, Board of Governors of the Federal Reserve System.

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

Gennaioli, N., A. Shleifer, and R. Vishny (2012). Neglected risks, financial innovation, and financial fragility. *Journal of Financial Economics 104*(3), 452–468.

Gennaioli, N., A. Shleifer, and R. W. Vishny (2013). A model of shadow banking. *The Journal of Finance 68*(4), 1331–1363.

Giannetti, M. and R. Meisenzahl (2021). Ownership concentration and performance of deteriorating syndicated loans.

Gorton, G. (2017). The history and economics of safe assets. *Annual Review of Economics 9*, 547–586.

Gorton, G. and A. Metrick (2013). Securitization. In *Handbook of the Economics of Finance*, Volume 2, pp. 1–70. Elsevier.

Gorton, G. and G. Pennacchi (1990). Financial intermediaries and liquidity creation. *The Journal of Finance 45*(1), 49–71.

Greenwood, R., S. G. Hanson, and J. C. Stein (2015). A comparative-advantage approach to government debt maturity. *The Journal of Finance 70*(4), 1683–1722.

Griffin, J. M. and J. Nickerson (2020). Are CLO collateral and tranche ratings disconnected? *Available at SSRN 3707557*.

Gromb, D. and D. Vayanos (2002). Equilibrium and welfare in markets with financially constrained arbitrageurs. *Journal of Financial Economics 66*(2-3), 361–407.

Holmström, B. and J. Tirole (1998). Private and public supply of liquidity. *Journal of political Economy 106*(1), 1–40.

Holmström, B. and J. Tirole (2001). Lapm: A liquidity-based asset pricing model. *the Journal of Finance 56*(5), 1837–1867.

Krishnamurthy, A. and A. Vissing-Jorgensen (2012). The aggregate demand for treasury debt. *Journal of Political Economy 120*(2), 233–267.

Kundu, S. (2021). The externalities of fire sales: Evidence from collateralized loan obligations. *Available at SSRN 3735645*.

Lee, S. J., D. Li, R. Meisenzahl, and M. Sicilian (2019). The us syndicated term loan market: Who holds what and when?

Loumioti, M. and F. P. Vasvari (2019). Portfolio performance manipulation in collateralized loan obligations. *Journal of Accounting and Economics 67*(2-3), 438–462.

Modigliani, F. and M. H. Miller (1958). The cost of capital, corporation finance and the theory of investment. *The American Economic Review 48*(3), 261–297.

Nagel, S. (2016). The liquidity premium of near-money assets. *The Quarterly Journal of Economics 131*(4), 1927–1971.

Neuhann, D. (2019). Inefficient asset price booms. *Available at SSRN 3095730*.

Nicolai, F. (2020). Contagion in the market for leveraged loans. *Working Paper*.

Standard & Poor's (2016). CLO spotlight: How do CLO managers perform in times of stress? *S&P Global Ratings Credit Research.*

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

Taylor, A. and A. Sansone (2006). *The handbook of loan syndications and trading.* McGraw Hill Professional.

Van Binsbergen, J. H., W. F. Diamond, and M. Grotteria (2021). Risk-free interest rates. *Journal of Financial Economics*.

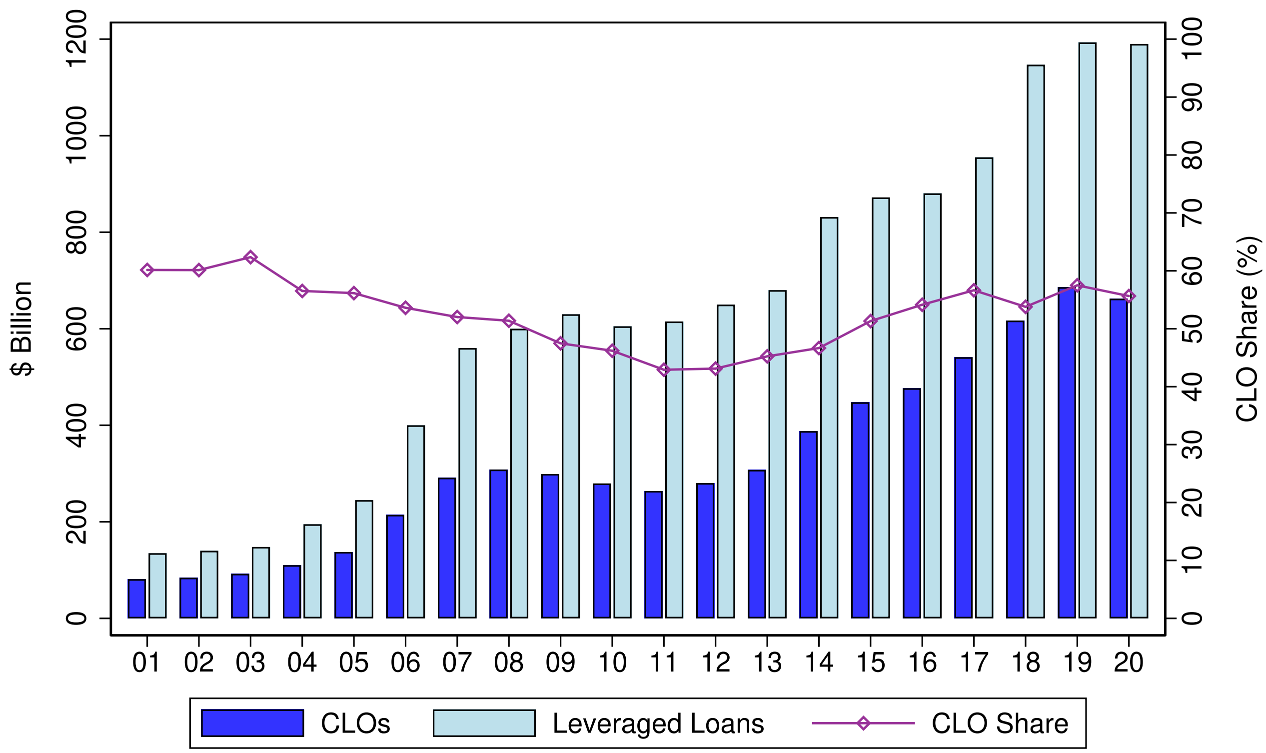


Figure 1: **Leveraged loans and CLOs outstanding, 2001–2020.**
This figure plots annual aggregate par values outstanding for leveraged loans (i.e., institutional term loan facilities) and CLOs in the US market. Data source: SIFMA.

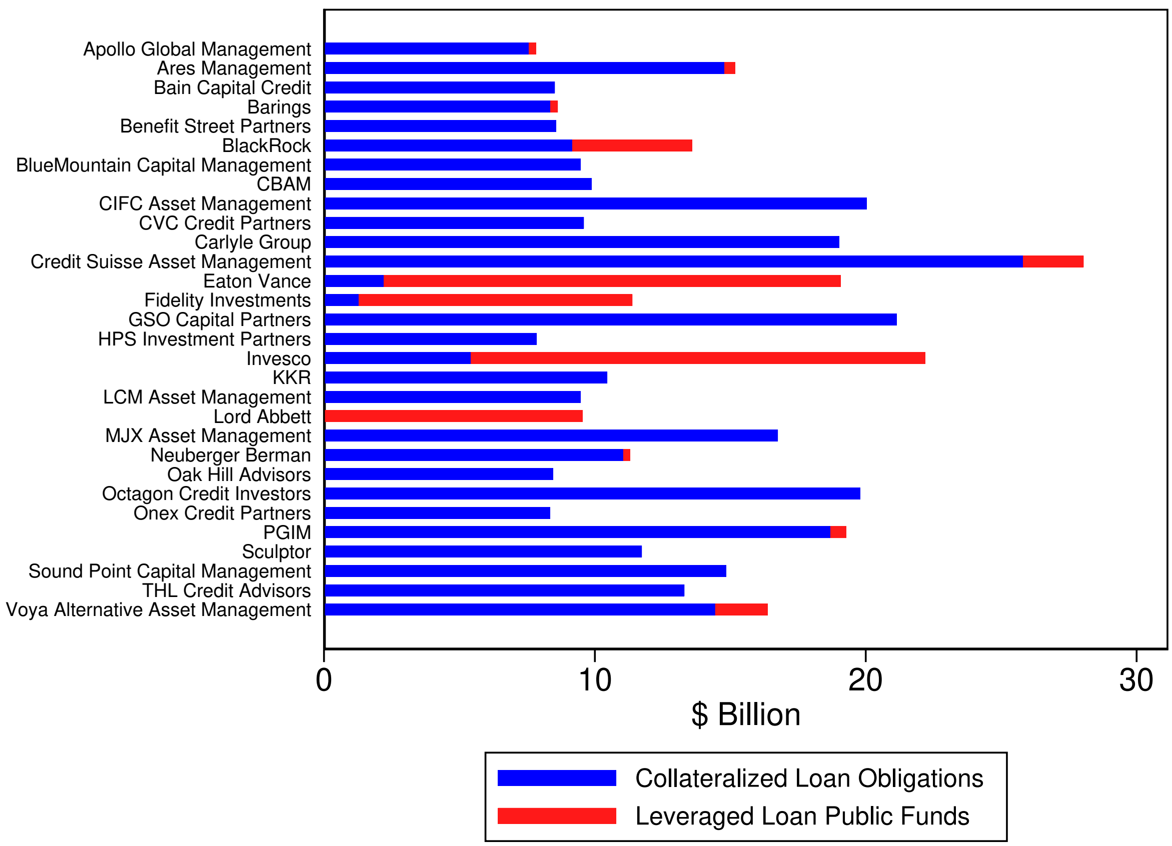


Figure 2: **Asset managers and nonbank intermediaries.**
This figure presents the size of assets under management for US CLOs and leveraged loan funds (open-end and closed-end mutual funds and exchange-traded funds) operated by the 30 largest asset managers at the end of 2019. Data come from Creditflux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

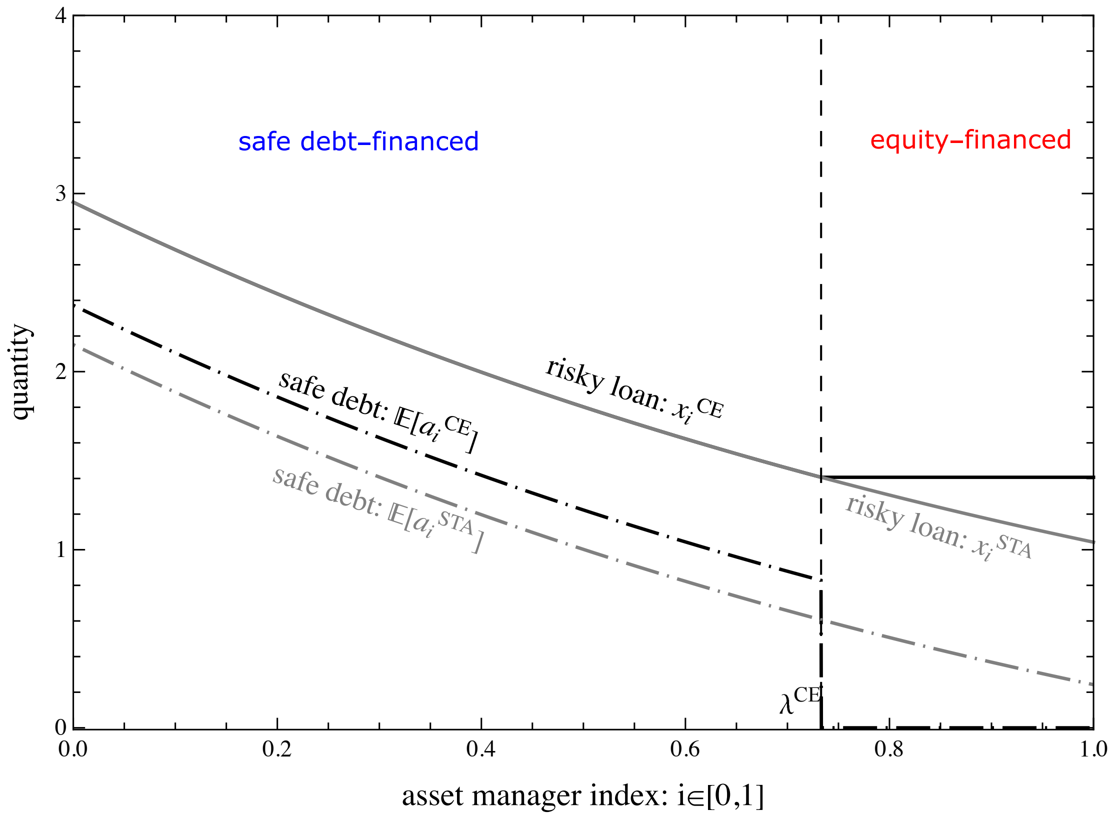


Figure 3: **Competitive equilibrium.**
This figure illustrates the lending and financing choices in competitive equilibrium. Superscripts CE and STA indicate the equilibrium with a secondary market and the static benchmark, and x_i and $\mathbb{E}[a_i]$ denote manager i's quantities of loan origination and average safe debt issuance, respectively. Functional form and parameter values: $c(x) = x^{1.2}$, $p = 0.95$, $R = 1.2$, $\pi = 0.8$, $\gamma = 0.3$, $\xi = 0.14$, $x_L = 0.8$.

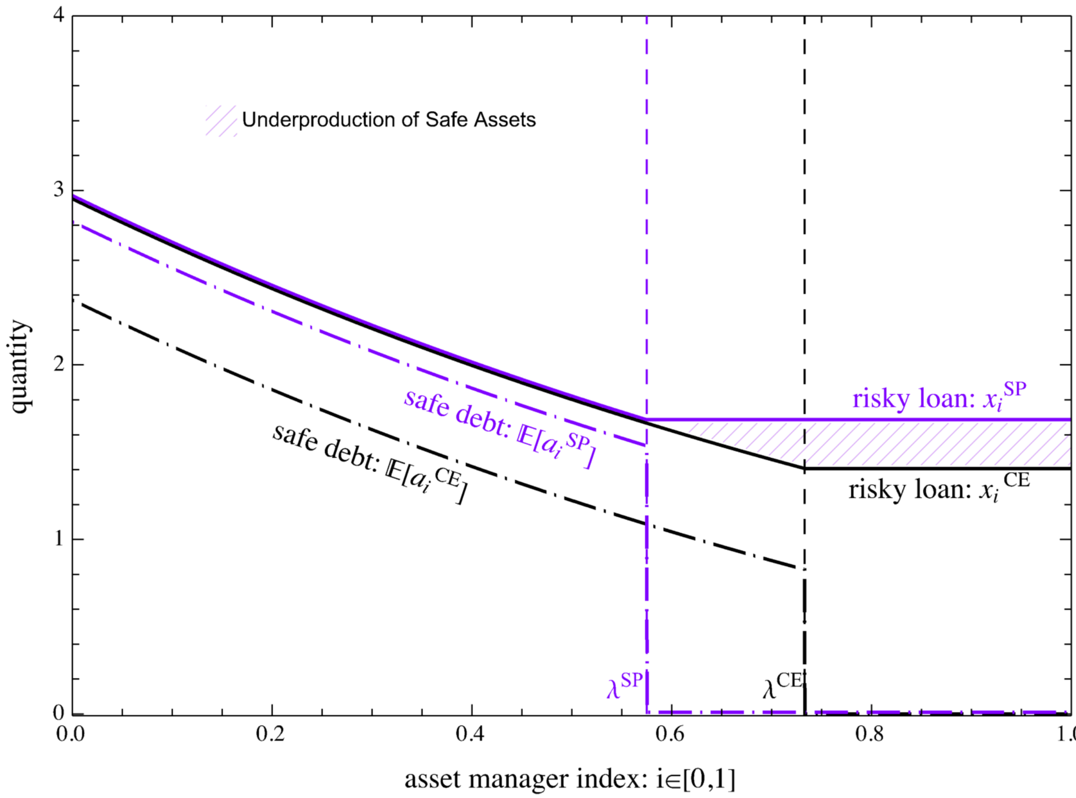


Figure 4: **Constrained inefficiency.**
This figure illustrates the constrained efficiency of the equilibrium. Superscripts CE and SP indicate the competitive and the social planner's allocations, and x_i and $\mathbb{E}[a_i]$ denote manager i's quantities of loan origination and average safe debt issuance, respectively. The area of the shaded region represents the quantity of underproduction of safe assets in equilibrium. Functional form and parameter values are the same as in Figure 3.

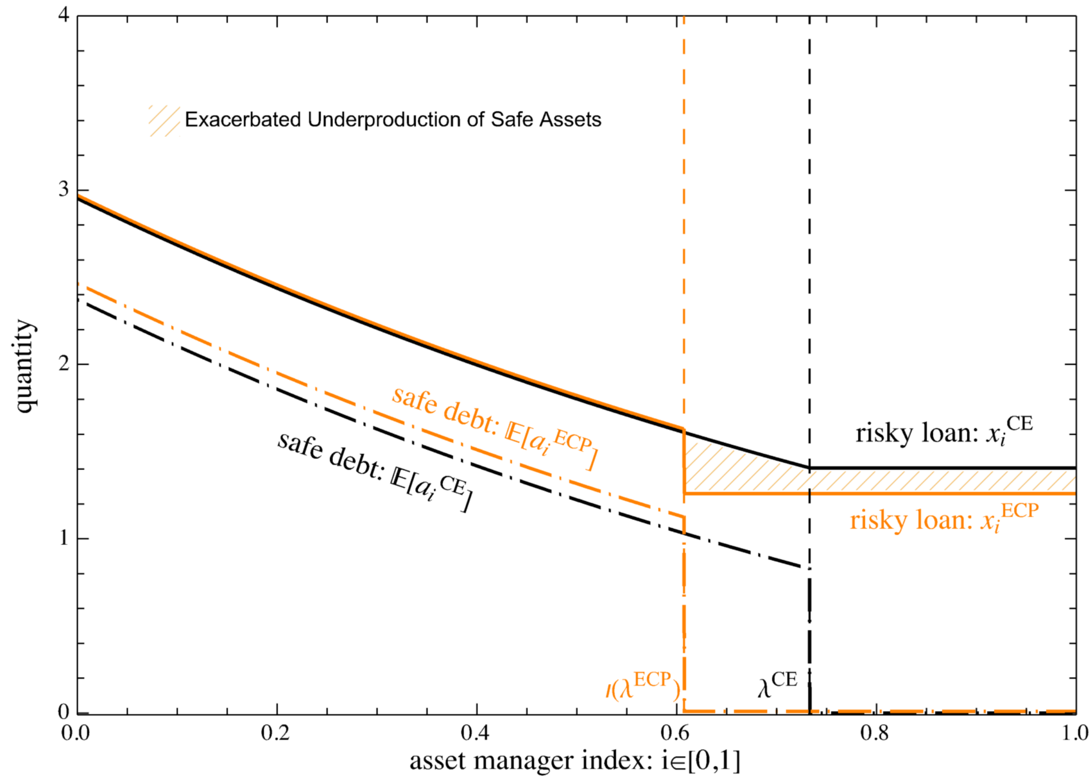


Figure 5: **Equilibrium under the entry cost policy.**
This figure illustrates the equilibrium when an entry cost is imposed any intermediaries that issue safe debt. Superscripts CE and ECP indicate the original and policy-distorted competitive allocations, and x_i and $\mathbb{E}[a_i]$ denote manager i's quantities of loan origination and average safe debt issuance, respectively. The area of the shaded region represents the quantity of incremental underproduction of safe assets in distorted equilibrium. Entry cost $\zeta_i = \zeta i$, $\zeta = 0.1$, and other functional form and parameter values are the same as in Figure 3.

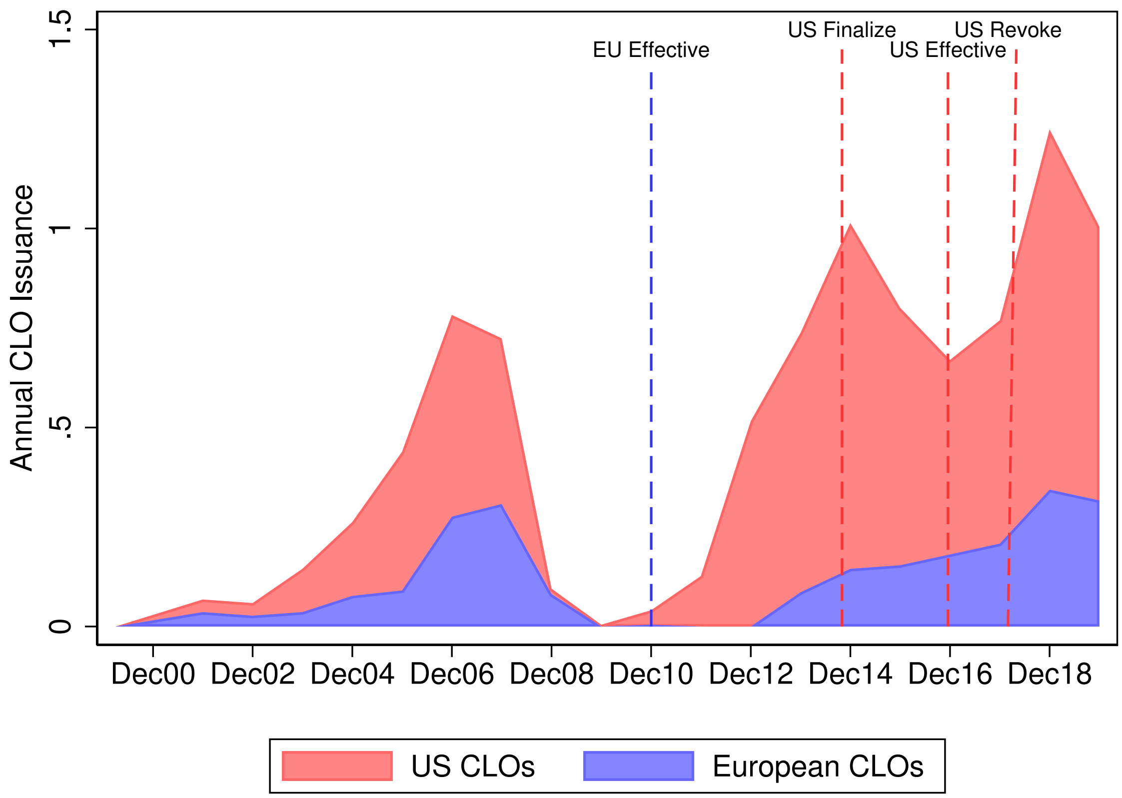


Figure 6: **Risk retention and CLO entry in the US and European markets.** This figure plots the timing of regulatory events and annual average number of an asset manager's CLO deals issued in the US and European markets. The Capital Requirements Directive II introduced in Europe requires 5% risk retention 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: Proofs

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

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

Proof of Lemma 3. The complementary slackness condition (6) 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 (5) 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 (7) 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 (7) is an equilibrium. Also, by Equation (7), the supply of safe assets is the same as in the static benchmark because that $x_i = x_i^{STA}$ in Lemma 1 for all $i \in \mathcal{I}$.

Proof of Proposition 1. If a competitive equilibrium exists, the cutoff type's indifference condition (8) implies that

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

which is well-defined and strictly positive by assumption 1. The two groups of intermediaries' lending choices follow from substituting η_i and (A.1) into (4). Given the two groups' optimal safe debt choices and secondary market trades in (3), the market clearing condition (2) can be rewritten as

$$\frac{q_l}{q_h}\int_0^\lambda x_{i,l}\,\mathrm{d}i = \int_\lambda^1 x_{i,h}\,\mathrm{d}i. \tag{A.2}$$

By law of large numbers, $\int_0^\lambda x_{i,l}\,\mathrm{d}i = \lambda x_L$, and $\int_\lambda^1 x_{i,h}\,\mathrm{d}i = (1-\lambda)(x_i - x_L)$. Both $\frac{q_l}{q_h}$ and x_i can be written as functions of λ, so the two Equations (A.1) and (A.2) 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:

$$\chi^{CE}(\lambda) = \frac{\lambda(1-p)\pi x_L}{1-p+\gamma-2\xi\lambda} - (1-\lambda)\Big(c'^{-1}\Big(pR+1-p+\gamma-2\xi\lambda\Big) - x_L\Big). \tag{A.3}$$

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

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

Apply similar arguments as in the proof of Lemma 3 to the planner's optimality conditions (12)-(14), 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. 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 (13) 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 $\psi^{SP} = \gamma - \xi_\lambda$. This implies the planner's financing choices

$$a_i^{SP} = \begin{cases} x_i^{SP} - x_{i,l} + x_{i,l}\pi, & \text{if } i \le \lambda^{SP} \\ 0, & \text{if } i > \lambda^{SP} \end{cases}. \tag{A.4}$$

The planner's lending choices follow from substituting $\eta_i^{SP} = \max\{\xi_\lambda - \xi_i, 0\}$ and $\psi^{SP} = \gamma - \xi_\lambda$ into (12):

$$x_i^{SP} = \begin{cases} c'^{-1}\Big(pR + 1 - p + \gamma - \xi_i\Big), & \text{if } i \le \lambda^{SP} \\ c'^{-1}\Big(pR + 1 - p + \gamma - \xi_{\lambda^{SP}}\Big), & \text{if } i > \lambda^{SP} \end{cases}, \tag{A.5}$$

Given the cutoff property, the binding constraint (ACC) is equivalent to

$$\pi \int_0^\lambda x_{i,l}\,\mathrm{d}i = \int_\lambda^1 (x_i - x_{i,l})\,\mathrm{d}i, \tag{A.6}$$

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

$$\chi^{SP}(\lambda) = \pi\lambda x_L - (1-\lambda)\Big(c'^{-1}\Big(pR + 1 - p + \gamma - 2\xi\lambda\Big) - x_L\Big). \tag{A.7}$$

Similar to χ^{CE} defined in (A.3), $\chi^{SP} : [0,1] \mapsto \mathbb{R}$ 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.

is strictly better off and then characterize the constrained inefficiency of the equilibrium.

Manager Welfare. The manager payoff in static securitization is

$$V_i^{STA} = px_i^{STA}R + (1-p)(x_i^{STA} - x_{i,l} + \pi x_{i,l}) + (\gamma - \xi_i)a_i^{STA} - c(x_i^{STA}). \tag{A.8}$$

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

$$V_i(\phi_i) = \max_{x_i}\ px_iR + (1-p)(x_i - x_{i,l} + \pi x_{i,l}) + \phi_i(x_i - x_{i,l}) - c(x_i). \tag{A.9}$$

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

Constrained Inefficiency. By construction, $\chi^{SP}(0) = \chi^{CE}(0)$ and $\chi^{SP}(\lambda) > \chi^{CE}(\lambda), \forall \lambda \in (0,1]$. This implies $\chi^{SP}(\lambda^{CE}) > \chi^{CE}(\lambda^{CE}) = 0$, and hence $\lambda^{SP} \in (0, \lambda^{CE})$ by properties of χ^{SP}. Using aggregate relationship $A = X - x_L$, it follows that

$$A^{SP} - A^{CE} = X^{SP} - X^{CE} = \int_{\lambda^{SP}}^{1} (x_i^{SP} - x_i^{CE})\,\mathrm{d}i > 0 \tag{A.10}$$

because $x_i^{SP} > x_i^{CE}$ for any $i \in (\lambda^{SP}, 1]$ by Equations (9) and (A.5).

Proof of Proposition 3. If an equilibrium exists, the secondary market clearing condition (2) requires

$$\frac{q_l}{q_h} \int_0^{\iota(\lambda)} x_{i,l}\,\mathrm{d}i = \int_{\iota(\lambda)}^{1} \Delta x_{i,h}\,\mathrm{d}i. \tag{A.11}$$

The proof is based on an auxiliary Lemma on the relationship among equilibrium cutoff types. Given this lemma, the proposition follows immediately from the lending choices as functions of λ in Proposition 1 and the aggregate relationship in Equation (7).

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

I prove the lemma above by contradiction in two steps. Both steps are constructed using the cutoff type condition (8), the market clearing condition (A.11), and individually optimal lending choices (9) in Proposition 1. The aggregate excess demand equation in policy-distorted market is

$$\chi^{ECP}(\lambda) = \frac{q_l}{q_h} \int_0^{\iota(\lambda)} x_{i,l}\,\mathrm{d}i - \int_{\iota(\lambda)}^{1} (x_i - x_{i,l})\,\mathrm{d}i. \tag{A.12}$$

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

Step 1: Suppose $\lambda^{ECP} < \lambda^{CE}$, and hence $\iota(\lambda^{ECP}) < \lambda^{ECP} < \lambda^{CE}$. By Equation (8), this implies $(\frac{q_l}{q_h})^{ECP} < (\frac{q_l}{q_h})^{CE}$, and hence

$$\left(\frac{q_l}{q_h}\right)^{ECP} \int_0^{\iota(\lambda^{ECP})} x_{i,l}\,\mathrm{d}i < \left(\frac{q_l}{q_h}\right)^{ECP} \int_0^{\lambda^{CE}} x_{i,l}\,\mathrm{d}i < \left(\frac{q_l}{q_h}\right)^{CE} \int_0^{\lambda^{CE}} x_{i,l}\,\mathrm{d}i. \tag{A.13}$$

For equity-financed intermediaries, by Equation (9), the hypothesized inequality also implies $x_i^{ECP} > x_i^{CE}$, which further implies

$$\int_{\iota(\lambda^{CE})}^{1} x_i^{ECP}\,\mathrm{d}i > \int_{\lambda^{CE}}^{1} x_i^{ECP}\,\mathrm{d}i > \int_{\lambda^{CE}}^{1} x_i^{CE}\,\mathrm{d}i. \tag{A.14}$$

Given Equation (A.2),

$$\left(\frac{q_l}{q_h}\right)^{CE} \int_{0}^{\lambda^{CE}} x_{i,l}\,\mathrm{d}i = \int_{\lambda^{CE}}^{1} (x_i^{CE} - x_{i,l})\,\mathrm{d}i, \tag{A.15}$$

so inequalities (A.13) and (A.14) jointly imply

$$\left(\frac{q_l}{q_h}\right)^{ECP} \int_{0}^{\iota(\lambda^{ECP})} x_{i,l}\,\mathrm{d}i < \int_{\iota(\lambda^{CE})}^{1} (x_i^{ECP} - x_{i,l})\,\mathrm{d}i. \tag{A.16}$$

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

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

$$\left(\frac{q_l}{q_h}\right)^{ECP} \int_{0}^{\iota(\lambda^{ECP})} x_{i,l}\,\mathrm{d}i > \int_{\iota(\lambda^{CE})}^{1} (x_i^{ECP} - x_{i,l})\,\mathrm{d}i, \tag{A.17}$$

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