Intermediary Frictions and the Corporate Credit Cycle: Evidence From CLOs *

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Abstract

I quantify the contribution of intermediary agency frictions to the cyclicality of lending by non-bank intermediaries. I focus on collateralized loan obligations (CLOs) and exploit an institutional feature that leads to variation in CLOs' ability to trade their assets and thus in their agency problems with debt investors. I document that CLOs' cost of debt contains a significant compensation for agency problems. Agency problems intensify in volatile periods, raising CLOs' cost of debt, and reducing the issuance of new CLOs. To mitigate this effect, CLOs restrict their ability to trade. Calibrating a novel model of CLO issuance to these reduced-form estimates, I find that half of the steep fall in CLO issuance during volatile periods can be attributed to agency frictions. A counter-factual analysis reveals that without CLOs restricting their ability to trade, CLO issuance would be substantially more cyclical. The study highlights the importance of intermediary agency frictions for the lending cyclicality of non-bank intermediaries and how contract adjustments can dampen it.

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1 Introduction

Since the Global Financial Crisis (GFC) of 2007-2009, intermediary financing frictions have been proposed as an important amplifier of fluctuations in lending, and thus the real economy (e.g., Gertler and Kiyotaki (2010); He and Krishnamurthy (2012); Adrian, Colla, and Shin (2013); Brunnermeier and Sannikov (2014)). Intermediary financing frictions are often motivated by agency problems between the managers of intermediaries and outside investors (e.g., Jensen and Meckling (1976); Holmström and Tirole (1997)). Despite the pervasive nature of this explanation, extant research has not directly focused on measuring the extent to which intermediary agency problems contribute to lending cyclicality, perhaps because variation in such agency frictions is usually not observable.

In this paper, I focus on collateralized loan obligations (CLOs) and exploit an institutional feature of CLOs that leads to measurable variation in intermediary agency problems based on debt overhang. Such debt overhang problems arise because CLOs actively trade their assets to maximize the value to equity investors, occasionally against the interest of debt investors. For variation in these problems, I exploit that CLOs are only allowed to engage in discretionary trading during the initial reinvestment period of the CLO, the length of which is set when the CLO is issued. After issuance, CLOs' remaining discretion in trading – and thus their capability to act against debt investors' interest – is plausibly exogenous across CLOs. With this variation, I estimate the extent of debt overhang problems in CLOs as reflected in their debt prices on the secondary market. Consistent with debt overhang problems intensifying in volatile periods, investors' required compensation for exposure to debt overhang problems increases when measures of economic risk rise. I calibrate a model of CLO issuance to these reduced-form estimates to quantify the contribution of agency frictions to the lending cyclicality of these non-bank financial intermediaries. I find that intermediary agency frictions can explain more than half of the cyclicality in CLO issuance. This is despite managers shortening the reinvestment period (i.e., restricting their ability to trade), thereby mitigating the debt overhang problem, when issuing new CLOs in volatile periods. A counterfactual analysis shows that without these contractual adjustments, CLO issuance would fall by 1.5 times as much for a large shock. This demonstrates that dynamic contractual changes to mitigate agency frictions can substantially dampen the lending cyclicality of non-bank intermediaries.

CLOs are large intermediaries that invest in leveraged loans, which are syndicated term loans to large speculative grade corporations. CLOs are financed with 90% debt that is tranched into different seniorities and 10% equity. They had about 1 trillion USD in assets under management worldwide in 2021,[1] held 62% of US leveraged loans in 2018,[2] and their lending to US corporations is about one-third of total commercial and industrial lending by US banks.[3] CLOs are actively managed closed-end funds with an average life of 7 years. Their managers are often affiliated with hedge funds or private equity firms (e.g., Blackstone).

CLOs constitute an ideal setting to quantify the effect of agency frictions on intermediated lending because their structure gives rise to agency conflicts between the manager and debt investors: (1) Managers maximize the value to equity investors because their compensation is closely tied to equity payouts; and (2) the locked-in financing prevents debt investors from disciplining the manager by redeeming their funds (Calomiris and Kahn (1991); Diamond and Rajan (2001)). I propose and provide evidence for a specific debt overhang problem present in CLOs. In particular, CLOs sell loans at fire sale prices to avoid violating a dividend covenant (called overcollateralization (OC) test) (e.g., Kundu (2020a); Elkamhi and Nozawa (2022)), which allows them to preserve equity payouts even when their assets are worth less than their outstanding debt.

Such debt overhang problems can lead to financial frictions that amplify shocks to CLO issuance. Indeed, CLO issuance and therefore lending to corporations by CLOs is highly cyclical. CLO issuance is strongly correlated with measures of aggregate risk, such as the Cboe Volatility Index (VIX).[4] When the expected volatility rises, CLO issuance falls sharply. For instance, CLO issuance fell from 27 billion USD to 0 during the GFC, and dropped by 77% and 47% during the oil price shock 2014-2016 and the worldwide outbreak of COVID-19 in Spring 2020, respectively. CLOs' cut in credit supply in volatile periods is not only

[1]See Bloomberg article "Global CLO Market Approaches $1 Trillion Milestone as Sales Soar".

[2]Based on data from a speach by Fed Chairman Jerome Powell Business titled "Debt and Our Dynamic Financial System".

[3]Commercial & Industrial loans on bank balance sheets in the US were about 2.4 trillion USD in 2021 (see FRED), while US CLOs had more than 800 billion USD in assets under management (see VOYA).

[4]The Cboe Volatility Index (VIX) is a measure of the expected volatility for a given stock market index, and derived from option prices. CLO issuance is particularly correlated with the Russell 2000 VIX, which reflects expectations about volatility for the smallest 2000 stocks in the Russell 3000 index and better captures the set of firms CLOs lend to than the S&P500 index.

sizable in absolute terms but also substantially larger than that of banks (Fleckenstein, Gopal, Gutierrez, and Hillenbrand (2020)).

To quantify how much of the cyclicality in CLO issuance is due to intermediary agency frictions, I start by estimating their implied costs. For this, I rely on an insight from the theoretical model I present later: The entire extent of the debt overhang problem is reflected in CLO debt prices. For cross-sectional variation in the debt overhang problem, I exploit that it depends on CLOs' discretion in trading, and that CLOs can only engage in discretionary trading during the initial reinvestment period. Since the reinvestment period is set at issuance, CLOs' remaining discretion and thus the extent of the debt overhang problem is plausibly exogenous across CLOs thereafter.

I find a strong positive relation between the remaining time in the reinvestment period and secondary market spreads on CLO debt. The results imply a 12.4 bps higher cost of debt per year in which managers can trade at their discretion. For equity investors and the manager, the higher financing costs mean a 1.12 percentage points lower return per year of active trading, ignoring any benefit. This is substantial, given that the average realized return on CLO equity is 10% (Cordell, Roberts, and Schwert (2021)).

I conduct two additional tests to confirm that what I measure is indeed compensation for exposure to agency frictions: (1) the cost of debt for discretion varies significantly with the current equity ratio of the CLO, consistent with a higher equity ratio better aligning the incentives of equity and debt investors, thus mitigating the debt overhang problem; and (2) CLOs' abnormal return from trading becomes negative when the current equity ratio is zero (i.e., CLOs' portfolio value is less than their outstanding debt), which demonstrates that the debt overhang problem is also reflected on the asset side of the balance sheet.

Further, I find that the agency friction becomes more severe when the expected volatility in the economy rises. Specifically, the cost of debt for discretion increases with the VIX – a measure of expected volatility in the stock market –, even after controlling for changes in the equity ratio, and after absorbing aggregate factors that affect asset prices. This suggests that a higher economic risk increases the probability that CLOs act against the interest of debt investors. For a one standard deviation increase in the VIX, a CLO with a standard 5-year reinvestment period faces a 20.7 bps rise in financing costs relative to an otherwise similar CLO without reinvestment period (i.e., static CLO). This lowers the return to equity investors by 186.3 percentage points, all else equal. Accordingly, CLOs reduce their discretion by shortening the length of the reinvestment period. For instance, during the outbreak of COVID-19 in spring 2020, the average length of the reinvestment period of newly issued CLOs fell from 5 to 2 years. While giving up discretion mitigates the agency problem, it comes at a cost because trading during the reinvestment period generates a positive alpha when CLOs' and their debt investors' incentives are well aligned (i.e., the current equity value is positive).

To clarify and quantify the mechanism through which an intensifying debt overhang problem amplifies the cyclicality in CLO issuance, I propose a dynamic intermediation model. The model features a financial intermediary with an agency problem between its manager and outside investors. The agency problem arises because (1) the manager's (equity) and outside investors' (debt) claim on the intermediary differ; (2) the manager has discretion over the trading of assets held by the intermediary; and (3) financing is long-term, which prevents investors from disciplining the manager by redeeming their funds (Calomiris and Kahn (1991), Diamond and Rajan (2001)).[5] In contrast to standard models with intermediation frictions, in my model, the manager trades against the interest of debt investors in equilibrium with some probability, which is thus reflected in debt prices. This allows me to match the model to the reduced-form estimates of the cost of debt due to discretion to infer the extent of the debt overhang problem.

The model has two state variables – the manager's net worth and the return volatility of the intermediary's assets –, which are assumed to be correlated, consistent with empirical observations.[6] In bad times, a negative return realization (e.g., defaults among the loans held by the intermediary) that lowers the manager's net worth and a rise in volatility increase the probability that the intermediary acts against the interest of debt investors. This intensification of the debt overhang problem raises the intermediary's financing costs, making them less attractive relative to an outside option. Hence, lending by this intermediary falls. Due to firms' downward-sloping financing demand (e.g., because only some firms have

[5]After adjusting the relative distribution of cash flows between the manager and outside investors to the respective compensation contract, the model can also be applied to other intermediaries with long-term funding such as venture capital funds, private equity funds, private debt funds, closed-end mutual funds, and hedge funds.

[6]Figure 1 shows that CLO issuance is correlated with both the Cboe Russell 2000 VIX and US speculative grade corporate default rates.

access to other sources of financing like the bond market) loan spreads rise until managers are again indifferent between investing in the equity of intermediaries and the outside asset. The debt overhang problem and thus the fall in issuance is mitigated by the manager using less discretion in trading (e.g., by shortening the reinvestment period). However, this comes at the cost of a lower alpha when the manager has good incentives.

To quantify this mechanism, I subject the model to the same fall in net worth and rise in expected volatility as implied by a one standard deviation increase in the VIX, and then compare the model-implied to the actual fall in CLO issuance. I directly infer the change in managers' net worth from the observed fall in equity payouts. The rise in (expected) volatility of CLOs' assets, however, is not directly observable. Simply exposing the model to the empirical surge in the cost of debt due to debt overhang problems would ignore that managers can re-optimize their discretion for new CLOs. Thus, I indirectly infer the change in expected volatility from the rise in the cost of debt due to debt overhang problems. For this, I use the model to price CLO debt for different levels in discretion, run the same regression of CLO debt spreads on CLO managers' discretion as in the data and pick the volatility value that equalizes the regression coefficients. Since the reduced-form estimates of the cost of debt due to debt overhang problems are arguably independent of other explanations of the credit cycle, this approach allows to isolate the cyclicality coming from agency frictions.[7] The remaining model parameters such as the inefficiency of bad trading can be directly inferred from empirical observations.

Following a shock to managers' net worth and volatility of future returns as implied by a one standard deviation increase in the VIX, CLO issuance falls by 18% in the model. This is more than half of the actual decline of 33% in the data. The model-implied change in issuance is entirely due to agency frictions amplifying the primitive shocks because agents are assumed to be risk-neutral. Hence, the cyclicality in CLO issuance that is not explained by the model can either be due to the direct effect of the primitive shocks (i.e., risk-averse managers and investors being more reluctant to issue new CLOs following the higher risk), or other explanations for the credit cycle, such as changes in investors' sentiment, firms' loan demand, or a rise in information asymmetry. Importantly and despite not targeting it

[7]Inferring the rise in volatility from debt prices instead of the regression coefficients would attribute any change in investor sentiment or information asymmetry to a change in volatility, and bias the estimated contribution of agency problems to CLO issuance.

in the calibration, the model closely matches the empirical decline in CLOs' reinvestment period (0.96 year vs. 0.83 years), which is a unique prediction of the proposed mechanism and strongly related to the fall in issuance in the model. In addition, the model implied rise in CLOs' cost of debt at origination (which takes into account contractual adjustments that mitigate agency problems) matches the actual rise in CLOs' cost of debt.

In a counter-factual analysis, I calculate the implied fall in issuance if managers were not able to adjust their discretion when issuing a new CLO. In this scenario, CLO issuance would fall substantially more, in particular for very large shocks. For instance, CLO issuance would fall by almost one-third more following the same shock rise in VIX as experienced during the GFC if managers were not able to adjust their discretion. Overall, the quantification results stress the importance of intermediary agency frictions for the amplification of shocks through intermediary balance sheets, and the dampening role of dynamic adjustments of covenants.

The paper proceeds as follows. In Section 2, I discuss the related literature, followed by a brief primer on CLOs and the data in Section 3. Section 5 presents the estimation of CLOs' cost of debt due to debt overhang problems and their evolution over the credit cycle. In Sections 6 and 7, I document CLOs' contractual adjustments to reduce the debt overhang problem, and their trade-offs. Section 8 presents evidence of managers' net worth being important for CLO issuance, for which the theoretical model proposed in Section 9 provides the mechanism. In Section 10, I quantify the contribution of agency frictions to the CLO issuance cycle.

2 Related Literature

This paper contributes to a large literature on financial frictions in intermediaries and a growing literature that focuses particularly on non-bank intermediaries. The empirical literatue of financial frictions in intermediaries studies their effect on lending and real economic outcomes.[8] I contribute to this literature by focusing non-banks and by quantifying to what

[8]Micro-evidence is provided by e.g., Peek and Rosengren (2000), Khwaja and Mian (2008), Paravisini (2008), Ivashina and Scharfstein (2010), Chava and Purnanandam (2011), Schnabl (2012), Chodorow-Reich (2014), Amiti and Weinstein (2018), Huber (2018), Acharya, Eisert, Eufinger, and Hirsch (2018). Aggregate evidence is provided by e.g., Gilchrist and Zakrajšek (2012) and Saunders, Spina, Steffen, and Streitz (2021).

extent one particular micro-foundation of financial frictions, namely agency problems, can explain the cyclicality in lending by intermediaries. Similar to most reduced-form papers of this literature, I exploit a narrow setting that allows to isolate the friction. In addition, I combine these estimates with a model to quantify the aggregate contribution to the cyclicality of lending.

Structural quantitative studies typically target aggregate moments to calibrate the model and quantify the importance of financing frictions (e.g., He and Krishnamurthy (2013), Krishnamurthy and Li (2020)). This paper, instead, calibrates the model to micro-moments that are arguably independent from other explanations for the lending cycle. However, this comes at the cost of focusing on one particular – though large and important – type of intermediary, i.e., CLOs. Moreover, I quantify in counter-factual exercises the extent to which contractual adjustments that mitigate the agency friction help dampen its effect on lending and reduce its cyclicality.

The theoretical literature on intermediary financial frictions and their contribution to lending and real outcomes is equally large.[9] To make the model match the empirical setting, I introduce two features that are to the best of my knowledge new to the literature. First, bad behavior by the manager can occur in equilibrium with some probability, and thus is reflected in debt prices.[10] Second, the degree of the agency problem is endogenous, which can dampen but does not eliminate the financing friction.

The paper also contributes to the growing literature on non-bank intermediaries and in particular CLOs. The growth of non-banks in the last 20 years has been documented by e.g., Irani, Iyer, Meisenzahl, and Peydró (2020) and Gopal and Schnabl (2020).[11] In particular,

[9]E.g., Gorton and Pennacchi (1990), Holmström and Tirole (1997), Gertler and Kiyotaki (2010), Acharya and Viswanathan (2011), Adrian and Boyarchenko (2012), He and Krishnamurthy (2012, 2013), Adrian and Shin (2014), Brunnermeier and Sannikov (2014), Moreira and Savov (2017), Rampini and Viswanathan (2019), Diamond, Hu, and Rajan (2022).

[10]Most models with intermediary financing frictions either directly assume an equity constraint on intermediaries or feature an intermediary net worth constraint micro-founded by rent-seeking (e.g., Holmström and Tirole (1997)), or risk-shifting (e.g., Acharya and Viswanathan (2011)). In these models the behavior by the intermediary is deterministic and only managers with a minimum level of net worth obtain financing. Therefore, bad behavior by the manager occurs only off-equilibrium and is not reflected in intermediary financing costs. The theoretical model in this paper deviates by making the behavior of the manager depend on the realization of a return shock, and assuming sufficient incompleteness in intermediary financing contracts so that the debt overhang problem manifests with some probability in equilibrium and is thus reflected in the intermediary's financing costs.

[11]The growth of non-banks has also changed the role of banks which went from an originate-to-hold to an originate-to-distribute model (e.g., Bord and Santos (2012), Blickle, Fleckenstein, Hillenbrand, and Saunders

the rise of CLOs has led to lower credit spreads and more credit for firms during booms (Ivashina and Sun (2011), Shivdasani and Wang (2011), Nadauld and Weisbach (2012)), but also a stronger reduction of credit and a larger increase in credit spreads during busts (Fleckenstein, Gopal, Gutierrez, and Hillenbrand (2020)). My paper provides and quantifies a mechanism for why CLOs extend and contract credit so sharply over the credit cycle.

Other papers on CLOs have studied the adverse selection of loans into CLOs (Benmelech, Dlugosz, and Ivashina (2012), Bord and Santos (2015)) and CLO performance (Liebscher and Mählmann (2017), Cordell, Roberts, and Schwert (2021), Fabozzi, Klingler, Mølgaard, and Nielsen (2021)).[12] I also find that managers can generate alpha through trading but that this depends crucially on the value of the CLO manager's claim on the assets. Trading can be value destroying because CLO managers sell risky loans at fire-sale prices to avoid OC test failures (Loumioti and Vasvari (2019), Elkamhi and Nozawa (2022), Kundu (2020b)) – in particular loans of firms they have no relationship with (Bhardwaj (2021)) –, which has real effects for affected firms (Kundu (2020a)). I interpret trading to avoid OC test failures as a manifestation of agency problems between CLO managers and debt investors that affects the issuance of CLOs, and provide direct evidence for it.

Finally, most of the literature on the financial stability of non-banks has focused on open-end funds (e.g., Chen, Goldstein, and Jiang (2010), Acharya, Schnabl, and Suarez (2013), Kacperczyk and Schnabl (2013), Goldstein, Jiang, and Ng (2017)), which issue demandable claims and are thus exposed to runs. This paper documents for the case of CLOs that also closed-end funds can be unstable lenders due to agency problems that among other factors arise because claims are not demandable.

3 CLO Primer and Data

(2020)).

[12] In particular, Cordell, Roberts, and Schwert (2021) find that CLOs earn on average a lower return on their assets than the S&P/LSTA U.S. Leveraged Loan 100 Index when not adjusting for risk but excess returns through trading after adjusting for risk. Consistent with managers having skills, Liebscher and Mählmann (2017) and Fabozzi, Klingler, Mølgaard, and Nielsen (2021) find that CLO managers' trading returns are persistent and predictable by how actively they trade now and traded in the past.

3.1 CLO Primer

Balance Sheet. CLOs are a very important intermediary for large corporations in the US and Europe. They have been growing substantially in the last 20 years from about $9 billion global assets under management in 2002 to $1 trillion in 2021.[13] CLOs invest almost exclusively in syndicated loans issued by large non-investment grade firms (so-called leveraged loans). As of 2019, CLOs held more than 62% of US leveraged loans and therefore provided almost 30% of (term) debt financing to large US speculative grade corporations.[14] Thus, lending by CLOs to US corporations is about one third of total Bank lending to US corporate and non-corporate businesses together.[15]

CLOs are financed with long-term debt and equity, where the debt is tranched into different seniorities. The most senior and typically AAA rated tranche constitutes on average 62% of total CLO financing. The equity tranche, which sits at the bottom of the capital structure, is on average 11.1% of the CLO size. The average legal maturity of debt tranches is 12.6 years but due to a call option for equity investors and principal repayments, the realized average maturity is 6.5 years (see details below). Both the loans held and the bonds issued by CLOs trade on a secondary market. The assets and liabilities are in almost all cases floating rate and pay a spread above the LIBOR or SOFR (since December 2021), hence CLOs are not exposed to significant interest rate risk.[16]

CLO Management. In contrast to other forms of securitization (e.g. Mortgage Backed Securities), CLOs are actively managed. This is possible because CLOs' assets – broadly syndicated loans – are traded in a relatively liquid over-the-counter market.[17] The average

[13] https://www.bloomberg.com/news/articles/2021-05-28/structured-weekly-global-clo-outstandings-approach-1-trillion

[14] Large US speculative grade corporations obtain (term) debt financing from either the US leveraged loan or the US high yield bond market. Both markets are estimated to have about $1.2 of assets outstanding in 2019 (Standard and Poors (2019), Standard and Poor's (2020)), while assets under management of US CLOs that invest in US leveraged loans was $709 biliion in Q4-2018 (see https://www.federalreserve.gov/newsevents/speech/powell20190520a.htm)).

[15] US CLOs' assets under management in 2021 were above $800 billion, and Commercial & Industrial loans on US banks' balance sheets totaled $2.4 trillion in 2021.

[16] A few CLOs issued also tranches with a fixed coupon, however, such a fixed-rate tranches typically then constitute a very small share of a CLO's total liabilities. For instance, CLO *Carlyle US CLO 2019-2* issued a fixed rate AA tranche, which constituted 4% of the total CLO size.

[17] Trading volume in the broadly syndicated loan market was USD 80 billion with more than 1,500 unique loans being traded in May 2022 (see, https://www.lsta.org/content/secondary-trading-settlement-monthly-july-2022-executive-summary/)

portfolio turnover is 38% per year[18] and CLO managers are often affiliated with private equity firms, hedge fund managers or asset managers. For instance, among the largest CLO managers by assets under management are the respective credit arms of private equity firms Blackstone, Ares, Carlyle, Apollo, and KKR (see Figure A1 in Appendix A2 for the top 20 CLO managers). CLO managers' performance fee is similar to that of hedge funds, and private equity funds, both in structure and magnitude. The performance fee is usually 20% of all equity payouts above a hurdle rate (typically 12%).[19]

CLO Life Cycle. As illustrated in Figure 2, the life of a CLO is characterized by three periods. In the warehouse period, the CLO manager sets up the CLO, using its own equity contributions, outside equity financing, and a credit line from the arranger bank to purchase an initial portfolio of loans. Once the desired portfolio is almost fully ramped-up, and credit ratings for the different CLO debt tranches are obtained, the CLO manager together with the arranger bank markets the deal to potential debt investors. On the pricing date, the terms of the CLO such as the spread on each debt tranche are finalized and the CLO is legally issued. The CLO manager uses the newly acquired debt financing to repay the warehouse credit line, and to build up the remainder of the portfolio. Subsequently, the CLO enters the so-called reinvestment period. The length of this period is determined at origination and an important contract term. It varies from 0 (" static CLO") to up to 10 years, and is on average 5 years. During this period, managers can actively trade at their own discretion and reinvest principal repayments from the loan in their portfolios into new loans. The only cash flows that are paid out to investors in this period are interest payments received from the loan portfolio. These interest payments are distributed to investors every quarter such that interest on a tranche is only paid once more senior tranches received their promised interest. The manager receives a senior fee (on average 15 bps) – paid before all debt –, a junior fee (on average 35 bps) – paid before equity payouts – and the aforementioned performance fee. With the end of the reinvestment period starts the amortization period during which trading by the manager is either fully prohibited or strongly constrained.[20] Moreover, reinvestments of

[18] This is calculated as total purchases over total assets.

[19] I do not observe performance fees and hurdle rates in my data. However, 20% is the typical performance fee mentioned by practitioners. See, e.g. https://www.cloresearch.co.uk/blog/thoughts-on-clo-incentive-fee-structure/

[20] In case some trading is still allowed, it is typically limited to sales of downgraded or upgraded loans (see the excerpt of the indenture of an example CLO in Appendix A1.

principal proceeds are restricted to unscheduled repayments. Scheduled principal payments, instead, are used to pay down the principal of the outstanding debt in order of their seniority. Interest payments follow the same logic as during the reinvestment period. In most cases the life of a CLO ends before its legal maturity. Outside the non-call period, which lasts for the first 1-2 years of the CLO, CLO equity investors can call the deal, sell all assets and repay the outstanding debt. This happens typically when 50% of the most senior and thus cheapest CLO debt tranche is repaid.

3.2 Data

This paper relies on two main data sources. Information on CLOs' general contract terms, assets, liabilities, trading, equity distributions, and covenant test results come from Creditflux. Secondary market debt prices on CLO bonds are from Empirasign. All analyses in this paper are either based on the Creditflux or the matched Creditflux-Empirasign sample.

Creditflux. Creditflux collects the data from monthly trustee reports that a trustee bank (different from the arranger bank) such as State Street compiles and distributes to the investors on behalf of the CLO manager. Since the Empirasign sample is restricted to CLOs that predominantly invest in US broadly syndicated loans (called US CLOs), and therefore excludes European CLOs and US Middle-Market CLOs, I also restrict the Creditflux to US CLOs for consistency. US CLOs constitutes about 80% of the global CLO market. Moreover, I exclude observations before December 2008 due to poor coverage. The observations are at a monthly frequency but with gaps, resulting in 58,877 CLO $\times$ month observations from December 2008 to December 2020 with 1,904 CLOs, managed by 172 different CLO managers.

Empirasign. Empirasign obtains CLO debt prices from secondary market auctions, the main form of trading in CLO debt. An investor who intends to sell a portfolio of CLO debt approaches a dealer bank that organizes a first-price sealed bid auction of the bonds, called Bids Wanted in Competition (BWICs). The bank emails the list and size of the bonds to other dealer banks that submit their own bids and bids on behalf of their clients before the deadline set by the seller. The seller decides then whether to accept the highest bid or to let the auction fail for each bond separately. The second highest (i.e., highest non-winning) bid per offered bond is communicated to all bidders participating in the auction and collected by Empirasign.[21] The reported bids are quoted in cents per dollar of face value. I transform these prices into spreads over the treasury rate taking into account the timing of each coupon payment similar to Gilchrist and Zakrajšek (2012) and Saunders, Spina, Steffen, and Streitz (2021). I describe the approach in more detail in appendix A3.1. I match the resulting sample of spreads on the tranche level to Creditflux by (a) a fuzzy match based on the CLO name and tranche name and –if not matched– (b) manually using Bloomberg tickers retrieved from Bloomberg. The resulting sample consists of 9,427 tranche × month observations with 4,226 tranches issued by 1,280 CLOs managed by 134 managers. The sample period in the matched Creditflux-Empirasign sample is from April 2012 to December 2020.

Table 1 reports summary statistics for the main variables in the sample of CLOs observed at origination in Creditflux (Panel A), the Creditflux sample used in the trading analysis (Panel B), and the matched Creditflux-Empirasign sample on which the spread analysis is based (Panel C). The size of CLOs in the sample is narrowly distributed around the average of about USD 500 million of which typically 11.1% is financed by equity investors. The remainder is financed through debt, which costs on average 167 bps per year. The wide-range of the cost of debt is mainly to due low spreads pre-GFC. Managers can on average trade at their own discretion for 4.9 years, however, for 4.6% of CLOs the manager cannot engage in discretionary trading at all, i.e., they are static.

CLOs sell and buy on average loans worth 19% and 40% of their total size, respectively. The difference is explained by principal repayments that are reinvested into new loans. Trading generates only a small positive excess raw return on average, however, CLOs tend to sell riskier loans than they buy as indicated by the weighted average rating factor of their trading portfolios. For about 10% of the CLO × month observations the market value of assets falls below the face value of outstanding debt (i.e., the marked-to-market equity ratio becomes 0). Quarterly equity payouts relative to the CLO size are on average 45 bps, but this can vary quite substantially across CLO × month observations. Since many CLOs are called by equity investors within 1-2 years after the end of the reinvestment period, about 90% of the observations in the trading panel are of CLOs that are still within their reinvestment

[21] While dealer banks have to report CLO transactions to FINRA, they are only included in the regulatory version of TRACE and therefore not publicly available (see, e.g. Hendershott, Li, Livdan, and Schürhoff (2020))

period (i.e., active).

The secondary market spread of CLO tranches is on average 407 bps but varies substantially due to the different seniorities of debt tranches. The remaining time in the reinvestment period is 3 years in the spread panel and less than five percent of the traded bonds in the sample are of CLOs outside the reinvestment period. The analysis estimates the agency cost of debt for different levels in aggregate volatility, measured with the Russell 2000 volatility index (VIX). I standardize the VIX over the entire available sample from 2004 to 2022 in order to make analyses across different samples comparable. Despite the relative short sample period from 2012 to 2020, the standard deviation of the VIX in this sample is equal to the overall standard deviation of the VIX. To deal with outliers, all variables in this study are winsorized at the 1%-level at both tails.

4 Cyclicality in CLO Issuance

The goal of this paper is to quantify the contribution of intermediary agency frictions to the cyclicality in CLO issuance. Figure 1 reveals that CLO issuance is indeed highly cyclical. It plots the quarterly CLO issuance from 2004 to 2020 along with the VIX in Panel A, and the US corporate default rate in Panel B. The VIX is a measure of expected volatility in the stock market, derived from option prices. I use the Russell 2000 VIX to better capture firms that issue leveraged loans. In bad times, when the risk in the economy rises and CLOs suffer losses from defaults, CLO issuance falls sharply. For instance, during the GFC 2007-2009 the expected volatility and default rates tripled, while CLO issuance fell from 27 billion USD pre-crisis to 0. Similarly, CLO issuance fell by 77% and 47% during the oil price shock 2014-2016 and the worldwide outbreak of COVID-19 in spring 2020, respectively.

5 Agency frictions and CLOs' cost of debt

5.1 *Source of agency conflict in CLOs*

I argue in this paper that a large part of this cyclicality in CLO issuance is explained by agency frictions. Agency frictions arise in CLOs due to three features of their structure:

(1) The manager's interest can differ from that of debt investors because the manager's compensation is closely tied to equity payouts through junior and performance fees, and they often retain part of the equity tranche;[22] (2) managers have the opportunity to act in their own interest since they can actively trade the loans in the portfolio at their own discretion during the reinvestment period; and (3) due to the locked-in financing debt investors cannot discipline managers who act against their interest by redeeming funds (Calomiris and Kahn (1991), Diamond and Rajan (2001)). In particular, this gives rise to agency problems based on debt overhang because the manager has the incentive to maximize the value to equity investors, potentially at the expense of debt investors.

The classic debt overhang problem is risk-shifting (Jensen and Meckling (1976)). For this reason, CLOs have several covenants that try to mitigate this problem. The most important one is the overcollateralization (OC) test because it is specifically designed to disincentivize risk-shifting.[23] On each quarterly interest payment date, the test relates the value of the loan portfolio to the amount of outstanding debt. If this ratio is above a pre-determined threshold, interest income from the underlying loans in excess of interest payments on the debt tranches is used to pay the manager a junior and performance fee as well as dividends to equity investors. If the CLO fails the test, excess interest payments are used to pay down principal on the most senior debt tranche. In other words, the CLO's current leverage as calculated for the OC test must be sufficiently low for the manager and equity investors to receive payments. Crucially, the calculation of the asset value for the OC test disadvantages risky loans. While all other loans are valued at their face value, some CCC rated and all defaulted loans are valued at their market value. Specifically, if the CLO holds a higher share in CCC rated loans than a pre-determined threshold – typically 7.5% –, CCC rated

[22]Under the US risk retention rule, which came into effect in December 2016, CLO managers had to retain 5% of the economic interest in CLOs they manage. A court ruling from February 2018 exempted CLOs from the rule, however, many CLO managers are still retaining significant interest in their US CLOs to comply with EU risk retention rules, making their US CLOs eligible investments for European investors. (see e.g., this article from Asset Securitization Report: https://asreport.americanbanker.com/news/more-clo-managers-take-on-risk-retention-to-meet-market-demand)

[23]Other covenants are restrictions on the weighted average rating factor, the weighted average maturity, and the weighted average spread for the loans in a CLOs' portfolio. Moreover, the are concentration limits, meaning a maximum share of the portfolio can be invested in loans of a given industry or firm. For instance, the Carlyle US CLO 2019-2, Ltd. can invest at maximum 40% in the top three industries and 12.5% in the top five firms in its portfolios, according to Fitch Ratings (see, https://www.fitchratings.com/site/pr/10084017). If these restrictions are violated, the manager is not allowed to engage in trading that worsens them, which reduces the manager's ability to engage in risk-shifting.

loans in excess of this threshold are marked-to-market, where the CCC rated loans with the lowest market value are considered as excess loans. Therefore, CLO managers have a strong incentive to sell certain CCC rated and therefore very risky loans to prevent a mark down of their portfolio that might cause equity payouts and manager fees be diverted to debt investors.[24]

Indeed, as I show in Table A5 of Appendix A4.3, this type of covenant successfully prevents risk-shifting. CLOs engage in less risky – instead of riskier – trading when the asset value falls below the face value of outstanding debt, i.e., when the equity claim on a marked-to-market basis becomes worthless. However, the OC test causes another (but presumably lesser) agency problem. As shown by Elkamhi and Nozawa (2022), Kundu (2020a), and Bhardwaj (2021), CLOs sell loans at fire sale prices to avoid failing the OC test and therefore preserve payouts to equity investors and the manager. This trading around covenants constitutes a value-reducing debt overhang problem because it (1) diverts cash flows away from debt investors towards the manager and equity investors, and (2) reduces the overall value of the loan portfolio. Despite this, as I show theoretically in Section 9, the OC test is part of the optimal contract if risk-shifting is more inefficient than fire-selling risky loans to avoid test failures, and contracts are incomplete (i.e., one cannot write contracts against risk-shifting).[25] In fact, it can be even optimal to increase the manager's incentive to trade against OC test violations, worsening the debt overhang problem caused by the OC test, when the risk-shifting problem becomes more severe. In this sense, the risk-shifting problem is still present in the background.

By avoiding OC test violations, the manager and equity investors can receive dividend payments even when the market value of assets is below the face value of outstanding debt. While corporations in the US would need to file for bankruptcy if their obligations exceed

[24]Consider the following stylized example: Consider a CLO that initially bought 100 loans with a $1 face value each and that has a CCC threshold of 7.5%. If the CLO currently holds 5% of its portfolio in CCC loans that are still trading at par and 5% in CCC loans that are trading at 50 cents per dollar of face value, then half of the discounted CCC loans are considered as excess CCC loans. All CCC rated loans combined are valued at 7.5*1 + 2.5*0.5 = 8.75. All other (higher rated) loans are valued at par, i.e., 90 in sum, independent of their market value and thus the total value of the CLO for the purpose of the OC test is 98.75. If the manager sells 2.5 in face value of the CCC loans that trade at par for B rated loans, then no remaining CCC rated loan in the portfolio would count as excess because the CLO no longer exceeds its CCC bucket of 7.5%. Thus, the total value of the CLO for the purpose of the OC test would be 100.

[25]For this reason, preventing the manager from trading against the OC test by requiring all debt to be repaid before any dividend payments can be made would be counterproductive as it takes away the incentive to not engage in risk-shifting.

their assets and would not be allowed to pay dividends, this is not the case for special purpose vehicles such as CLOs. Figure 3 plots the average equity payouts for different ranges in the market-to-market equity ratio, defined as the market value of assets minus the face value of outstanding debt divided by the market value of assets. While payouts fall when asset values decline – either because some CLOs violate their OC tests or because interest payments from defaulted loans cease –, they still constitute on average 120 bps annually of the CLO size when the equity is wiped out.

5.2 Identification Strategy

The goal of this paper is to quantify the extent to which agency problems contribute to the cyclicality of lending by CLOs. For variation in agency problems I exploit that the manager's ability to engage in discretionary trading varies over the life of the CLO. More specifically, as outlined in section 3.1, CLOs can only engage in discretionary trading during the reinvestment period, and become almost entirely passive thereafter. The debt overhang based agency problem outlined in the previous section, namely trading against OC test failures, crucially depends on the manager's ability to trade. Importantly, the length of the reinvestment period is set at issuance of the CLO. Therefore, at each point in time after the CLO is issued, the remaining period in which the manager can still engage in discretionary trading and therefore the extent of the debt overhang problem is plausibly exogenous across CLOs.

I confirm empirically that trading indeed falls drastically with the end of the reinvestment period. Figure 4 plots the average monthly trading volume relative to the CLO size for all CLOs that are a given number of months away from the end of their reinvestment period. Loan purchase volumes (Panel A) drop by almost two third from 43.10% to 17.31% annually when CLOs leave their reinvestment period. Similarly, sales volumes fall by half from 20.43% to 10.60% annually with the end of the reinvestment period (Panel B). The difference in purchase and sales volumes during the reinvestment period is due to reinvestments of repaid loans.

Since the manager's ability to trade varies with whether the CLO is still in the reinvestment period, also the debt overhang problem varies with the reinvestment period. I provide evidence for this in appendix A4.2. Specifically, I show that CLOs that are still active (i.e., within their reinvestment period) are more likely to sell CCC rated loans, which makes their OC test results less persistent and therefore the CLO less likely to fail the OC test conditional on the same vulnerability to do so. This leads to higher equity payouts for active CLOs, even if the equity value is fully wiped out, i.e., the market value of assets below the face value of outstanding debt

5.3 Empirical Specification

To measure the extent of the debt overhang problem I rely on an insight from the theoretical model that I propose in section 9: the entire debt overhang problem is reflected in the prices of CLO debt. According to this model, CLO debt prices reflect the investors' required compensation for (1) the expected loss from default if there was no friction and (2) the expected loss from the debt overhang problem, which depends on the manager's remaining discretion in trading.

Hence, I run the following regression to estimate the extent of the debt overhang problem:

$$Log(Spread_{i,m,f,t}) = \alpha_{i,f} + \beta Years\,Active\,Left_{i,t} + \delta_{m,f,t} + \gamma X_{i,m,f,t} + \epsilon_{i,m,f,t}, \tag{1}$$

where $Spread_{i,m,f,t}$ is the secondary market spread for debt tranche f of CLO i managed by manager m in month t. $Years\,Active\,Left_{i,t}$ is the remaining length of the reinvestment period of CLO i in month t and is therefore the remaining time in which the manager can engage in discretionary trading. The coefficient of interest, β, is the average compensation debt investors require for granting the manager one year of discretionary trading. CLO tranche fixed effects ($\alpha_{i,f}$) absorb variation across CLO tranches such as time-constant contract terms. Manager $\times$ seniority $\times$ month fixed effects ($\delta_{m,f,t}$) control for any time-varying differences across CLO managers, for instance the manager's skills, and variation in aggregate factors that can affect pricing of CLO debt such as investors' sentiment.

Th identification of β rests on the assumption that there are no other factors that are priced by debt investors and that vary over the life of the CLO and thus with the time left in the reinvestment period. There remain two main concerns with respect to this assumption: (1) the quality of the loan portfolio and therefore the collateral backing the CLO debt might change throughout a CLO's life; and (2) CLO investors might prefer a shorter maturity. CLO debt repayments start with the end of the reinvestment period which makes the remaining maturity correlated with the remaining time in the reinvestment period.

I address the first concern by adding several measures of collateral quality as controls. The baseline version includes the loan portfolio's weighted average rating[26], weighted average remaining loan maturity, weighted average spread, and share invested in CCC rated loans. Most importantly, there is a large overlap in portfolios of CLOs of the same manager. On average 89% of the loans held by a CLO in a given month are also held by other CLOs of the same manager in that month[27]. Therefore, even difficult to observe differences in portfolios across CLOs are largely absorbed by the manager $\times$ seniority $\times$ month fixed effects. In addition, I take into account the current market value of the loan portfolio for each tranche separately. Specifically, I calculate the market value based subordination (i.e., reverse leverage or buffer) for each tranche by subtracting the principal value of all tranches at least as senior as the tranche at hand from the market value of the assets, divide it by the market value of assets, and at it as control.[28] This takes into account both the current value of the collateral and the leverage of the CLO.

To address the second concern, I control for the expected remaining month to maturity of the CLO. The effective maturity of debt tranches is predictable, given the current maturity profile of the loan portfolio and assumptions on the maturity of loans CLOs reinvest in. While during the reinvestment period proceeds from maturing loans are reinvested into new loans (with an average maturity of 5 years), they are used to pay down debt tranches in their order of seniority after the reinvestment period. Once about 50% of the most senior debt tranche is repaid, equity investors usually call the deal, i.e., sell all assets and repay the debt notes.[29] Therefore, I estimate the expected effective maturity date for each CLO based on

[26] For this, I use Moody's weighted average rating factor (WARF) as it is reported in CLOs' trustee reports and thus included in the Creditflux data. Moody's calculates rating factors by assigning each rating category a numerical value based on the ten year expected default rate. The WARF is the CLO portfolio's average rating factor with each loan's weight determined by its share in the portfolio.

[27] The number is identical if weighting by the amount held of each loan.

[28] Formally: $subordiation_{i,f,t} = MVA_{i,t} - \sum_j^J FV_j$, where FV_j is the face value of tranche j and J is the set of tranches of CLO i in month t that are at least as senior as tranche f, including tranche f. To calculate $MVA_{i,t}$ I use the average transaction price of the loan in a month (across all CLOs), or – if missing – the average trustee price reported across all CLOs.

[29] The reasons is that at this point a big chunk of the cheap senior funding is repaid and only the more expensive debt is outstanding. Consequently, it is usually not economical anymore to continue the deal.

the assumption that maturing loans are reinvested into new loans with 5 year maturity and the deal is called once 50% of the most senior debt is repaid. I include the remaining months to the expected effective maturity date as control. This leaves still sufficient variation to identify the coefficient of interest because at origination CLOs with different length in their reinvestment period invest in portfolios with the same average maturity.[30] Consequently, a CLO with a two year reinvestment period at origination will hold loans that mature later and hence have a longer expected maturity than a CLO with two years remaining in its initial five year reinvestment period.

Besides the controls for the collateral quality and remaining maturity, the vector of controls $X_{i,m,f,t}$ includes the months since origination and a dummy variable that indicates whether the CLO is callable. The first further accounts for any life cycle effects and the latter for the exposure to early repayments or refinancing if aggregate credit spreads change – for instance following a positive shock to the economy.

Effectively, this specification allows to compare CLOs with nearly identical current portfolios and capital structures, managed by the same manager at the same point in time, and with the same contract terms but that differ in their managers' discretion in trading and therefore in their potential future portfolio. If debt investors expect managers with some probability to misuse their discretion by altering the portfolio against their interest, then more discretion should raise CLOs' cost of debt.

5.4 Results

Consistent with debt overhang problems being priced by the debt investors, the results in Table 2 show a positive relationship between the remaining reinvestment period and CLOs' cost of debt. Column (1) presents the results without any fixed effects and only the controls. The coefficient implies that one more year of discretionary trading for the manager increases CLOs' cost of debt on average by a factor of 0.07 (or 7%). Columns (2) and (3) successively introduce the two types of fixed effects, which reduces the effect consistent with capturing important confounders. In the tightest and preferred specification (Column (3)), which

[30]The (unreported) slope coefficient from regressing the average maturity of the loan portfolio at origination on the length of the reinvestment period both measured in years is 0.002 and is statistically insignificant with a p-value of 0.655.

compares CLOs of the same manager in the same month while controlling for time-constant CLO characteristics, one more year of discretionary trading raises CLOs' cost of debt by a factor of 0.03 (3%). With an average spread of 414 bps in the sample (see Table 1, Panel (C)), this implies that CLOs have to pay on average a 12.4 bps annually per year in which the manager is allowed to trade. This is a large effect from the perspective of equity investors. For the average CLO with an equity ratio of about 10% this implies a 112 bps lower return for equity investors per year of trading.

Figure 5 presents the relationship between managerial discretion and the costs of debt graphically. It plots the average logarithmic spread for each percentile of remaining years in the reinvestment period after residualizing both variables with the control vector and manager $\times$ seniority $\times$ month fixed effects. The figure confirms that the relationship is linear, monotonic, precisely estimated and not driven by outliers.

The results are robust to many alternative specifications that are reported in Appendix A4.4. This includes different controls for portfolio risk (weighted average beta with respect to a market index, and weighted average return volatility of the portfolio), different functional forms for the expected remaining maturity, and linear instead of logarithmic spreads. Interestingly, the results are also very similar on the primary market despite the fact that the length of the reinvestment period is then endogenous.

The theory that is presented later predicts that the likelihood of the manager acting against the interest of debt investors increases when the value of the equity claim is lower and the expected volatility of the underlying assets' return is higher, which raises the financing costs due to agency problems. I test these two predictions by interacting the remaining years in the reinvestment period with the marked-to-market equity ratio – calculated based on the current market value of assets and the notional value of outstanding debt –, and the VIX as a proxy for the expected volatility of loan returns. The VIX is a measure of the expected volatility in the stock market, and is derived from option prices. To better capture the set of firms that typically borrow from CLOs, I use the Russell 2000 VIX, which captures the expected volatility of the Russell 2000 index. In addition, this specification includes the remaining maturity interacted with the VIX as control, which allows the effect of the remaining maturity to vary over the credit cycle, and thus absorbs potential measurement errors in reported prices. In particular, since the observed CLO debt prices are the second highest bid in an auction, generally less depth in those auctions in volatile periods leads to measurement errors that would more strongly affect the spread of tranches with shorter remaining maturity.[31] Indeed, the effect of the remaining maturity on loan spread becomes more negative when the VIX rises (not reported).

Table 3 presents the results. Debt investors require more compensation for exposure to agency problems when the VIX rises, consistent with agency problems becoming more severe in volatile periods. A one standard deviation increase in the VIX raises the baseline coefficient by one-third (Column (1)).[32] Times of high VIX are usually also associated with low asset prices. Hence, the effect could be either due to a rise in expected volatility of loan returns, a lower marked-to-market equity ratio after losses or both. A lower marked-to-market equity ratio indeed increases the cost of discretion as shown in Column (2). A 10 percentage points lower equity ratio raises CLOs' cost of debt for discretion by a factor of 0.01. This is consistent with a larger equity claim better aligning the manager's and debt investors' interests and hence reducing the probability of a future agency conflict. However, the results in Column (4) imply that even when keeping the equity ratio constant, the cost of debt due to agency problems increases in the expected volatility. The magnitude implies that when the VIX is one standard deviation above its mean, a CLO with a five year reinvestment period faces 20.7 bps higher costs of debt and its equity investors a 186.3 bps lower return (all else equal).[33] To put this in context, the VIX was 4.7, and 3.7 standard deviations above its means during the height of the Global Financial Crisis (September 2008), and the worldwide COVID-19 outbreak (March 2020), respectively.

The coefficients are robust to using different measures that proxy for the expected volatility in the loan market. Table A14 in Appendix A4.4 presents results when using the ratio of loan downgrades to upgrades – a popular measure of loan market volatility among practitioners –, and average loan spreads from Saunders, Spina, Steffen, and Streitz (2021).

[31]Intuitively, the common discount would be distributed across fewer years if the remaining maturity is shorter.

[32]I standardize the VIX with respect to its entire available sample from 2004 to 2022 to keep the interpretation consistent across different sample periods throughout the paper.

[33]Assuming as before an average cost of debt of 414 bps as in the spread sample and an average equity ratio of 10%: $0.01 \cdot 414 \cdot 5 = 20.7$, $20.7 \cdot 9 = 186.3$.

6 Contractual Adjustments to Mitigate Agency Problem

6.1 Discretion over the Credit Cycle

The results in the previous section show that the intensifying agency problem in volatile periods makes discretion more costly for the manager. Accordingly, one would expect the manager to choose less discretion, i.e. a shorter reinvestment period, when originating a new CLO in volatile periods. Figure 6 presents results that are consistent with this. It shows that when the VIX rises (Panel (A)), and only few CLOs are originated (Panel (B)), those CLOs that are still issued tend to have a shorter reinvestment period. For instance, the average length of the reinvestment period of new CLOs fell from almost 7 years to about 2 years during the Global Financial Crisis 2008/2009 and from 5 years to little over 2 years during the worldwide outbreak of COVID-19 in spring 2020.

Similarly, Figure 7 shows that the share of static CLOs –those without any reinvestment period– among new CLO originations significantly increases in volatile periods. During the Global Financial Crisis 2008/2009 static CLOs made up 52% of all new CLOs, up from close to zero pre-crisis. Similarly, the share of static CLOs rose from zero to 9% during the oil price shock 2014-2016 and to 7% when COVID-19 broke out in spring 2020. Thus, CLO managers seem to reduce their discretion also on the extensive margin.

I further investigate more formally the margins at which managers adjust the discretion by regressing the length of the reinvestment period of newly issued CLOs on the VIX in the month prior to origination. Table 4 reports the result. A one standard deviation higher VIX is associated with on average a 0.84 years shorter reinvestment period for newly issued CLOs (Column (1)). The coefficient is identical when including manager fixed effects, which reveals that this relationship is not coming from a selection on managers (i.e., managers that tend to choose more discretion reducing their issuance in bad times) but from the same manager adjusting the discretion over time (Column (2)). Moreover, the adjustment occurs on both the intensive and extensive margin. The coefficients in Column (3) and (4) show that even when conditioning on CLOs that are not static – where the manager can trade at least for some time – the length of the reinvestment period varies strongly with the VIX, consistent with intensive margin adjustments. Along the extensive margin, a one standard deviation higher VIX is associated with a 3% higher probability that a issued CLO is static (Column (5)). Again, this coefficient is almost unchanged when including manager fixed effects, consistent with extensive margin adjustments not being driven by manager selection (Column (6)).

One might worry that managers choose a shorter reinvestment period because investors suddenly become more impatient and prefer an earlier repayment of their investment. However, under this argument one would then expect that CLOs invest in loans with shorter maturity in volatile periods consistent with investors' preferences. This is not the case as revealed by Figure 10. The average maturity of the loan portfolio at origination is basically flat over the credit cycle. For instance, CLOs originated in 2019Q4 invested in loans with an average maturity of 5.29 years, while for CLOs originated during the COVID outbreak in 2020Q2 this number was only marginally lower with 5.09 years.

In sum, this evidence suggests that due to a more intense agency problem in volatile periods CLO managers make contractual changes in the form of a shorter discretionary trading period to mitigate this problem.

6.2 OC Test Threshold over the Credit Cycle

As argued in Section 5.1, the OC test is specifically designed to prevent risk-shifting by providing the manager with an incentive to sell risky assets. If risk-shifting is more inefficient than trading against the OC test and the risk-shifting problem becomes more severe in volatile periods – for instance because there are more extreme states of the world that can be gambled on – it is optimal to adjust the CLO contract such that trading against the OC test becomes relatively more attractive for the manager. I show this formally in an extension of the baseline model in Appendix A5.5. One way to make trading against the OC test more attractive for the manager is to increase the OC test threshold, as shown in Appendix A5.4. This implies that more cash flows are diverted to debt investors if the manager does not trade against a OC test failure, raising the *prize* from trading against OC test failures.

Figure 8 provides evidence consistent with this hypothesis. It plots the average OC test threshold of newly originated CLOs along with the VIX. Whenever the VIX rises, newly originated CLOs set a higher OC test threshold, consistent with the risk-shifting problem increasing in the background which requires a stronger incentive for the manager to not violate the OC test.

I test this relationship more formally by regressing the OC threshold of newly issued CLOs on the VIX in the month prior to origination. The coefficient reported in Columns (7) of Table 4 indicates that a one standard deviation increase in the VIX is associated with a 0.9 higher threshold. This means that now the asset value relative to outstanding debt as calculated for the OC test must be 0.9 percentage points higher for the OC test not to be violated, implying that conditional on a test violation more cash flows need to be directed to debt investors before the CLO is in compliance with the OC test gain. The coefficient is very similar with and without manager fixed effects, which suggest that the change of the OC threshold over the cycle comes from the same manager reducing the OC threshold rather than a selection on managers.

7 The Benefit of Discretion: Return from Trading

This begs the question of why is not a higher share of CLOs issued in volatile periods static? And why are not more CLOs issued in volatile periods when the intensification of the agency problem can be solved by simply limiting trading? The answer to both questions is that reducing the manager's discretion comes at a cost. Under proper incentives, managers use their discretion to trade optimally and increase the value of the portfolio.

I estimate the alpha in trading by CLO managers as the intercept in a regression of CLOs' trading returns on its risk. Specifically, for each CLO in each month I construct a long-short portfolio that is long in all loans bought by that CLO in this month and short in all loans sold. Then, I regress the return of this long-short portfolio over the following three months on its weighted average rating. The idea is that any mispricing exploited by CLO managers through trading vanishes within three months.

$$Return_{i,t}^{t\mapsto t+3} = \alpha + \beta Risk_{i,t} + \epsilon_{i,t}, \tag{2}$$

A more detailed description of the portfolio and return construction is provided in Appendix

A3.2. It is important to note, that trading returns are net of transaction costs. The returns are constructed based on actual transaction prices, and for the 3-months forward prices I employ sales prices for the long-leg and purchase prices for the short-leg of the portfolio.

To estimate the additional alpha from discretion, I include an indicator for whether the CLO is within the reinvestment period. Panel A in Table 5 presents the results. The coefficients in Column (1) reveal that active CLOs – those that are in their reinvestment period – earn on average a 9.6 bps higher annualized return relative to their size after controlling for risk. The average monthly abnormal return from trading is close to 0 and insignificant for CLOs outside their reinvestment period. Columns (2)-(4) successively add CLO and year-month × manager fixed effects to better isolate the return differential that is entirely due the manager's ability to trade during the reinvestment period. CLO fixed effects address the worry that CLOs with a longer reinvesment period might have generally better trading abilities. Year-month × manager fixed effects absorb any time-varying manager level information or trading skill and allow for the comparison of active and passive CLOs of the same manager in the same month. The coefficient of the tightest specification in Columns (4) indicates that trading during the reinvestment period increases the value of the CLO by on average 12 bps per year. This implies (all else equal) a 6 percentage point higher return to equity investors (and the manager) of a CLO with a 5 year reinvestment period relative to a static CLO.[34] Of course, this ignores entirely the results from above that more discretion is costly as debt investors require compensation for the risk that the manager acts against their interest. I discuss this trade-off in more detail below.

Figure 9 highlights graphically the higher abnormal return from trading during the reinvestment period. It plots the average return from trading after controlling for risk and absorbing variation across manager × month for all CLOs with a given number of months away from the end of their reinvestment period. It confirms that the abnormal return from trading is significantly lower outside the reinvestment period.

The trade-off when granting the manager discretion – which is at the heart of this paper – is most apparent in the results in Panel B of Table 5. It reports the coefficients from regressing trading returns of active CLOs on a dummy variable that indicates whether the

[34]Assuming that costs of debt are independent of the reinvestment period and the equity ratio is 10%: $12 \cdot 5 \cdot 10 = 600$ bps

marked-to-market value of the equity tranche is zero and adjusting for risk. The marked-to-market value of the equity tranche is zero when the market value of assets is below the face value of outstanding debt. The constant in Column (2) implies that CLOs earn on average 12 bps annually in risk-adjusted returns relative to their size through trading when the marked-to-market value of the equity ratio is positive. However, the return becomes -22 bps when the outstanding debt exceeds the market value of assets and hence the manager's incentives are potentially misaligned with that of debt investors. The difference in risk-adjusted returns from trading between managers with strong and week incentives varies from 49 bps to 15 bps when successively adding CLO and year-month $\times$ manager fixed effects (Columns (3)-(5)). While the difference is still statistically significant in the tightest specification with CLO and year-month $\times$ manager fixed effects (Column (5)), it is substantially smaller than in the regression model with only CLO fixed effects. This is not surprising given that there is very little variation in the equity ratio at origination across CLOs (see Table 1) and a strong overlap in holdings among CLOs of the same manager in the same month. Thus, the inclusion of year-month $\times$ manager fixed effects absorbs most of the variation in the equity ratio. Nonetheless, the results highlight that discretion for the manager boosts the value of the CLO as long as the manager's incentives are well aligned with that of outside investors. If not, managers misuse their discretion and destroy value through trading.

The results are robust to various alternative specifications. This includes accounting for risk by calculating abnormal returns based on rolling estimates of portfolio betas[35], controlling for average industry-based stock price betas and using different time horizons (Tables A8 and A9 in Appendix A4.3). Importantly, when the manager's discretion is limited – outside of the reinvestment period – trading returns do not depend on the equity ratio of the CLO, suggesting that post-reinvestment period constraints prevent not only value-enhancing but also value-destroying trading by the manager (Table A10 in Appendix A4.3).

[35]Instead of controlling for the risk of the portfolio, one can also directly estimate the abnormal return of the long-short portfolio. The abnormal return is defined as the actual return over the following three months minus the predicted return based on the portfolio's average beta and the market return. Cordell, Roberts, and Schwert (2021) use a similar approach and also find positive abnormal returns but on the loan instead of CLO-month level (see their Internet Appendix). Appendix Table A8 reports results repeating the analyses with the abnormal return as independent variable. The results remain very similar, however, the fact that the abnormal return of the long-short portfolio loads positively on the average rating highlights the challenge of estimating betas for illiquid loans.

8 Reduced-Form Effect of Financing Frictions on CLO Issuance

In Section 9, I will argue based on a theoretical model that the uncovered agency problem and the resulting discretion trade-off affect the level of CLO issuance. The model predicts that in bad times when the expected volatility of loan return rises and losses lead to a decline in managers' net worth, the agency problem grows and therefore issuance declines. The model's state variables – the volatility of asset returns and the manager's net worth – are driving the level of issuance. While I will use the calibrated model to quantify the effect of the growing agency problem in bad times on CLO issuance in Section 10, it is still worthwhile to estimate the effect on issuance also in reduced-form.

For this I exploit that the agency problem crucially depends on the CLO manager's net worth, and that CLO equity payouts are observable and reasonable proxies for changes in the net worth of the CLO manager. Of course, agency problems between the manager and debt investors are not unique in making the manager's net worth important for the level of issuance. Any theory that tries to explain lending with financial frictions requires mechanisms that make both outside debt, and outside equity financing costlier than internal funds. While the evidence in section 5 shows that agency problems between the manager and debt investors make outside debt financing costly for CLOs, the result in this section that the manager's net worth is important for issuing a CLO is best interpreted as evidence for the costly issuance of outside equity. One reason why issuing outside equity might be costly is that it gives the manager less incentive to exercise costly effort to generate alpha (see, e.g. Jensen and Meckling (1976), Hébert (2018)).

Figure 11 presents aggregate evidence that shows a positive correlation between equity payouts and CLO issuance. For instance, average payouts relative to the size of the equity tranche fell from 20% pre-GFC to about 7% in 2009Q3. However, one cannot conclude this relationship is causal as other factors might drive the joint evolution of equity payouts and issuance in the aggregate. Therefore, I further study the link between equity payouts and issuance in the cross-section of CLO managers. Absent any financing friction, managers' decision to issue a CLO should not be driven by cash payouts they receive but solely by their investment opportunities. However, there might be unobservable factors that are correlated with both equity payouts and a manager's investment opportunities. For instance, some managers might invest in their skills which improves their returns but also makes it more attractive for these managers to issue a new CLO. To improve the identification of a causal link between payouts and issuance, I focus on the COVID outbreak in 2020 and use a manager's pre-COVID exposure to the four industries most affected by COVID as an instrument for equity payouts, which results in the following two-stage regression specification:

$$\begin{aligned} &\textbf{First Stage: } \widehat{Equity\,Payouts}_m^{03/20-12/20} = \delta_0 + \delta_1 \overline{COVID\,Exposure}_m^{09/19-02/20} + u_m \\ &\textbf{Second Stage: } CLO\,Issuance_m^{03/20-12/20} = \beta_0 + \beta_1 \widehat{Equity\,Payouts}_m^{03/20-12/20} + \epsilon_m \end{aligned}, \quad (3)$$

where $Equity\,Payouts_m^{03/20-12/20}$ are the combined equity payouts from March to December 2020 of CLOs managed by manager m, and $CLO\,Issuance_m^{03/20-12/20}$ is the total CLO issuance of manager m in the same period. To account for the manager's size, I scale both equity payouts and CLO issuance with the manager's average CLO volume under management in the prior 6 months. $\overline{COVID\,Exposure}_m^{09/19-02/20}$ is manager m's average share invested in industries most affected by COVID in the prior six months.[36] This includes investments in *Oil & Gas*, *Hotel, Gaming and Leisure*, *Consumer Transportation*, and *Retail*, which are the four industries with the lowest cumulative return in the loan market from February to April 2020.[37] The instrument leads to unbiased estimates under the assumption that the pre-COVID exposure to industries most affected by COVID only impacts CLO issuance through equity payouts. This assumption seems reasonable because the COVID outbreak came as a surprise and affected a diverse group of industries. However, one remaining concern is that CLO managers might still specialize in specific industries and corporations. If firms most affected by the COVID outbreak have less demand for loans following the shock and firm-CLO relationships are sticky, then the pre-COVID exposure to industries hit most strongly affects CLO issuance beyond the net worth channel. To address this concern, I also report the results of a specification that includes only the amount of CLO issuance that is invested in *all other* industries as the dependent variable.

[36]Despite the generally high degree of diversification within CLO portfolios, there is sufficient variation in COVID exposure across CLO managers. The mean and median COVID exposure is 15%, the standard deviation is 4%, and the values at the 10th and the 90th percentile are 11% and 20%, respectively.

[37]This is based on Moody's industry classification and transaction prices as reported in Creditflux.

Table 6 presents the results. The coefficient of the first stage in Column (1) reveals that there is a strong relationship between managers' exposure to the four industries most affected by COVID and their equity payouts. A 10 percentage point larger share invested in these industries is associated with 0.1 percentage points higher quarterly equity payouts over CLOs under management.[38] The F statistic is 29.34 and above the Stock and Yogo (2005) critical value for 5% maximal bias, which indicates that the instrument is not weak. The OLS result in Column (2) shows that there is a strong correlation between equity payouts and CLO issuance across managers. $1 more of equity payouts per dollar of assets under management is associated with about $25 more in CLO issuance per dollar of assets under management. The effect increases to $40 with 2SLS estimation, using the COVID exposure as instrument. Column (4) reports the result of the reduced-form regression of CLO issuance on the COVID exposure. A 1 percentage point smaller share invested in industries most affected by COVID is associated with 0.5 percentage points less issuance relative to the pre-COVID assets under management. The results are very similar when only counting dollars of CLO issuance that are subsequently invested in industries less affected by COVID (Columns (5) and (6)). This shows that financing frictions matter for CLO issuance.

This has also implications for lending to firms. Fleckenstein, Gopal, Gutierrez, and Hillenbrand (2020) exploit the same identification strategy and stickiness in firm-CLO relationships to show that a decline in CLO issuance, induced by a fall in managers' net worth, leads to a contraction of loan issuance and higher loan spreads. Consistent with their cross-sectional causal evidence, there is a strong correlation in the time-series between leveraged loan issuance and CLO issuance, as illustrated in Figure A3 in Appendix A4.1.

9 Model of Agency Friction and CLO Issuance

This section presents a dynamic model of CLOs. The model serves two purposes. First, it clarifies the mechanism through which agency problems affect the issuance of new CLOs, and rationalizes the empirical findings so far. Second, and most importantly, it allows to quantify the contribution of agency frictions to the cyclicality in CLO issuance. The idea is to use

[38] This is about half of the average quarterly equity payout over CLO assets under management 0.22%, and therefore a large effect.

the model to quantify the effect that the rise in CLOs' cost of debt due agency problems in bad times has on CLO issuance, while allowing CLO managers to reoptimize the length of the discretionary trading period. The model features an intermediary agency friction that arises because (1) the manager's and outside investors' claims differ, (2) the manager can alter the assets and hence the distribution of cash flows, and (3) outside investors' financing is locked-in. The model can be applied to other intermediaries that share these three attributes, potentially private debt funds, private equity funds, venture capital funds, hedge funds, and closed-end mutual funds. The main text presents the key features of the dynamic model. Appendix A5 contains a more detailed derivation of the baseline model, proofs, model extensions and a deeper discussion of contracting assumptions.

9.1 Model Set Up

Environment. There are two types of agents: investors and overlapping generations of intermediary managers. A unit mass of representative intermediary managers are born in every period t and live until $t+1$. They are endowed with net worth $N_t \in [0,1]$, which they invest in t, and consume a share ρ of the return in $t+1$. The remainder $1-\rho$ is distributed across the unit mass of new managers born in $t+1$. This assumption is necessary because in equilibrium – as will become clear later – managers with the same net worth might choose different investments with identical expected but different realized returns. Keeping track of the evolution of the entire net worth distribution would be technically challenging without imposing this assumption, and is a common way to circumvent this problem (e.g., Acharya, Lenzu, and Wang (2021)).

Manager t can invest in either a risk-free asset with return r_t^f or a pool of loans with expected cash flow $\overline{R}_t$. The pool of loans requires a fixed investment of 1, for instance, to achieve a minimum level of diversification. To invest in the pool of assets, the manager therefore sets up an intermediary. The manager's investment in the intermediary is in the form of equity, while the remaining required investment is in the form of debt provided by investors.[39] Investors are competitive, can also invest in the risk-free asset and elastically

[39]This fits well the financing structure of CLOs because they are mainly financed by outside debt, managers often retain part of the equity tranche, and earn part of their fees based on distributions to equity investors. Appendix A5.8 presents an extension of the model that allows managers to also issue outside

provide financing. One can think of the risk-free asset as alternative forms of financing for firms, for instance direct lending through bonds. Both the manager and investors are risk-neutral and have no time preferences.

The manager manages the intermediary and therefore has discretion over the trading of assets by the intermediary. The timing is depicted below:

t	$t+1$
Manager Raises $1-N_t$ in debt	Return is realized
Contract specifies face value D_t and discretion f_t	Manager trades assets with discretion f_t
Assets are acquired	Cash flows are distributed

Importantly, the timing within date $t+1$ follows from top to bottom. In $t+1$ and after observing the return on the portfolio (e.g., some initial defaults or updating of default probabilities), the manager decides how to trade. Subsequently, cash flows in the new portfolio are realized and distributed to investors, the manager born in t, and the manager born in $t+1$.

Discretion trade-off. Trading by the manager can either be value enhancing or value destroying. The degree to which the manager can deviate from the initial portfolio is governed by $f \in [0, \overline{f}]$. I refer to it as *discretion.* It is bound below by 0 and has a natural limit, when the manager is unconstrained, at $\overline{f}$. The discretion can be brought below its natural limit through covenants, investment mandates, or – as in the empirical setting of this paper – by shortening the period in which the manager can actively trade. Managers can either use their discretion for good trading which improves the return on the loans by $\alpha(f)$, with $\alpha(0) = 0$, $\alpha'(f) > 0$, and $\alpha''(f) \leq 0$. The marginal return when enganging in good trading declines (weakly) in discretion, consistent with managers using their discretion to first go after their best trading ideas. Alternatively, the manager can engage in bad trading, which reduces the return on the loan portfolio by $f\gamma$. However, such inefficient trading provides the manager with utility fB at the expense of investors. B can either be the higher value of the equity claim and the according decline in the value of the debt claim from risk-shifting, or the cash flows that the manager diverts away from debt investors when not failing the OC

equity at a cost.

test due to trading. I discuss both risk-shifting and trading against OC test failures, their interlink, and how they map to the model in more detail in Appendix sections A5.4 and A5.5. One insight from this is that if risk-shifting is more inefficient than trading against the OC test, it is optimal to include the OC test in the contract with B set such that managers weakly prefer selling risky assets to avoid failing the OC test over buying risky assets to increase the option value of their equity claim.

The degree of the agency problem crucially depends on discretion f, which can be contracted on. The key trade-off is that more discretion allows the manager to grasp more profitable trading opportunities but also to misuse it to inefficiently divert value away from debt investors.

Optimal trading in t+1: The return on the initial portfolio in $t+1$ is $R_{t+1} = \overline{R}_t - \sigma_t \epsilon_{t+1}$, where $\epsilon_{t+1} \in [\underline{\epsilon}, \overline{\epsilon}]$ is a return shock with $\mathbb{E}[\epsilon] = 0$, density function $g(\epsilon)$ and cumulative density $G(\epsilon)$. After observing the realization of ϵ_{t+1}, the manager born in t will generate alpha in $t+1$ if and only if the manager's payoff after generating alpha and paying debt obligations is larger than the private value from bad trading:

$$\overline{R}_t - \sigma_t \epsilon_{t+1} + \alpha(f_t) - D_t \geq f_t \cdot B, \tag{4}$$

where D_t is the face value of debt promised to debt investors in t to be paid in $t+1$. This leads to a reservation value for the return shock – denoted $\widetilde{\epsilon}_t$ –below which good trading is optimal.

$$\widetilde{\epsilon}_t = \frac{\overline{R}_t - D_t + \alpha(f_t) - f_t \cdot B}{\sigma_t} \tag{5}$$

Note, the manager will only engage in bad trading if the resulting inefficiency is borne by debt investors, which makes states of bad trading by the manager coincide with states in which the intermediary defaults (see the detailed derivation in Appendix A5.2).

One important difference to other models with intermediary agency problems (e.g., Holmström and Tirole (1997), He and Krishnamurthy (2013), Adrian and Shin (2014), Brunnermeier and Sannikov (2014)) is that bad behavior by the manager occurs following a shock and not deterministically immediately after raising financing. This implies that there is no fixed net worth constraint which insures that bad behavior happens only off-equilibrium. Instead, bad trading occurs with a certain probability in equilibrium, which depends on the manager's net worth, and is reflected in financing costs.

Debt Pricing in t: Debt investors in t require a net return of r_t^f in expectation. Given f_t and $\widetilde{\epsilon}_t$, they demand the face value D_t paid when there is no default to compensate them for losses in the default states:

$$G(\widetilde{\epsilon}_t)D_t + \int_{\widetilde{\epsilon}_t}^{\overline{\epsilon}} (\overline{R}_t - \sigma_t \epsilon_{t+1} - f_t \cdot (B+\gamma)) \cdot g(\epsilon_{t+1}) d\epsilon_{t+1} = (1 - s_t N_t) \cdot (1 + r_t^f), \tag{6}$$

where s_t is the share of their net worth managers invested in the intermediary, and $(1-s_tN_t)$ the investment by debt investors.

Manager Problem in t: Managers allocate their net worth between the risk-free asset and the equity financing of the intermediary, and choose the optimal discretion to trade in the next period in case they decide to invest in the intermediary. Through the costs of debt financing, the manager fully internalizes the agency problem and therefore the manager's expected return from investing in the intermediary, $\mathbb{E}_t[R_{t+1}^M]$, reflects the expected return from trading:

$$\max_{s_t, f_t} \ \rho \left(\mathbb{E}_t[R_{t+1}^M(s_t N_t)] + (1 - s_t) \cdot N_t \cdot (1 + r_t^f) \right)$$

$$\text{with } \ \mathbb{E}_t[R_{t+1}^M] = \overline{R_t} - (1 - s_t N_t) \cdot (1 + r_t^f) + \underbrace{G(\widetilde{\epsilon}_t)\alpha(f_t) - (1 - G(\widetilde{\epsilon}_t)) \cdot f_t \cdot \gamma}_{\text{Expected return from trading}}$$

$$\text{s.t. } \ \widetilde{\epsilon}_t = \frac{\overline{R}_t - D_t + \alpha(f_t) - f_t \cdot B}{\sigma_t}$$

$$D_t = \frac{(1 - s_t N_t) \cdot (1 + r_t^f) - (1 - G(\widetilde{\epsilon}_t)) \cdot (\overline{R}_t - f_t \cdot (B + \gamma)) + \sigma_t \int_{\widetilde{\epsilon}_t}^{\overline{\epsilon}} \epsilon_{t+1} g(\epsilon_{t+1}) d\epsilon_{t+1}}{G(\widetilde{\epsilon}_t)}$$

$$f_t \in [0, \overline{f}]$$

The states of the economy are defined by two variables: the manager's net worth N_t and the volatility of next periods returns σ_t. The two state variables are governed by the following laws of motion:

$$N_{t+1} = (1 - \rho) \left[\int_0^1 R_{t+1}^M(s_{i,t} N_{i,t}, f_t) + (1 - s_{i,t}) \cdot N_{i,t} \cdot (1 + r_f^t) di \right] \tag{7}$$

$$\text{with} \quad R^M_{t+1}(s_{i,t}N_{i,t}, f_t) = \begin{cases} \overline{R}_t - \sigma_t\epsilon_{t+1} + \alpha(f_t) - D_t & \text{if } \epsilon_{t+1} \leq \widetilde{\epsilon}_t \\ f_t \cdot B & \text{if } \epsilon_{t+1} \geq \widetilde{\epsilon}_t \end{cases}$$

$$\sigma_{t+1} = \overline{\sigma} + \eta(\sigma_t - \overline{\sigma}) + \psi\epsilon_{t+1} \tag{8}$$

Next period's net worth depends on the realized return from investing the intermediary's equity, and the share the manager invested in the intermediary. The volatility variable follows a AR(1) process with mean $\overline{\sigma}$ and is exposed to the same shock as the return process.[40] The idea is that bad times are characterized by both an increase in loan defaults that lower the return for the intermediary and a rise in volatility of future returns. This is consistent with Figure 1, which plot the time-series of CLO issuance along with the VIX and default rates.

Market Clearing: It turns out that each manager will either invest all the net worth or none of it in the intermediary. More net worth in the intermediary reduces the face value of debt, which in turn lowers the probability of bad trading by the manager, which in turn further reduces the face value of debt. Hence, conditional on investing in the intermediary being valuable, the marginal return from investing more equity in the intermediary is at least as high as the risk-free rate. In equilibrium, a mass m^*_t of managers will therefore invest their entire net worth in the intermediary, whereas the remaining mass of managers invests in the risk-free rate until the expected return from investing in the intermediary and the risk-free asset are equalized. Markets clear because firms whose loans the intermediary invests in have (in aggregate) a downward sloping demand for funding, for instance because some of their projects turn net-present-value (NPV) negative when financing costs rise, or because some firms have access to outside financing options (e.g., the bond market):

$$\text{Firm's loan demand: } \overline{R}(m_t) = R_0 - \delta^F log(m_t),$$

$$\text{with } m_t = \int_0^1 \mathbb{1}_{\{s_{i,t}>0\}} di$$

$$\Rightarrow \text{market clearing: } log(m_t) = \frac{1}{\delta^F}\left[R^0 - (1 + r^f_t) + G(\widetilde{\epsilon}_t)\alpha(f_t) - (1 - G(\widetilde{\epsilon}_t)) \cdot f_t \cdot \gamma\right],$$

where $\frac{1}{\delta^F}$ is the elasticity of firms' loan demand.

Equilibrium: Therefore, the dynamic equilibrium is a sequence of discretion $\{f_t\}_0^\infty$, and

[40] The 3-months VIX also follows a AR(1) process.

CLO manager portfolio choices $\{s_t\}_0^\infty$, such that:

(i) f_t^* is optimal:

$$\begin{cases} f_t^* = 0 & \text{if } N_t \leq \underline{N_t} \\ \frac{Bg(\widetilde{\epsilon}_t^*)(\alpha(f_t^*)+f_t^*\cdot\gamma)}{\sigma G(\widetilde{\epsilon}_t^*)} = G(\widetilde{\epsilon}_t^*)\cdot\alpha'(f_t^*) - (1-G(\widetilde{\epsilon}_t^*))\cdot\gamma & \text{if } N_t > \underline{N_t} \end{cases}$$

(ii) $\widetilde{\epsilon}^*$ satisfies the constraint: $\widetilde{\epsilon}_t^* = \frac{N_t\cdot(1+r_t^f)-f_t^*\cdot B-\sigma_t\int_{\widetilde{\epsilon}_t^*}^{\overline{\epsilon}}\epsilon g(\epsilon)d\epsilon}{\sigma_t G(\widetilde{\epsilon}_t^*)}$

(iii) markets clear: $log(m_t^*) = \frac{1}{\delta^F}\left[R^0 - (1+r_t^f) + G(\widetilde{\epsilon}_t^*)\alpha(f_t^*) - (1-G(\widetilde{\epsilon}_t^*))\cdot f_t^*\cdot\gamma\right]$

(iv) and the state variables N_t and σ_t follow the laws of motion as described by Equations 7 and 15, respectively.

9.2 Equilibrium Analysis

Figure 12 presents the equilibrium levels of discretion and intermediary issuance (or lending) depending on the manager's net worth and the volatility of loan returns, the two state variables, for a specific numerical example. Appendix A5.3 contains the general proofs of these relationships, assuming a uniform distribution of return shocks.

Both optimal discretion and aggregate issuance increase in the manager's net worth. A lower net worth reduces the probability of good trading in the next period, which lowers the marginal expected return of discretion and thus its optimal level. The subsequent lower expected return from trading makes investing in the intermediary's equity less attractive. Hence, fewer managers decide to set up an intermediary and invest in its equity until loan rates rise to a point where the return on intermediary equity equates the risk-free rate again. The relationship is non-linear, which is a common and desired feature of models with intermediary frictions (see e.g., He and Krishnamurthy (2013), Brunnermeier and Sannikov (2014)). In this model, this arises because if the net worth is sufficiently high, discretion reaches its natural limit $\overline{f}$, and at the same time net worth's marginal effect on the default probability is small. At this point, a higher net worth increases the expected return from trading only slightly. Thus, if managers' net worth is very high, small negative shocks to the manager's net worth (or small positive shocks to return volatility) have only a tiny effect on discretion and issuance. If, however, the shocks are sufficiently large, both discretion and issuance fall sharply. In contrast to models in which bad behavior by the manager only occurs off-equilibrium (e.g., Holmström and Tirole (1997), He and Krishnamurthy (2013), Adrian and Shin (2014), Brunnermeier and Sannikov (2014)), there is no fixed net worth constraint. Intermediaries can still be issued even if managers' net worth is small, however, it becomes less attractive to do so.

A rise in the volatility lowers the threshold $\widetilde{\epsilon}_t^*$ and hence the probability that the manager trades to enhance value, $G(\widetilde{\epsilon}^*)$.[41] The higher probability of bad trading makes discretion less attractive. This not only lowers the optimal level of discretion but also reduces the expected return from investing in the intermediary's equity. Consequently, fewer managers decide to set up an intermediary until the expected return on the initial loan portfolio – due to firms' downward sloping demand for credit– equalizes the expected return on intermediary equity with the risk-free rate again. The downward adjustment of discretion dampens the fall in the expected return from trading and therefore the issuance of new intermediaries.

Appendix A5.1 discusses the contracting assumptions, and the assumption that outside financing is long-term and in the form of debt. Appendix A5.5 extends the baseline model by including the interaction of the risk-shifting problem and OC test. Appendix A5.6 shows formally under which conditions long-term financing is optimal, despite giving rise to agency problems. Appendix A5.7 extends the baseline model by allowing managers to refinance the liabilities early, which helps mitigate the cyclicality in lending if refinancing costs are not too high. Finally, the extension discussed in Appendix A5.8 gives managers the option to also raise outside equity financing, but at a cost.

[41] After first glance at Equation 26, one might suspect that the direction in which the probability of good trading changes depends on whether good or bad trading is initially more likely because more probability mass is shifted to the extremes. However, it turns out that the rise in volatility reduces the expected return to debt investors conditional on default by so much that the face value of debt must rise which reduces $\widetilde{\epsilon}^*$ even if it was already below 0.

10 Contribution of Agency Frictions to CLO Issuance Cycle

To quantify the contribution of agency frictions in CLOs to the cyclicality in their issuance, I calibrate the model to the data. Then, I shock the calibrated model with the same rise in expected volatility and decline in manager net worth as implied by a one standard deviation increase in the VIX. Subsequently, I compare the model implied to the actual fall in CLO issuance following the same shock in the VIX to back out the contribution of agency frictions to the cyclicality in CLO issuance. In contrast to the baseline version of the model, I allow managers to issue outside equity at a cost – as in the extension presented in Appendix A5.8 –, which is realistically the case for CLOs. Additional details for the quantification exercise are presented in Appendix A6.

10.1 Calibration

Parameter calibration: Many model parameters are directly observable or can be estimated via OLS. Table 7 lists all parameter values. I set the inefficiency of bad trading per unit of discretion, γ, to 37 bps, which is the absolute value of the annualized abnormal return from trading of CLOs with zero marked-to-market equity as implied by the constant in Column (2) and the slope coefficient in Column (3) in Panel B of Table 5. For B, the amount of cash flows diverted from debt to equity investors per year of discretionary trading when the manager has bad incentives, I use the average annualized equity payouts conditional on a CLO's market-to-market equity value to be zero in the previous month. This amounts to 100 bps. I match firms' loan demand semi-elasticity δ^F to the slope coefficient from a regression of the monthly Excess Loan Premium from Saunders, Spina, Steffen, and Streitz (2021) on the logarithmic monthly institutional term loan issuance. This yields 70 bps, which implies that firms are willing to pay 35 bps per year more in spread when credit supply falls by 50%. This number is close to the 32 bps implied by the estimates of Diamond, Jiang, and Ma (2020) who also use syndicated loan data but a different methodology for their estimation. Firms financing demand in the leveraged loan market seems quite elastic, which is likely due to the fact that some of these firms can also tap the high yield bond market.

Given δ^F, I set R_0 such that the maximum possible issuance level (when the probability of default is zero and f is at its maximum) is 1. The level of R_0 directly affects the level of issuance but not its logarithmic change, which is solely defined by the elasticity of firm's financing demand and the change in the maximum achievable expected return from trading: $\Delta log(m_t^*) = \frac{1}{\delta^F}\Delta\left(G(\widetilde{\epsilon}_t^*)\alpha(f_t^*) - (1 - G(\widetilde{\epsilon}_t^*)) \cdot f_t^* \cdot \gamma\right)$. The risk-free rate r^f is set to 2%, the average 5 year treasury rate in the sample period. ρ, the share of income consumed by each manager, is $\frac{r^f}{1+r^f}$, which ensures that the expected net worth for newborn managers equals the net worth of the previous generation of managers.

I assume the equilibrium is initially in a *normal* state. This means, the initial volatility σ_0 is as implied by the average VIX in the sample period. I explain below how the volatility is backed out exactly. Further, I assume that the initial total (inside + outside) equity invested in CLOs, E_0, is 11.1%, which corresponds to the average equity ratio at origination (see Table 1). The inside equity ratio, i.e., managers' initial net worth N_0, is set to 7.77%, which I derive from the historical average management fees and equity payouts of CLOs from Cordell, Roberts, and Schwert (2021), and the assumption that managers retain half of the equity tranche.[42] The cost of equity issuance k is jointly determined with the alpha generated through trading. For the alpha function, I assume that $\alpha(f) = \alpha_0\left[-\frac{1}{2*\overline{f}}f^2 + f\right]$, which has a marginal alpha of zero at $\overline{f}$ and thus ensures that $f_t^* \leq \overline{f}$ in equilibrium, while being a differentiable function. $\overline{f}$ is set to 7.2, the length of the reinvestment period at the 90th percentile for CLOs at origination (1)). Given the maximum discretion, initial volatility, manager net worth, and CLO equity, I set the cost of equity issuance k and α_0 such that (1) the initial equity issuance is $\Delta E = E_0 - N_0 = 3.33\%$, and (2) the initial optimal discretion is 5 – the average length of the reinvestment period (see Table 1). The resulting α_0 implies an average alpha of 63.72 bps per unit of discretion (with discretion set to the maximum), which is higher than the estimated alpha of 11.78 bps per year of discretionary trading from Column (2) in Panel (B) of Table 5. This means that managers value the ability to trade beyond the alpha they can generate through trading, for instance

[42] Specifically, equity distributions and management fees together were historically on average 16.53% annually relative to the size of the equity tranche (Table III in Cordell, Roberts, and Schwert (2021)) and equity payouts were 9.88% (Table II in Cordell, Roberts, and Schwert (2021)). If managers retain half of the equity tranche, which they were required to under the risk retention rule that was in effect from 12/2016-02/2018 in the US, they obtain $\frac{0.5 \cdot 9.88\% + (16.53\% - 9.88\%)}{16.53\%} = 0.7\%$ of the total inside+outside equity distributions, which implies a net worth of $0.7\% \cdot 11.1\% = 7.77\%$.

because it allows them to achieve better diversification and thus bring their portfolio closer to the efficient frontier (even when there is no mispricing they can exploit). The estimated k implies a cost of equity issuance of 18.62% for the initial equity issuance, which is a bit higher compared to the literature's estimates of equity issuance costs for non-financial corporations (5%-10.7%) (see e.g., Hennessy and Whited (2007), Catherine, Chaney, Huang, Sraer, and Thesmar (2022)).

Shock calibration: Quantifying the contribution of agency problems to the cyclicality in CLO issuance requires that the model is shocked to the same extent as the data. For this, I use the change in expected volatility of loan returns and the decline in managers' net worth implied by a one standard deviation rise in the VIX. The main challenge is that the expected volatility of loan returns is not directly observable. While option implied expected volatility measures exist for the equity market (i.e., the VIX), they are not available for credit markets let alone the leveraged loan market. Thus, I use an indirect inference approach to back out the implied expected volatility from the reduced-form coefficient $\beta(\sigma)$ from the regression of CLO spreads on the remaining reinvestment period in Section 5. This coefficient is arguably independent of other explanations for the change in CLO financing costs over the credit cycle, and therefore allows me to isolate the contribution coming from agency frictions. Suppose, for instance, that adverse selection issues also contribute to a rise in CLOs' cost of debt in volatile periods as modeled by Moreira and Savov (2017). If one would back out the rise in expected volatility directly from the change in CLO credit spreads instead of indirectly from the change in the regression coefficient, one would falsely attribute any change in CLO credit spreads that is due to adverse selection issues to a change in volatility, and therefore overstate the effect coming from debt overhang problems. Inferring the change in volatility from the regression coefficient, instead, uses a moment that is unique to the agency friction channel modeled in this paper and thus robust to model misspecification.

I start by estimating the initial volatility, i.e. the volatility in *normal* times. Specifically, for each level of σ_i in a grid from 0 to 30%, I draw 300 levels of discretion between 0.8 and 4.9 (the 10th and 90th percentile in the spread panel, see Table 1) and random pricing errors, calculate for each draw the implied logarithmic spread, and regress it on the drawn level of discretion to obtain the regression coefficient $\beta(\sigma_i)$. Then, I select the initial volatility $\hat{\sigma}_0$ such that $\beta(\hat{\sigma}_0) = 4.34 + 0.94 \cdot (-0.05)$, the implied regression coefficient from Table 3 in

Section 5 for a level in the standardized VIX that corresponds to *normal* times (=-0.05), i.e., the average standardized VIX in the sample period.[43] Estimating the volatility following the shock, i.e., when the VIX is one standard deviation above the sample average, follows the same logic. It is set such that $\beta(\hat{\sigma}_1) = 4.34 + 0.94 \cdot (-0.05 + 1)$. Further details of this approach are documented in Appendix A6.

After solving for the equilibrium under the initial conditions, I simulate the model 300 times for 4 periods, where each simulation receives an impulse equivalent to a one standard deviation rise in the VIX in period 1. Specifically, the impulse is set such that the resulting losses to the intermediary are 1.19%, and thus 10.7% for the manager and outside equity investors. It is calibrated such that the latter matches the average relative fall in equity payouts following a one standard deviation rise in the VIX.[44] This is also similar to the losses implied by the rise in default rates. Global speculative default rates surge by 2.09 percentage points for a one standard deviation increase in the VIX, which implies losses of 1.04% if one assumes a standard 50% recovery rate for leveraged loans. ψ – which governs the effect of the shock on the volatility– is set such that the change in volatility from the initial period to the shock period matches the estimated rise in volatility (σ_1-σ_0). The persistence parameter of the volatility process, $\eta = 0.7$, set to match the AR(1) process parameters of the VIX. Following the common impulse in period 1, each simulation draws i.i.d. return shocks $\epsilon_t \sim N[0, 1]$. Allowing for shocks after the common impulse in period 1 follows the impulse response approach of other models in which the volatility of shocks is an important state variable (e.g., Alfaro, Bloom, and Lin (2021)).

10.2 Impulse Responses

Figure 13 plots the impulse responses of key variables in the data and the calibrated model following a shock equivalent to a one standard deviation rise in the VIX. The impulse responses in the data are estimated via Jordà (2005) local projections. Panel (A) reveals that agency frictions can explain a large part of the decline in CLO issuance in bad times. The

[43] The average standardized VIX is not 0 in the sample period from 2004Q1-2020Q4 because I standardize the VIX over its entire available period from 2004-2022 to make coefficients comparable across different sample periods.

[44] Equity payouts drop by 2.02 percentage points following a one standard deviation rise in the VIX and have an average value of 18.87% in normal times.

model implies an immediate decline in CLO issuance of 17%, which is about half of the maximum decline in the data of 32%.[45] The model implied fall in CLO issuance is entirely due to the amplification of the primitive shocks through agency frictions. Because the model assumes that both investors and managers are risk-neutral, the primitive shock to the volatility and net worth do not contribute to the fall in issuance. In practice, one would expected that even the primitive shock itself contributes to a decline in lending because managers and investors are risk-averse. The decline in CLO issuance that is not explained by the model can therefore be due to the primitive shock to volatility and net worth and/or other factors such as a rise in managers' or investors' sentiment, or adverse selection issues. Since investors in CLO bonds are also institutions – for instance banks, hedge funds, insurance companies and structured credit funds –, also financing frictions within those intermediaries might explain part of the remaining cyclicality in CLO issuance.

Panel (B) plots the the change in the discretion (i.e., the length of the reinvestment period) of newly issued CLOs following the shock. The model implies a shortening of the reinvestment period by about 0.96 years, which is quite close to the 0.83 year adjustment observed in the data. Thus, the model does a good job in matching this moment despite not being targeted in the calibration. This is a particularly strong achievement for the model because the change in discretion is a unique prediction of the proposed mechanism and very closely related to the change in issuance in the model.

Panel (C) shows the response of CLOs' cost of debt at origination to the impulse. The model implies a rise in the cost of debt by 17 bps, which is almost identical to the rise in financing costs of 20 bps in the data. This means that agency frictions account for almost the entire rise in financing costs of CLOs in volatile periods. Note, this change in financing costs is after the manager reoptimized the length of the reinvestment period.

Finally, the possibility to adjust managers' discretion greatly dampens the fall in issuance following a shock, in particular for large shocks. To illustrate this, I conduct a counter-factual analysis in which managers' discretion is always fixed at $f = f_0$ and the VIX rises by 4.7 standard deviations, as it did during the height of the GFC. Panel (D) plots the change in issuance for this counter-factual along with the change when the manager can optimally

[45] Note, the change in CLO issuance in the model is $\Delta log(m_{t+1}) = \frac{1}{\delta^F} \Delta \mathbb{E}[R^T_{t+1}]$, where $\Delta \mathbb{E}[R^T_{t+1}]$ is the change in the expected return from trading $\mathbb{E}[R^T] = G(\tilde{\epsilon}) \cdot \alpha(f) - (1 - G(\tilde{\epsilon}))f\gamma$. Due to firm's logarithmic loan demand function, the change in CLO issuance is scale invariant.

choose the level of discretion. If CLO managers were not able to adjust their discretion, the model implies that CLO issuance would fall by 104% (approximated through log changes), which is almost one-third more than the fall implied by the model with adjustable discretion (80%). This means that contractual adjustments that mitigate agency problems can dampen the cyclicality of CLOs substantially, in particular for very large shocks.

Figure 14 plots the responses in terms of loan issuance (Panel B) and primary market loan spreads (Panel A) for both the data and the model following a one standard deviation shock to the VIX. In the model, loan spreads rise because managers need a larger return from the underlying loans to compensate for the loss in expected return from trading in order to still invest in the equity of CLOs, and firms are willing to pay higher spreads to still receive financing for their best projects. In the calibrated model, loan spreads rise by 11 bps per year, which is a bit less than half of the 21-29 bps rise in primary market spreads observed in the data. The model implied rise in loan spreads is independent of changes in firm fundamentals because managers and investors are risk-averse, and entirely caused by the intensification of agency problems in bad times.

It is important to note that the general equilibrium adjustments of the model ignore any other investors in the institutional loan market because firms' demand elasticity is estimated for the entire leveraged loan market and not only for lending by CLOs. Firms' demand elasticity $\frac{1}{\delta^F}$ reflects firms' financing options outside the syndicated loan market. However, it does not reflect firms' alternative financing sources within the non-bank syndicated loan market. This could bias the results. If other non-bank lenders in the loan market are very stable and step in to substitute for CLOs' credit supply reduction, then loan spreads should not adjust as much as assumed which would bias the model implied fall in CLO issuance towards zero. In contrast, if other lenders are even more cyclical than CLOs then loan spreads would increase by more than what is implied by CLOs' credit supply contraction. Therefore, the model implied fall in CLO issuance would be too large. In practice, this bias is very small given that CLOs hold more than half of non-bank loans and are by far the largest investor in this market. Consistent with this, CLO and leveraged loan issuance closely follow each other – as shown in Panel (B) of Figure 14, suggesting that using the elasticity with respect to total leveraged loans instead of only those provided by CLOs does not impact the results significantly.

11 Conclusion

In this paper, I show that agency frictions can explain about half of the decline in lending by CLOs during crises. For this, I exploit an institutional feature that leads to variation in agency frictions across CLO, and the fact that CLO debt prices reflect the extent of the debt overhang problem. To quantify the effect on CLO issuance, I match a model of intermediaries with agency frictions to the reduced-form estimates. In a counter-factual exercise I show that CLO issuance would be more cyclical if managers were not able to adjust CLO contracts to mitigate agency problems. This demonstrates that covenants and other contract features can substantially dampen the credit cycle.

While this study focuses on CLOs because they provide rich data and an institutional setting that can be exploited for empirical analyses, the proposed mechanism relies on features – namely long-term funding and potentially diverting interests between the manager and investors – that might also present in other types of actively managed closed-end funds (e.g., venture capital funds, private equity funds, private debt funds, hedge funds, closed-end mutual funds).

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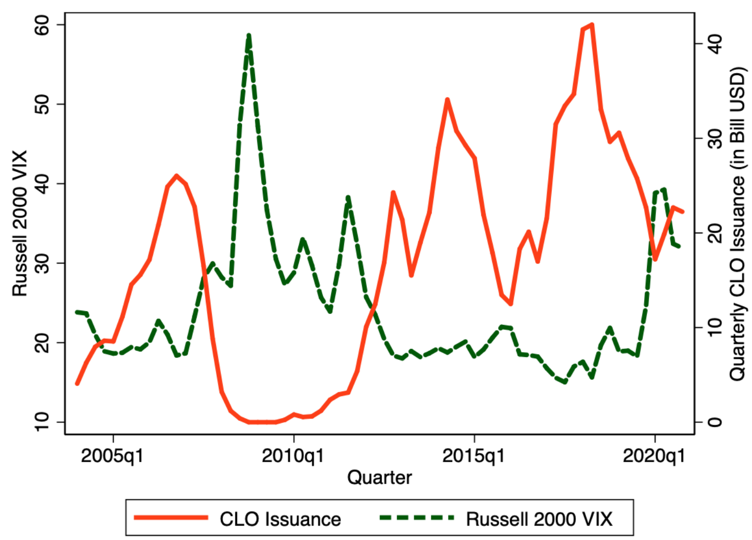
Figures

Figure 1: CLO Issuance

This figure plots the quarterly issuance of new CLOs that invest primarily in US broadly syndicated loans (in red) from 2004Q1 to 2020Q4, along with the Cboe Russell 2000 Volatility Index (VIX) (in green) in Panel (A), and the US annual speculative grade corporate default rate (in green) in Panel (B). CLO issuance is the sum of the notional value of all CLO tranches with pricing date in a given quarter. If the pricing date is missing, I use the closing date. The unit is in billion USD. The VIX is a measure of the expected volatility of the Russell 2000 index and is available on FRED. To construct the quarterly series I take the simple average of the daily VIX. I smooth both series by taking the average of the current and next quarter. The graph is almost identical when exlcuding refinancings and resets from CLO isssuance (Figure A2 in Appendix A4.1). The US annual speculative corporate default rate comes from S&P.

Panel A - CLO Issuance and Volatility



Panel B - CLO Issuance and Loan Defaults

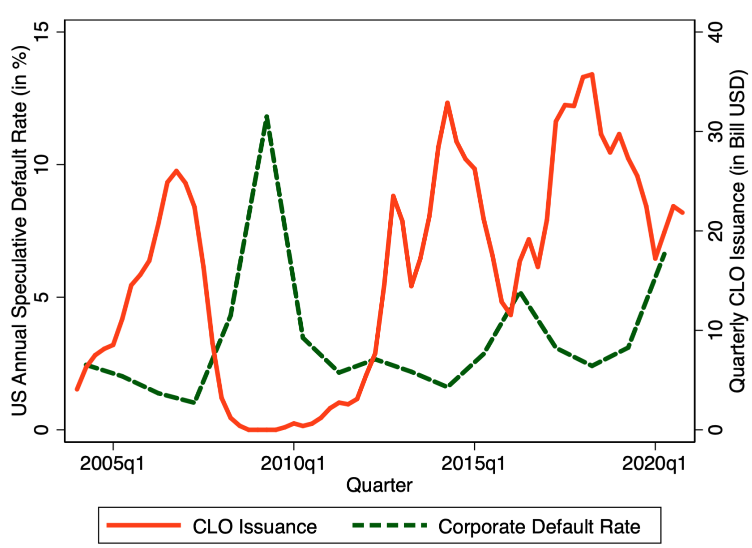


Figure 2: CLO Life Cycle

Figure 3: Equity Payouts by Marked-to-Market Equity Ratio

This figures plots the average quarterly equity payout across CLOs sorted by their marked-to-market equity ratio in the previous month. Equity payouts are defined as total payouts to the equity tranche relative to the CLO size (i.e., the sum of notional values of the CLO's outstanding tranches), in basispoints. The marked-to-market equity ratio is defined as the total market value of assets minus the face value of outstanding debt tranches, divided by the total market value of assets. The market value of assets is calculated as the market value of all loans held by a CLO plus cash holdings which are assumed to be 3% of the notional CLO size.

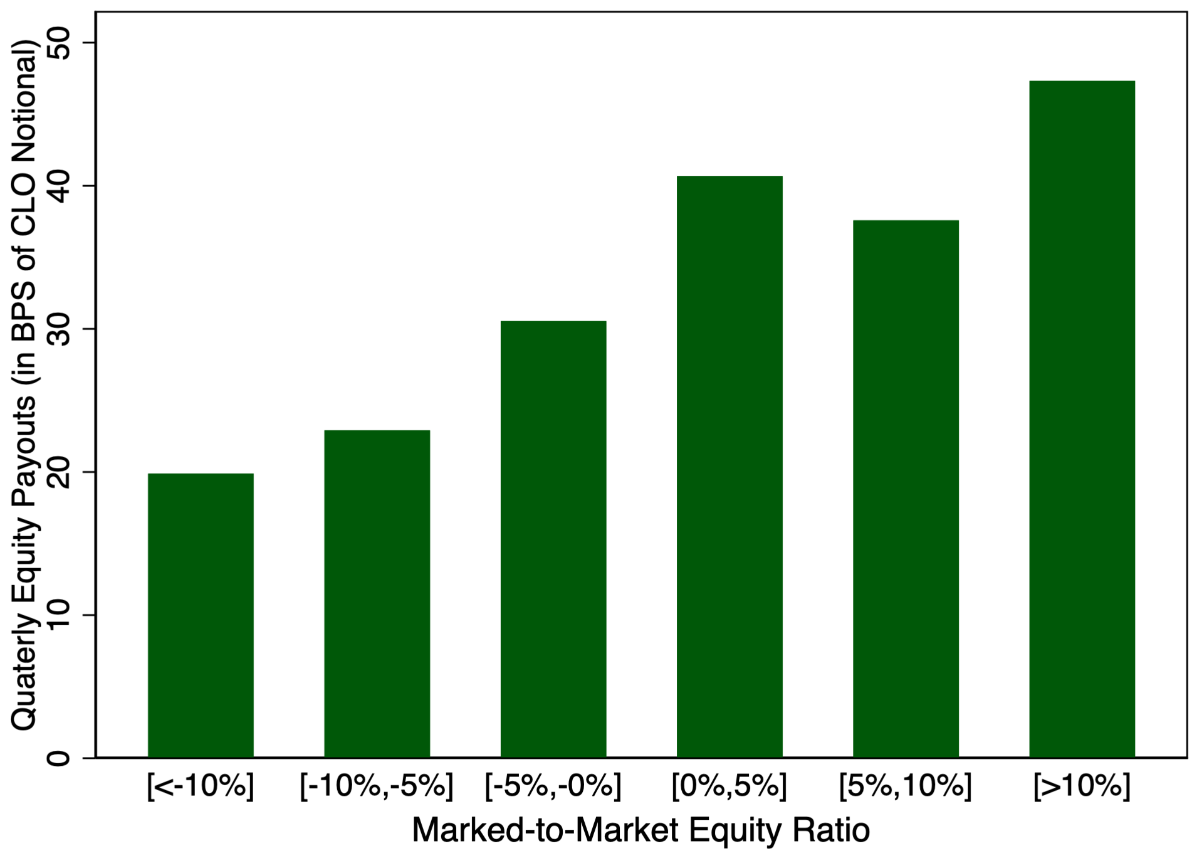
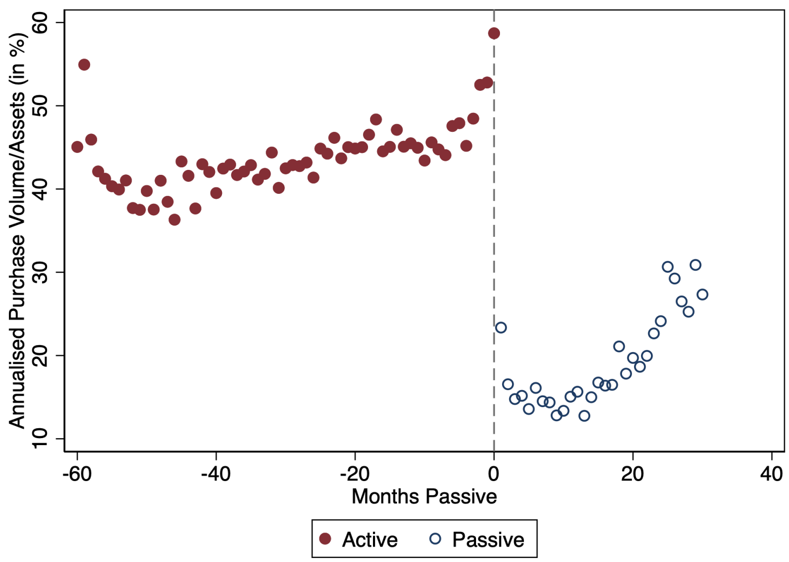


Figure 4: Loan Trading Volume over CLO Life Cycle

This figures plots the average volume of loan purchases (Panel (A)) and sales (Panel (B)) by CLOs. Each dot represents the average transaction volume of all CLO × month observations with a given distance (in months) to the end of the reinvestment period. Volumes in percent of the CLO size (=notional value of all outstanding tranches of this CLO) in that month, and mulptiplied by 12 to annualize. "Active" indicates CLOs during their reinvestment period and "Passive" indicates CLOs outside their reinvestment period. CLO × month observations that fall within the first six months after the CLO's pricing date or within the last five months the CLO is in the dataset are dropped. This ensures that initial loan purchases and portfolio wind-downs after a CLO is called are excluded, and results are based only on trading. To ensure sufficient observations per bin, it only plots volumes for CLOs that are within -60 to +30 months of the end of the reinvestment period. The sample period is from 2008/10 to 2020/12.

Panel A - Purchase Volume



Panel B - Sales Volume

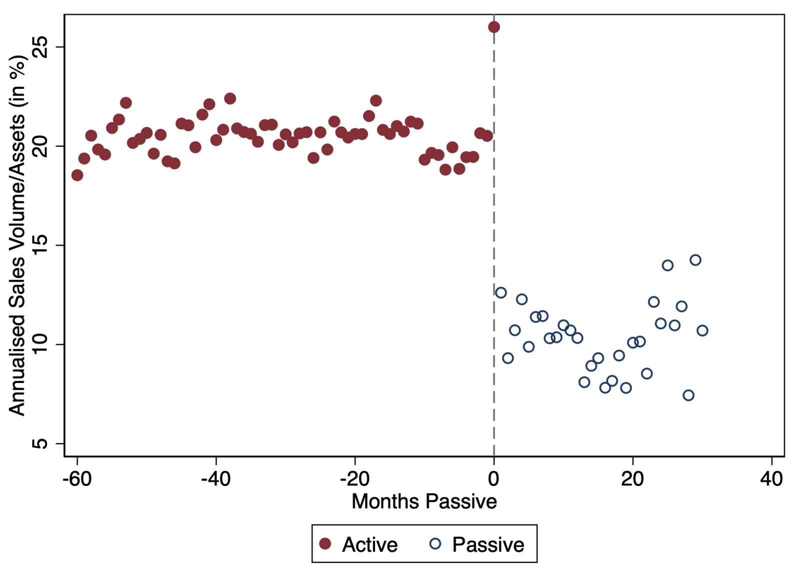


Figure 5: Manager Discretion and CLO cost of debt

This figures plots the relationship between the logarithmic secondary market spread on CLO debt and the remaining years in the CLO's reinvestment period. Both variables are residualized with manager × month × seniority fixed effects, the current tranche level subordination (=market value assets minus face value of all at least as senior tranches, divided by the market value assets), the weighted average maturity of loans in the portfolio, the weighted average spread of loans in the portfolio, the weighted average rating factor of loans in the portfolio, the share of CCC rated loans in the portfolio, the expected remaining maturity, the months since origination, and a dummy that indicates whether the CLO is callable. The spread is measured in basis points. The sample period is from 2012/04 to 2020/12.

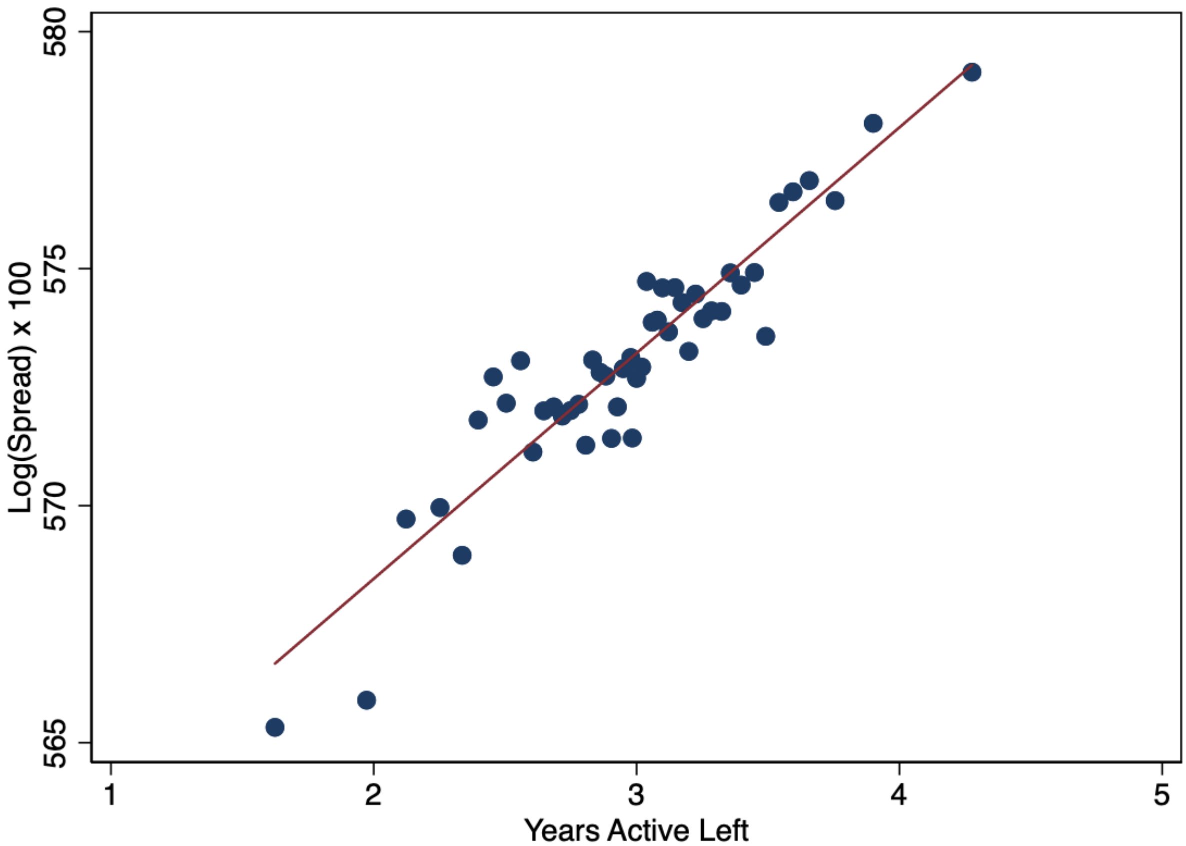
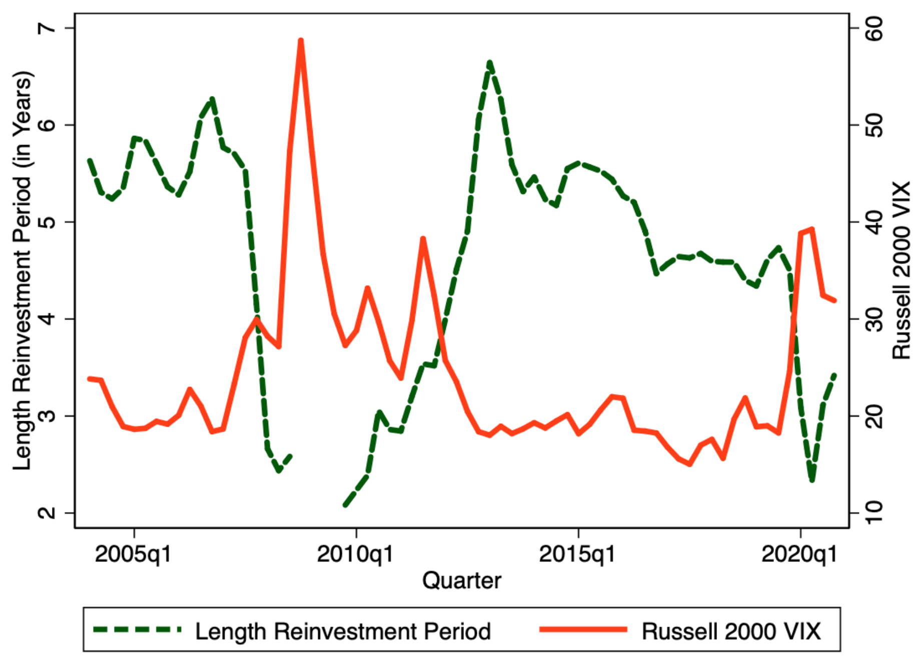


Figure 6: Time-series: Length of the Reinvestment Period of Newly Originated CLOs

This figures plots the weighted average length of the reinvestment period of newly issued CLOs (in green), along with the Cboe Russell 2000 Volatility Index (VIX) (in red) (Panel (A)) and total CLO issuance (in red) (Panel (B)) from 2005Q1 to 2020Q4. The length of the reinvestment period is defined as the time between the pricing date and the reinvestment date, measured in years. The VIX and CLO issuance are defined as described in Figure 1.

Panel A - Length Reinvestment Period of Newly Originated CLOs and the VIX



Panel B - Length Reinvestment Period of Newly Originated CLOs and CLO Issuance

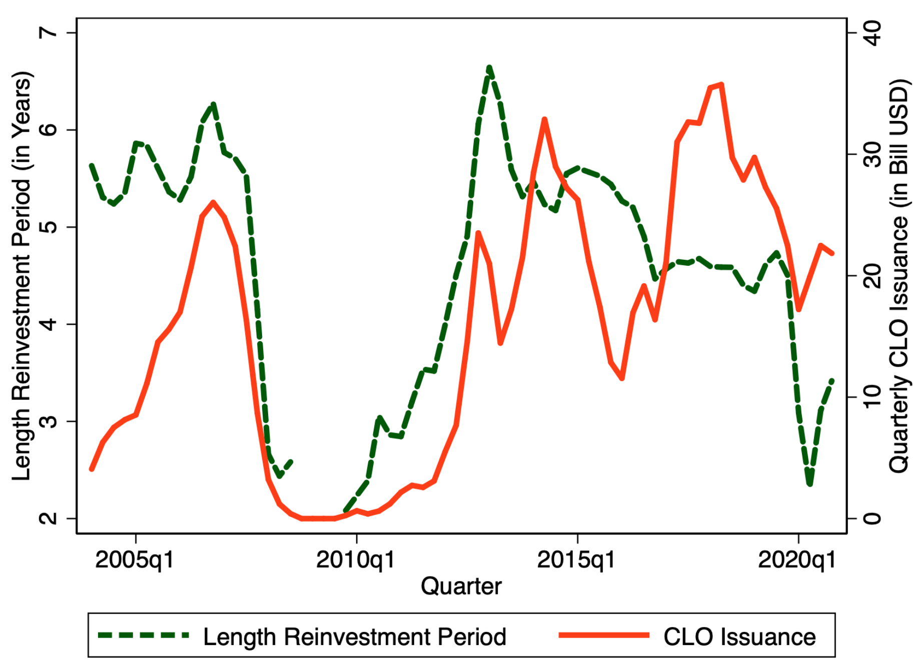
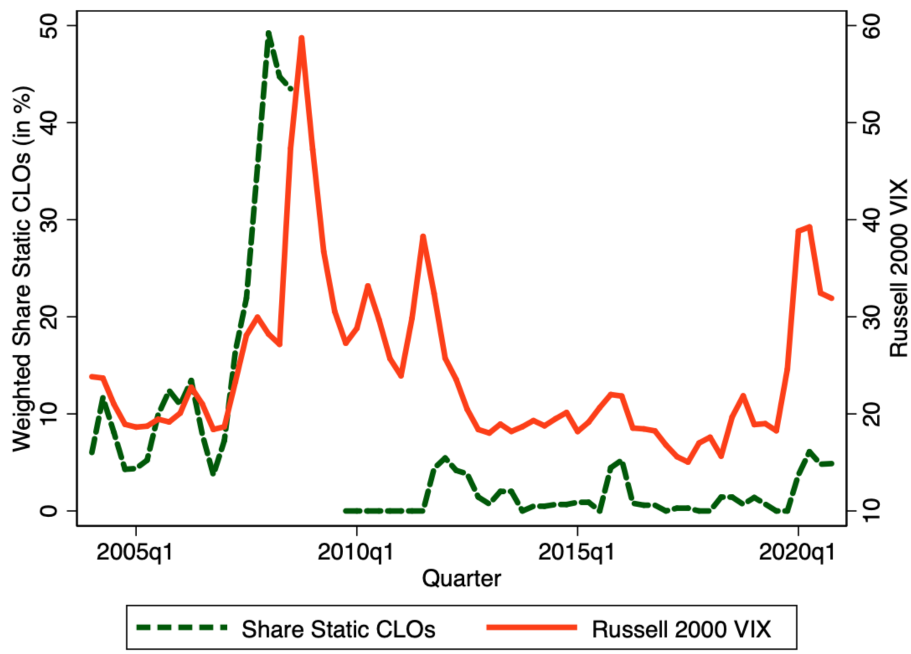


Figure 7: Time-series: Share of Static CLOs Among Newly Originated CLOs

This figures plots the weighted share of newly issued CLOs that are static (in green), along with the Cboe Russell 2000 Volatility Index (VIX) (in red) (Panel (A)) and total CLO issuance (in red) (Panel (B)) from 2005Q1 to 2020Q4. Static CLOs are defined as having no reinvestment period. The VIX and CLO issuance are defined as described in Figure 1.

Panel A - Share Static CLOs and VIX



Panel B - Share Static CLOs and CLO Issuance

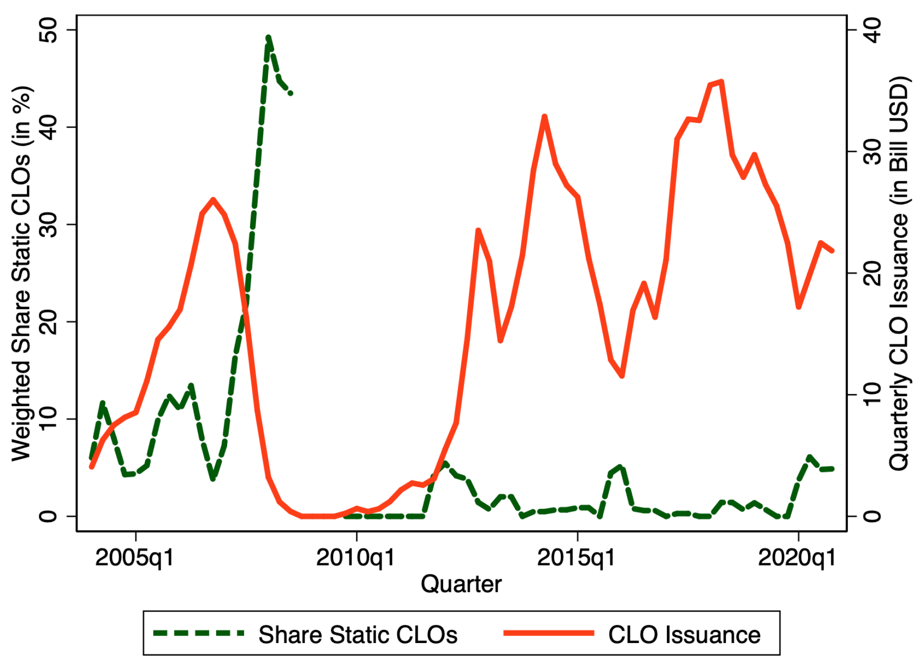


Figure 8: Time-series: Junior OC Test Threshold of Newly Originated CLOs

This figures plots the weighted average junior overcollaterlization (OC) test threshold of newly issued CLOs (in green), along with the Cboe Russell 2000 Volatility Index (VIX) (in red) from 2005Q1 to 2020Q4. I define the Junior OC threshold as the minimal original threshold of all OC tests of a CLO. While the OC thresholds of all tranches are set such that the most junior tranche fails the test first, the most junior tranche has usually the lowest threshold because the OC test of a given tranche relates the asset value to the face value of all equal and more senior tranches. Hence, the denominator is the largest for the most junior tranche. The VIX is defined as described in Figure 1.

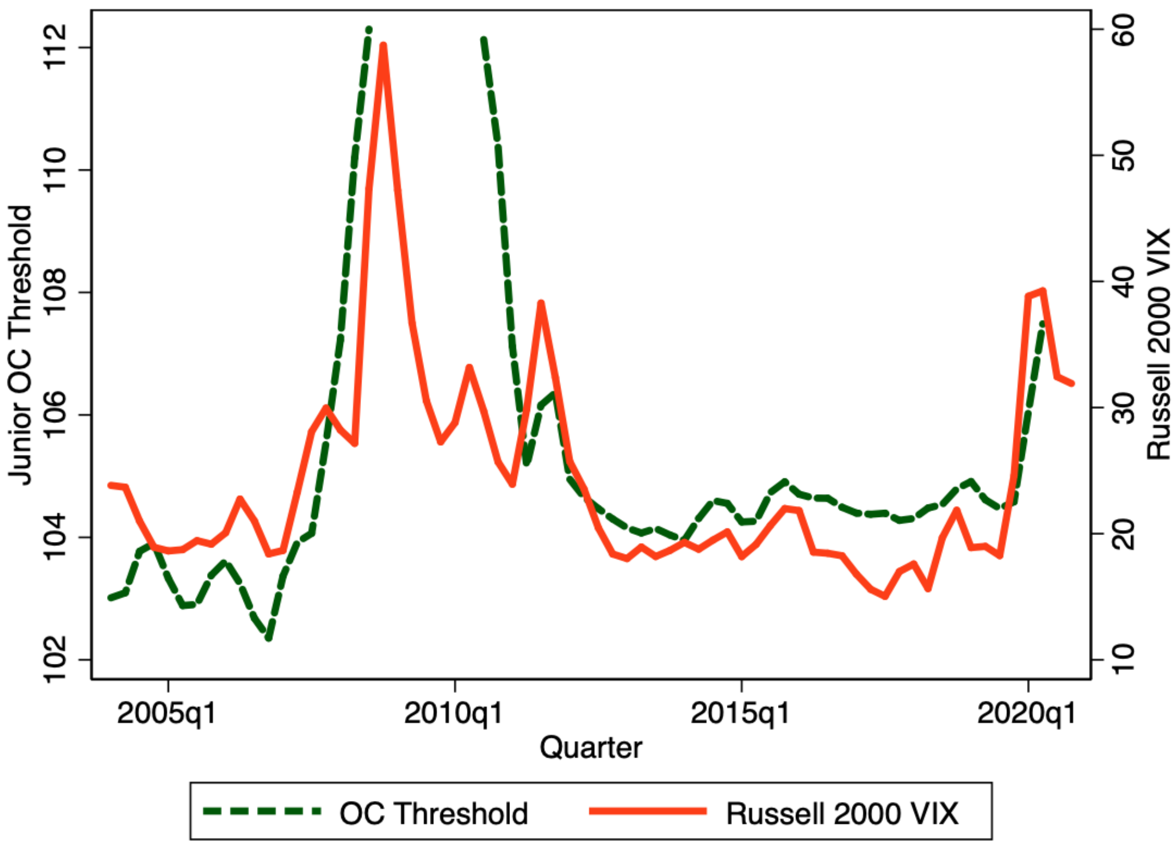


Figure 9: Monthly Trading Return

This figures plots the average risk-adjusted return of 50 equal sized bins of CLO $\times$ month observations sorted by their distance to the end of the reinvestment period. The risk-adjusted return is the trading return as described in Appendix A3.2 after residualizing with the weigted average rating factor of the long-short trading portfolio and manager $\times$ month fixed effects, and addding back the sample mean. "Active" indicates CLOs during their reinvestment period and "Passive" indicates CLOs outside their reinvestment period. CLO $\times$ month observations that fall within the first six months after the CLO's pricing date or within the last six months the CLO is in the dataset are dropped. This ensures that initial loan purchases and portfolio wind-downs after a CLO is called are excluded, and results are based only on trading. To ensure sufficient observations per bin, it only plots volumes for CLOs that are within -60 to +30 months of the end of the reinvestment period. The sample period is from 2008/10 to 2020/12.

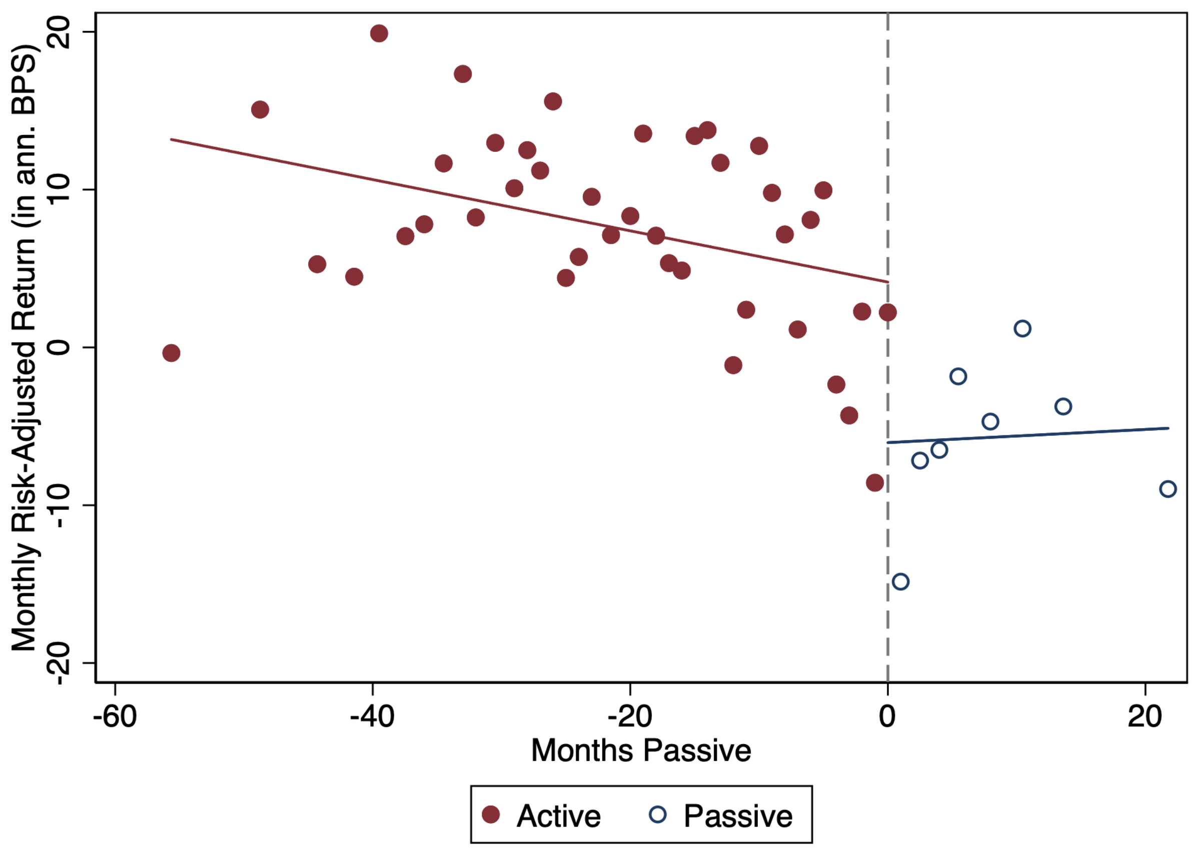


Figure 10: Time-series: Weighted Average Maturity of Loan Portfolio of Newly Originated CLOs

This figures plots the weighted average maturity of the loan portfolio at origination (red) along with the length of the reinvestment period of newly issued CLOs from 2005Q1 to 2020Q4. The weighted average maturity of the loan portfolio at origination is defined as a CLO's first observable result of the weighted average life test after origination. The length of the reinvestment period is defined as the time between the pricing date and the reinvestment date.

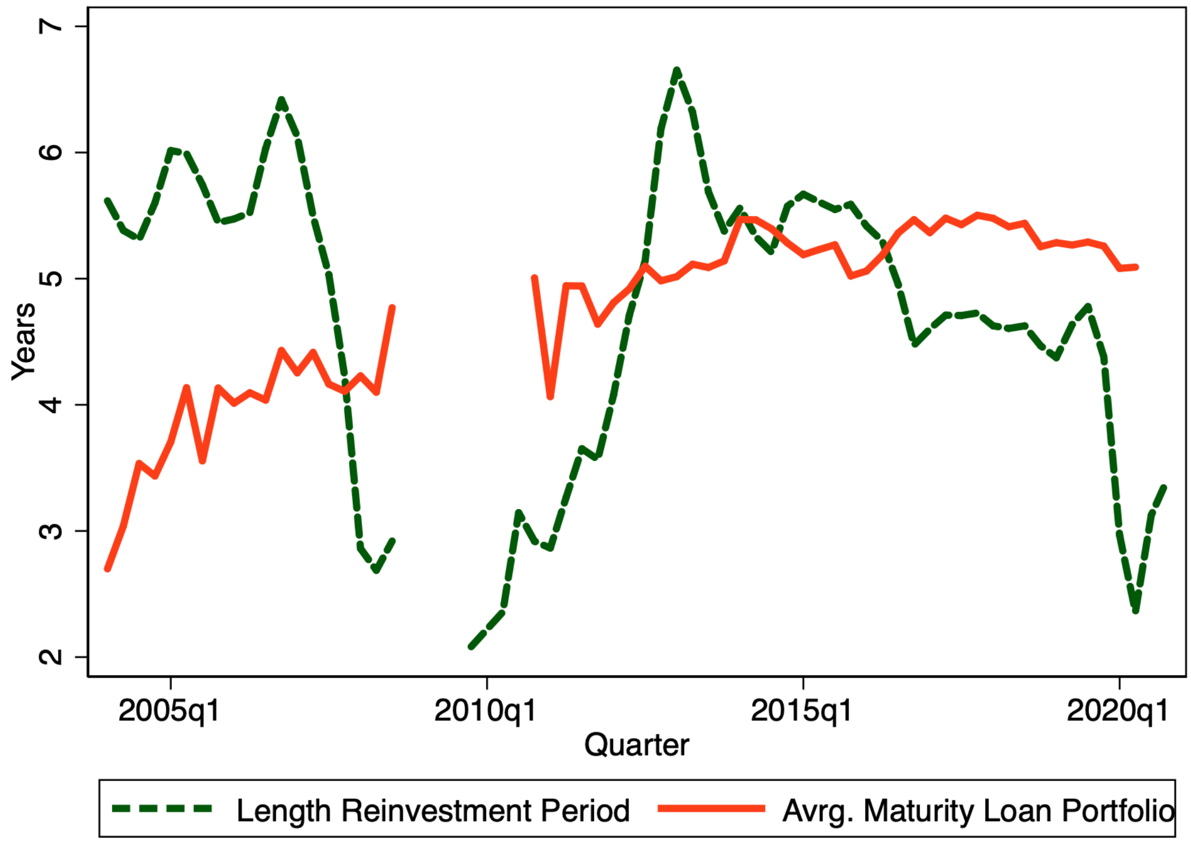


Figure 11: Time-series of Equity Payouts

This figures plots the quarterly average annualised equity payouts in percent of the notional size of the equity tranche of all outstanding CLOs from 2005Q1 to 2020Q4.

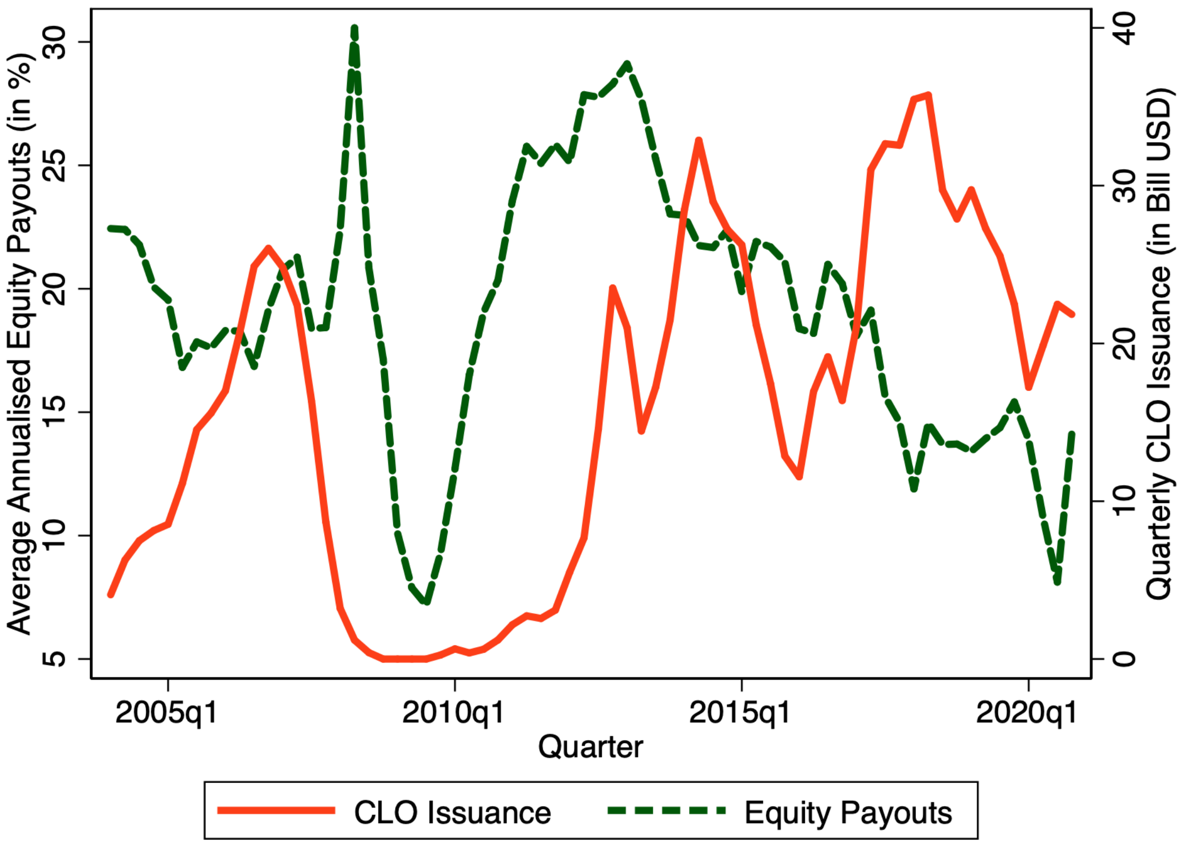
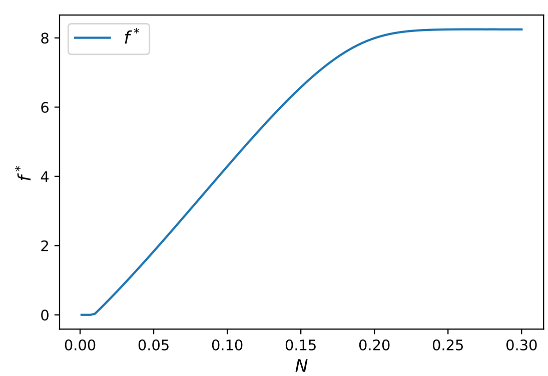


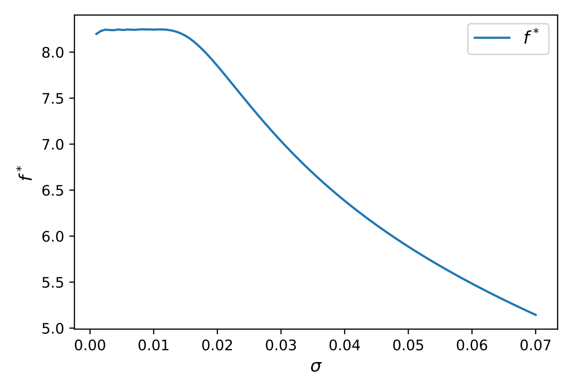
Figure 12: Relationship Between Endogenous Variables and State Variables in Theoretical Model

This figures plots optimal discretion and issuance depending on the manager's net worth and the volatility of returns for a numerical example. The parameters are calibrated as in Table 7 but with initial net worth of 20% and no equity issuance. Further, I assume that return shocks are distributed according to a standard normal distribution: $\epsilon \sim N(0, 1)$

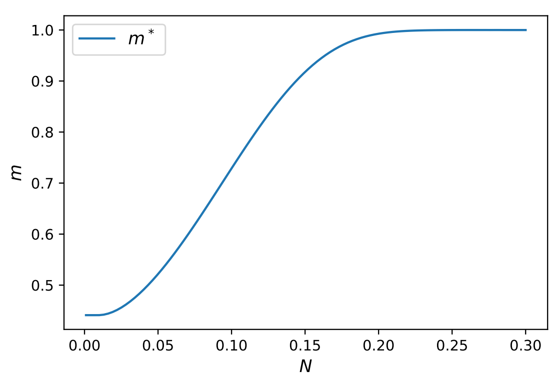
(A) Discretion by Manager Net Worth



(B) Discretion by Return Volatility



(C) Issuance by Manager Net Worth



(D) Issuance by Return Volatility

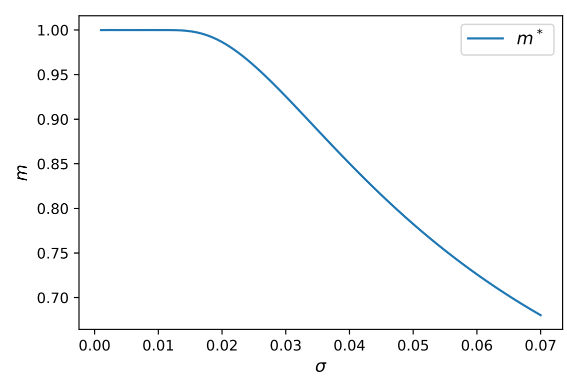


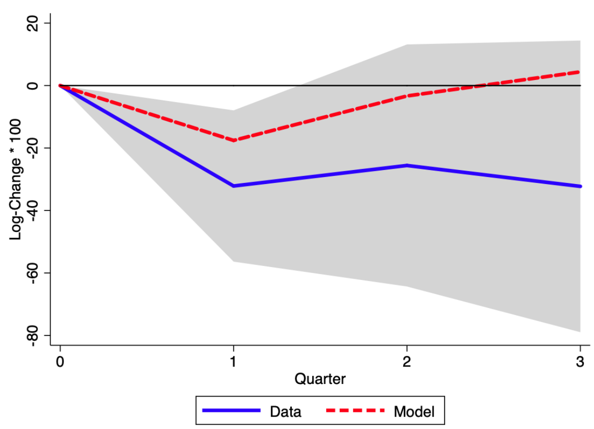
Figure 13: Impulse Responses to 1 SD Increase in VIX: Calibrated Model versus Data

This figures plots impulse responses over 3 quarters following a shock of 1 standard deviation increase in the Cboe Russell 2000 Volatility Index (VIX) in period 1. The red dashed line plots the average evolution of the variables as implied by the calibrated model with flexible discretion, except for Panel (C) which plots the median to mitigate the effect of outliers, following the common shock in period 1 across all simulations. The blue lines are the estimates from Jordà (2005) local projections with 2 lags. Specifically, it plots for each period $h \in 0, 2, ..., 3$ after the shock, the coefficient β^0_h from the following regression:

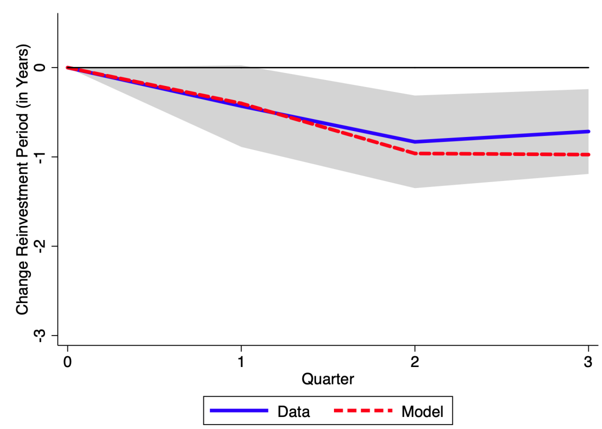
$$Y_{t,t+h} = \alpha_h + \beta_{0,h} VIX_t + \beta_{1,h} VIX_{t-1} + \delta_{1,h} Y_{t,t-1} + \delta_{2,h} Y_{t,t-2} + \epsilon,$$

where Y is the logarithmic issuance of CLOs in billion USD (Panel A), the length of the reinvestment period of newly issued CLOs (Panel B), and CLOs' average primary market cost of debt (Panel C). VIX is standardized across the entire sample from 2004-2022. The grey area represents the 95% confidence interval around the estimates based on Newey and West (1987) standard errors. The black dashed line in Panel (D) plots the impulse response as implied by the calibrated model with discretion fixed at $\overline{f}$ and following 4.7 deviation shock to the VIX.

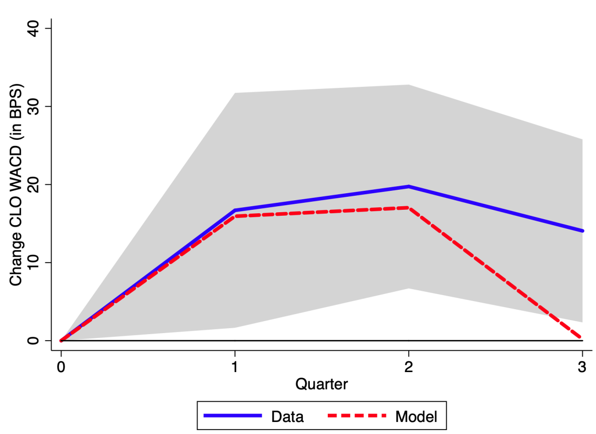
(A) Change in CLO Issuance



(B) Change in Discretion of New CLOs



(C) Change in Primary Market CLO Cost of Debt



(D) Change in CLO Issuance with Fixed Discr.

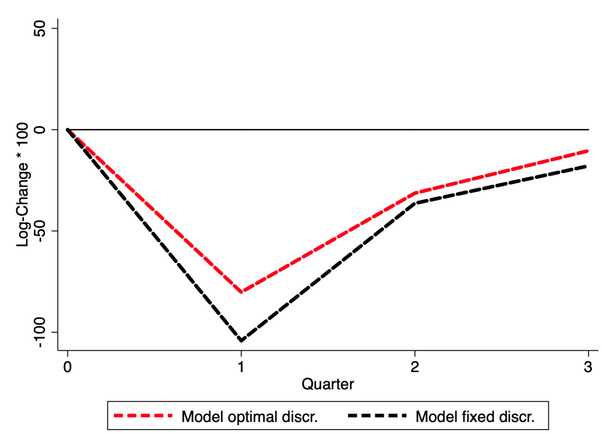


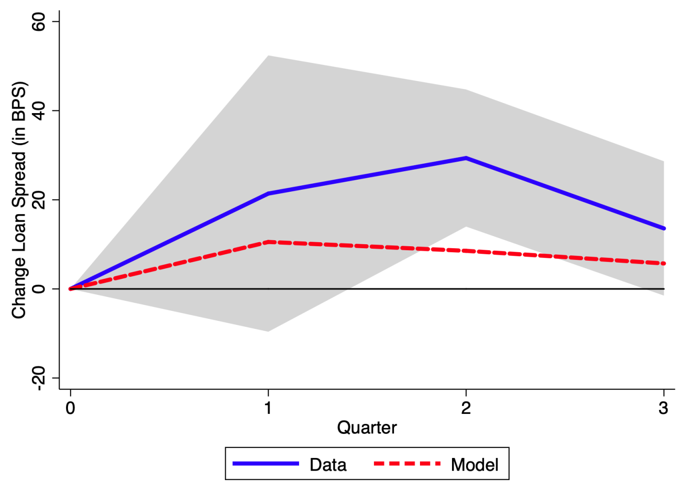
Figure 14: Impulse Response of Loan Spreads and Issuance Volume to 1 SD Increase in VIX

This figures plots impulse responses over 3 quarters following a shock of 1 standard deviation increase in the Cboe Russell 2000 Volatility Index (VIX) in period 1. The red dashed line plots the evolution of the variables as implied by the calibrated model with flexible discretion. The blue line are the estimates from Jordà (2005) local projections with 2 lags. Specifically, it plots for each period $h \in 0, 2, ..., 3$ after the shock, the coefficient β_h^0 from the following regression:

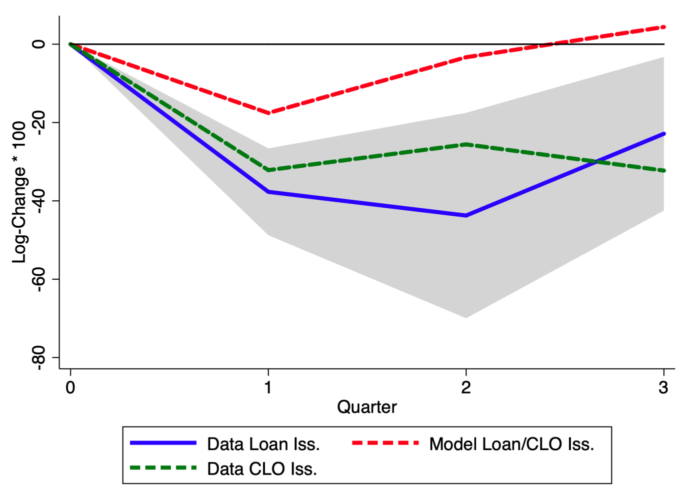
$$Y_{t,t+h} = \alpha_h + \beta_{0,h} VIX_t + \beta_{1,h} VIX_{t-1} + \delta_{1,h} Y_{t,t-1} + \delta_{2,h} Y_{t,t-2} + \epsilon,$$

where Y is the primary market loan spread (Panel A), the primary market loan issuance in the case of the blue line in Panel (B) and CLO issuance for the green dashed line in Panel (B). The grey area represents the 95% confidence interval around the estimates. Leveraged loan issuance are all new originations of institutional term loans (i.e., term loan B-K) that are syndicated in the US, not issued by financial firms (SIC codes 6000-6799, and included in LoanConnector DealScan. Primary Market Loan Spread is the weighted average quarterly loan spread of the same sample of loans. VIX is standardized across the entire sample from 2004-2022. The grey area represents the 95% confidence interval around the estimates based on Newey and West (1987) standard errors.

Panel A - Primary Market Loan Spread



Panel B - Loan Issuance Volume



Tables

Table 1: Summary Statistics

The table reports summary statistics for the main variables. Panel (A) contains variables at origination, Panel (B) includes variables from the *Trading Panel* on which the analysis of CLOs trading is based, and Panel (C) reports summary statistics for variables from the *Spread Panel* on which the analysis of CLOs' secondary market spreads is based. *Static CLO* indicates whether a CLO has no reinvestment period, *Weighted Average Life* is the average maturity of the loan portfolio at origination, and *Realized Maturity* is the time from origination until the CLO disappears from the Creditflux database. *Sales Volume* and *Purchase Volume* are monthly transaction volumes annualised and in percent of the notional CLO size. *Trading Return* is the annualised return of a long-short portfolio that is long in all loans bought and short in all loans sold by a CLO in a given month for three months. More details on the construction of the variable are provided in Appendix A3.2. *Wght. Average Rating Factor* is the weighted average rating factor as defined by Moody's of the long-short portfolio. *MtM Equity Ratio = 0* is a dummy variable that indicates whether the market value of a CLO's loan holdings plus 3% cash holdings are larger than the notional value of outstanding debt. *Active* indicates CLOs that are within their reinvestment period. *Expected Remaining Maturity* is calculated based on the assumption that maturing loans are reinvested in loans with 5 year maturity, and after the reinvestment period CLOs are called once 50% of the most senior tranche is repaid. *Subordination* is defined on the tranche level as the market value of a CLO's loan holdings plus 3% cash holdings minus the notional value of all debt tranches at least as senior, divided by the market value of loan holdings plus 3% cash holdings.

Panel A -Origination

	Mean	P10	Median	P90	Std. dev.
CLO Size (in Mil. USD)	492	322	464	666	186
Weighted Average Cost of Debt (in BPS)	167	50	185	225	71
Length Reinvestment Period (in Years)	4.9	2.9	5.1	7.2	2.1
Static CLO	4.6	0.0	0.0	0.0	20.9
Equity Ratio (in %)	11.1	7.6	9.3	12.8	9.1
Weighted Average Life (in Years)	5.0	3.9	5.2	5.7	0.8
Junior OC Threshold	104.2	101.8	104.2	105.5	1.9
Legal Maturity (in Years)	12.7	10.9	12.2	15.2	4.2
Realized Maturity (in Years)	6.5	1.2	6.8	10.4	3.5
Observations	2328				

Summary Statistics - Continued

Panel B - Trading Panel

	Mean	P10	Median	P90	Std. dev.
Sales Volume/CLO Size (in %)	19.2	0.0	13.3	44.8	21.1
Purchase Volume/CLO Size (in %)	39.9	2.9	33.9	79.8	33.9
Trading Return (Annualises BPS)	1.3	-95.0	7.0	104.7	131.9
Wght. Average Rating Factor Trades	-7.4	-42.1	-2.0	21.7	35.6
MtM Equity Ratio = 0	0.1	0.0	0.0	1.0	0.3
Quaterly Equity Payouts/CLO Size (in BPS)	41.0	14.9	37.9	70.1	24.0
Active	0.9	0.0	1.0	1.0	0.3
Observations	58877				

Panel C -Spread Panel

	Mean	P10	Median	P90	Std. dev.
Spread (in BPS)	421	121	285	891	353
Log(Spread)	5.7	4.8	5.7	6.8	0.8
Years Active Left (in Years)	3.0	0.8	2.9	4.9	1.7
Standardized Russell 2000 VIX	-0.2	-1.0	-0.5	1.2	1.0
MtM Equity Ratio (in %)	6.3	1.7	6.6	10.1	4.5
Expected Remaining Maturity (in Years)	5.2	4.1	4.9	6.3	1.2
Subordination (in %)	21.7	7.5	19.4	38.1	12.3
Wght. Average Life (in Years)	4.9	4.5	4.9	5.3	0.3
Wght. Average Loan Spread (in BPS)	366	328	355	421	42
Wght. Average Rating Factor	2884	2667	2863	3244	351
CCC Share (in %)	6.9	2.7	6.2	12.0	3.7
Time Since Origination (in Years)	2.9	0.8	2.6	5.7	1.8
Callable	0.3	0.0	0.0	1.0	0.5
Observations	9795				

Table 2: Effect of Discretion on CLOs' cost of debt

This table reports results on the effect of the remaining time of discretionary trading on the spread of deb tranches on the secondary market. The unit of observation is a CLO Tranche × Month pair. The results are from the regression as defined by Equation 1. *Log*(*Spread*) is the secondary market spread of a CLO tranche in a given month as defined in Appendix A3.1. *Years Active Left* is the remaining time in the reinvestment period in years. The controls include the current tranche level subordination (=market value assets minus face value of all equally or more senior tranches), the weighted average maturity of loans in portfolio, the weighted average spread of loans in the portfolio, the weighted average rating factor of loans in the portfolio, the share of CCC rated loans in the portfolio, the expected remaining maturity, the months since origination (not identified in Column (3)), and a dummy that indicates whether the CLO is callable. Standard errors are clustered on the month and CLO level. Significance levels: *(p<0.10), **(p<0.05), ***(p<0.01).

	Log(Spread) × 100		
	(1)	(2)	(3)
Years Active Left	7.74***	4.76***	3.44***
	(1.06)	(0.73)	(1.28)
Controls	Y	Y	Y
Tranche FE	N	N	Y
Manager x Month x Seniority FE	N	Y	Y
Obs.	9,795	5,231	3,199
Within R^2	0.840	0.086	0.031

Table 3: Effect of Discretion on CLOs' cost of debt: Heterogeneity wrt. Equity Ratio and Volatility

This table reports results on the effect of the remaining time of discretionary trading on the spread of deb tranches on the secondary market for different values in the Cboe Russell 2000 Volatility Index (VIX) and the marked-to-market equity ratio. The unit of observation is a CLO Tranche $\times$ Month pair. The results are from the regression as defined by Equation 1 plus the interaction of *Years Active Left* with the VIX and the marked-to-market equity ratio. *Log(Spread)* is the secondary market spread of a CLO tranche in a given month as defined in Appendix A3.1. *Years Active Left* is the remaining time in the reinvestment period in years. *MtM Equity ratio* is defined as the total market value of assets minus the face value of outstanding debt tranches, divided by the total market value of assets of a CLO in a given month. The market value of assets is calculated as the market value of all loans held by a CLO plus cash holdings which are assumed to be 3% of the notional CLO size. The VIX is standardized over the entire period from 2004 to 2022 to allow for comparison across different samples. The controls include the current tranche level subordination (=market value assets minus face value of all equally or more senior tranches), the weighted average maturity of loans in portfolio, the weighted average spread of loans in the portfolio, the weighted average rating factor of loans in the portfolio, the share of CCC rated loans in the portfolio, the expected remaining maturity interacted with the VIX, and a dummy that indicates whether the CLO is callable. Standard errors are clustered on the month and CLO level. Significance levels: *(p<0.10), **(p<0.05), ***(p<0.01).

	Log(Spread) × 100		
	(1)	(2)	(3)
Years Active Left	3.83***	4.32***	4.34***
	(1.22)	(1.22)	(1.23)
Years Active Left × R2000 VIX	1.11**		0.94*
	(0.52)		(0.53)
MtM Equity Ratio		23.97	15.88
		(20.72)	(17.08)
Years Active Left × MtM Equity Ratio		−14.38**	−9.49*
		(7.02)	(5.03)
Controls	Y	Y	Y
Tranche FE	Y	Y	Y
Manager x Month x Seniority FE	Y	Y	Y
Obs.	3,199	3,199	3,199
Within R^2	0.037	0.035	0.038

Table 4: Contractual Adjustments over the Credit Cycle

This table reports results from the regression of the length of the reinvestment period (Columns (1)-(4)), a vaiable that is 100 if a CLO is static and 0 otherwise (Columns (5)+(6)), and the junior OC test threshold (Columns (7)+(8)), respectively, on the Cboe Russell 2000 Volatility Index (VIX) in the month before origination. The unit of observation is a CLO. The VIX is standardized over its entire time-series from 2004-2022. The length of the reinvestment period is measured in years. The junior OC test threshold is measured in percent. Standard errors are clustered on the month and manager level. Significance levels: *(p<0.10), **(p<0.05), ***(p<0.01).

	Length Reinvestment Period				Prob(Static)		OC Threshold	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R2000 VIX$_{t-1}$	−0.84***	−0.85***	−0.76***	−0.77***	2.70***	2.83***	0.75***	0.75***
	(0.09)	(0.08)	(0.12)	(0.10)	(0.97)	(0.87)	(0.15)	(0.14)
Intensive Margin	N	N	Y	Y	N	N	N	N
Manager FE	N	Y	N	Y	N	Y	N	Y
Obs.	2,255	2,213	2,167	2,133	2,255	2,213	1,886	1,860
R^2	0.073	0.249	0.073	0.237	0.008	0.161	0.043	0.314

Table 5: Risk-adjusted Return from Trading

This table reports the risk-adjusted return from trading of CLOs within and outside their reinvestment period (Panel A) and for active CLOs depending on their equity ratio (Panel B). The unit of observation is a CLO × Month pair. The results are from the regression as defined by Equation 2. *Return*$^{t \mapsto t+3}$ is the return over the following three months of a long-short portfolio that goes in long in all loans bought and short in all loans sold by a CLO in a given month. The construction of this variable is further detailed in Appendix A3.1. *Avrg. Rating* is the weighted average rating of the same long-short portfolio in the trading month. *Active* indicates whether a CLO is within its reinvestment period in a given month. *MtM Equity ratio = 0* indicates whether a CLO currently has a marked-to-market equity ratio that is zero. The marked-to-market equity ratio is defined as the total market value of assets minus the face value of outstanding debt tranches, divided by the total market value of assets. The market value of assets is calculated as the market value of all loans held by a CLO plus cash holdings which are assumed to be 3% of the notional CLO size. Standard errors are clustered on the CLO and month level. Significance levels: *(p<0.10), **(p<0.05), ***(p<0.01).

Panel A - Active vs Passive CLOs

	Return$^{t \mapsto t+3}$ (in BPS)			
	(1)	(2)	(3)	(4)
Avrg. Rating	0.66***	0.67***	0.53***	0.49***
	(0.13)	(0.13)	(0.11)	(0.10)
Active	11.24***	34.22***	21.68***	14.33***
	(3.40)	(5.14)	(3.38)	(4.47)
Constant	−2.28			
	(2.57)			
CLO FE	N	Y	N	Y
Year-Month x Manager FE	N	N	Y	Y
Obs.	43,395	43,330	40,422	40,348
R^2	0.023	0.084	0.546	0.575

Risk-adjusted Return from Trading - Continued

Panel B - Heterogeneity with respect to Equity Ratio

	Return$^{t \mapsto t+3}$ (in BPS)				
	(1)	(2)	(3)	(4)	(5)
Avrg. Rating	0.64***	0.61***	0.61***	0.49***	0.45***
	(0.13)	(0.12)	(0.12)	(0.11)	(0.11)
MtM Equity Ratio = 0		−33.28**	−48.80***	−18.25***	−14.69***
		(13.04)	(11.06)	(4.28)	(4.57)
Constant	8.77***	11.78***			
	(2.82)	(2.22)			
CLO FE	N	N	Y	N	Y
Year-Month x Manager FE	N	N	N	Y	Y
Obs.	39,905	39,905	39,842	37,229	37,157
R^2	0.021	0.027	0.097	0.572	0.601

Table 6: Equity Payouts and CLO Issuance

This table reports the results of the two stage regression described in equation 3. $\overline{COVID\,Exposure}$ 09/19-02/20 is manager m's average share invested in the four industries most affected by COVID from 09/2019-02/2020, in percent. The four industries are *Oil & Gas*, *Hotel, Gaming and Leisure*, *Consumer Transportation*, and *Retail* and are the four industries with the lowest cumulative return in the loan market from February to April 2020. $Equity\,Payouts_m^{03/20-12/20}$ is defined as the combined equity payouts from March to December 2020 of CLOs managed by manager m, scaled by the manager's average CLO assets under management in 09/2019-02/2020, and multiplied by $\frac{3}{10} \cdot 100$ to obtain a quarterly value in percent of the pre-COVID AuM. $CLO\,Issuance_m^{03/20-12/20}$ is the total dollar volume of CLO issuance of manager m from March to December 2020, scaled by the manager's average CLO assets under management in 09/2019-02/2020, and multiplied by $\frac{3}{10} \cdot 100$ to obtain a quarterly value in percent of the pre-COVID AuM. Column (1) contains the first-stage coefficient, Column (2) the OLS estimate, Column (3) the two-stage-least square (2SLS) estimate, and Column (4) the reduced-form coefficient. Columns (5) and (6) contain the OLS and 2SLS coefficient when using the volume of CLO issuance that is subsequently invested in all but the four most COVID exposed industries as dependent variable. The volume of CLO issuance invested in all but the four most COVID exposed industries is calculated as the average share of holdings invested in all but the four industries since issuance until end 12/2020 multiplied with the issuance volume.Significance levels: *(p<0.10), **(p<0.05), ***(p<0.01).

	Equity Payouts	Issuance				
	(1)	(2)	(3)	(4)	(5)	(6)
COVID Exposure	-0.01***			-0.49**		
	(0.00)			(0.22)		
Equity Payouts		24.93***	39.73**		28.77***	47.17**
		(7.76)	(17.40)		(9.44)	(21.14)
Model	First Stage	OLS	IV	Reduced-Form	OLS Non-COVID Ind.	IV Non-COVID Ind.
F Statistic	29.34					
Obs.	118	118	118	118	98	98
R^2	0.202	0.082	0.053	0.042	0.088	0.052

Table 7: Calibrated Parameter Values

Parameter	**Value**	**Source**
Loss inefficient trading: γ	37 bps	The absolute value of the sum of the constant in Column (2) and the slope coefficient from the indicator of whether the MtM Equity Ratio is 0 in Column (3) of Table 5.
Diverted cash flow: B	100 bps	Average annualized equity payout relative to CLO size conditional on MtM Equity Ratio being 0.
Persistence of volatility shock: η	0.7	Parameter of quarterly VIX's AR(1) process in the sample period 2004Q1-2020Q4.
Inverse Firm's Loan Demand Semi-elasticity δ^F	70 bps	Slope coefficient from regression of monthly Excess Loan Premium on logarithmic US institutional loan issuance.
Intercept in firm's loan demand function R_0	0.97	Such that maximum issuance $\overline{m}$ is 1.
Marginal alpha if f=0: α_0	127 bps	$\alpha(f) = \alpha_0 \cdot \left(-\frac{1}{2*\overline{f}} f^2 + f\right)$, where α_0 is jointly determined with k such that given the initial conditions, $f_0^* = 5$ and $E_0^* = 0.111$.
Maximum discretion $\overline{f}$	7.2	90th percentile in the distribution of length in reinvestment period at origination.
Cost of equity issuance k	5.64	$c(\Delta E) = k \cdot (\Delta E)^2$. k is jointly determined with α_0 such that given the initial conditions, $f_0^* = 5$ and $E_0 = 0.111$
Risk-free rate r^f	2%	Average 5 year constant maturity rate in the sample period Q12003-Q42020.
Consumption share ρ	19.6%	$\rho = \frac{r^f}{1+r^f}$ such that $\mathbb{E}[N_{t+1}] = N_t$

A1 Excerpt from CLO indenture

This shows an excerpt of the indenture of *JMP Credit Advisors CLO III(R)* managed by the JMP Group[46]. It defines the trading criteria after the reinvestment period:

(b) Investment Criteria - Investment after the Reinvestment Period. After the Reinvestment Period, Principal Proceeds actually received with respect to sales of Credit Improved Obligations or Credit Impaired Obligations and Unscheduled Principal Payments may be reinvested in additional Collateral Obligations in accordance with the following requirements:

Credit Impaired Obligations are defined as:

"Credit Impaired Obligation": Any Collateral Obligation that in the Collateral Manager's judgment exercised in accordance with the Collateral Management Agreement has a significant risk of declining in credit quality and, with a lapse of time, becoming a Defaulted Obligation and, provided that, at any time a Restricted Trading Period is in effect a Collateral Obligation will be a Credit Impaired Obligation only if, in addition to the foregoing:

(a) such Collateral Obligation has been downgraded or put on a watch list for possible downgrade or on negative outlook by the Rating Agency since the date on which such Collateral Obligation was acquired by the Issuer;

(b) if such Collateral Obligation is a fixed rate obligation, there has been an increase in the difference between its yield compared to the yield on the relevant U.S. Treasury security of the same duration of more than 7.5% of its yield since the date of purchase;

(c) if the obligor of such Collateral Obligation has a projected cash flow interest coverage ratio (earnings before interest and taxes divided by cash interest expense as determined by the Collateral Manager) that is less than 1.00 or expected to be less than 0.85 times the current year's projected cash flow interest coverage ratio;

(d) the Market Value of such Collateral Obligation has decreased by at least 1.00% of the price paid by the Issuer for such Collateral Obligation due to a deterioration in the related obligor's financial ratios or financial results in accordance with the Underlying Instruments relating to such Collateral Obligation;

(e) if such Collateral Obligation is a loan, the price of such loan has changed during the period from the date on which it was acquired by the Issuer to the proposed sale date by a percentage either at least 0.25% more negative, or at least 0.25% less positive, as the case may be, than the percentage change in the average price of an average price of any Approved Index as determined by the Collateral Manager over the same period.; or

(f) with respect to which a Majority of the Controlling Class consents to treat such Collateral Obligation as a Credit Impaired Obligation.

Credit Improved Obligations are defined as:

[46] The indenture is available here: https://www.sec.gov/Archives/edgar/data/1302350/000143774918003092/ex_105646.htm

"Credit Improved Obligation":

(a) so long as a Restricted Trading Period is not in effect, any Collateral Obligation that in the Collateral Manager's judgment exercised in accordance with the Collateral Management Agreement has significantly improved in credit quality after it was acquired by the Issuer, which improvement may (but need not) be evidenced by one of the following:

(i) such Collateral Obligation has been upgraded or put on a watch list for possible upgrade by the Rating Agency since the date on which such Collateral Obligation was acquired by the Issuer;

(ii) if such Collateral Obligation is a fixed rate obligation, there has been a decrease in the difference between its yield compared to the yield on the U.S. Treasury security of the same duration more than 7.5% of its yield since the date of purchase;

(iii) if the obligor of such Collateral Obligation has a projected cash flow interest coverage ratio (earnings before interest and taxes divided by cash interest expense as determined by the Collateral Manager) that is expected to be more than 1.15 times the current year's projected cash flow interest coverage ratio;

(b) If a Restricted Trading Period is in effect, in addition to the foregoing, a Collateral Obligation will qualify as a Credit Improved Obligation only if:

(i) such Collateral Obligation has been upgraded or put on a watch list for possible upgrade by the Rating Agency since the date on which such Collateral Obligation was acquired by the Issuer;

(ii) if such Collateral Obligation is a fixed rate obligation, there has been a decrease in the difference between its yield compared to the yield on the U.S. Treasury security of the same duration more than 7.5% of its yield since the date of purchase;

(iii) if the obligor of such Collateral Obligation has a projected cash flow interest coverage ratio (earnings before interest and taxes divided by cash interest expense as determined by the Collateral Manager) that is expected to be more than 1.15 times the current year's projected cash flow interest coverage ratio;

(iv) if the Market Value of such Collateral Obligation has increased since the date of its acquisition by at least 1.0% of the original purchase price at which such Collateral Obligation was acquired by the Issuer;

(v) if such Collateral Obligation is a loan, the price of such loan has changed during the period from the date on which it was acquired by the Issuer to the proposed sale date by a percentage either at least 0.25% more positive, or 0.25% less negative, as the case may be, than the percentage change in the average price of any Approved Index over the same period; or

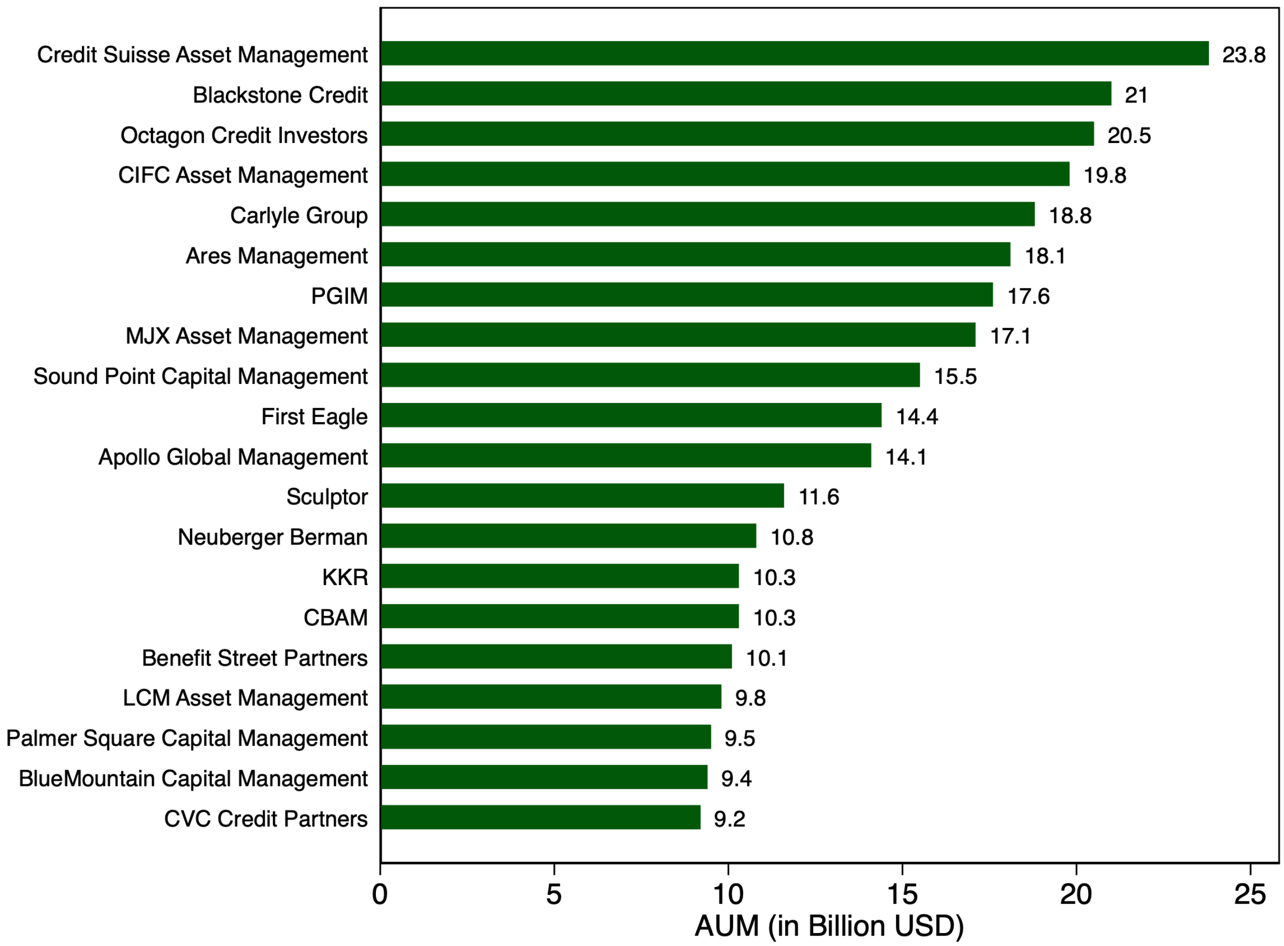
(vi) with respect to which a Majority of the Controlling Class votes to treat such Collateral Obligation as a Credit Improved Obligation.

The CLO in this example is not allowed to trade outside the reinvestment period, unless the sold loan either significantly improved or declined in value and rating.

A2 Additional CLO Primer

Figure A1: Assets under Management by CLO Manager in December 2020

This figure plots total CLO assets under management for the largest 20 CLO managers in December 2020. Assets under management are calculated based on the total notional values of outstanding CLO tranches for CLOs that primarily invest in US syndicated loans.



A3 Detailed Definition of Key Variables

A3.1 Spread calculation

The spread calculation mostly follows the approach of Gilchrist and Zakrajšek (2012) and Saunders, Spina, Steffen, and Streitz (2021). To calculate the secondary market spread of CLO tranche i at date t, I start by solving for the internal rate of return $irr_{i,t}$ that equates the secondary market price $P_{i,t}$ in cents per dollar of face value with the discounted value of the coupon payments C_i plus the floating rate swapped to a fixed rate:

$$P_{i,t} = \sum_{h=0}^{H} \frac{C_i + LIBOR^{swap}_{t,t+h-90 \rightarrowtail t+h}}{(1 + irr_{i,t})^h} + \frac{100}{(1 + irr_{i,t})^H}, \tag{9}$$

where h denotes the days to the next interest payment divided by 365, and H the expected maturity date as described in Table 1. I assume that each CLO makes quarterly interest payments starting 3 months after the pricing date and pays the floating 3-months USD LIBOR set 3 months prior to the paymentdate in addition to the promised fixed coupon. Note, that the transition from LIBOR to SOFR occured after the end of my sample period. I swap the stream of floating 3-months LIBOR rates to a stream of fixed rates using LIBOR forward curves downloaded from Bloomberg. CLO debt are quoted as clean prices, hence I use $\frac{h}{90} \cdot (C_i + LIBOR_{t+h-90,t+h-90 \rightarrowtail t+h})$ for the next coupon paymentdate to account for the fact that an investor would only receive the coupon for the period it held the loan.

After solving numerically for the IRR, I price a synthetic risk-free bond with the same series of coupon payments using zero coupon rates $zc_{t,t \rightarrowtail t+h}$ from Gürkaynak, Sack, and Wright (2007):

$$P^{rf}_{i,t} = \sum_{h=0}^{H} \frac{C_i + LIBOR^{swap}_{t,t+h-90 \rightarrowtail t+h}}{(1 + zc_{t,t \rightarrowtail t+h})^h} + \frac{100}{(1 + zc_{t,t \rightarrowtail t+h})^H}, \tag{10}$$

Using the calculated prices of the synthetic risk-free bond and Equation 9, I solve for the internal rate of return $irr^{rf}_{i,t}$ of the synthetic risk-free bond. The spread on CLO tranche i at date t,$s_{i,t}$, is then defined as the difference between the internal rate of return of the CLO tranche and a risk-free bond with the same payment profile:

$$s_{i,t} = irr_{i,t} - irr^{rf}_{i,t}$$

A3.2 Trading Return calculation

The return on the long-short portfolio is defined as:

$$Return_{i,t}^{t \mapsto t+3} =$$
$$= \left(\sum_{b}^{B_{i,t}} \left(\frac{P_{b,t+3} + \frac{C_b}{4}}{P_{b,t}} - 1 \right) \frac{vol_{b,t}}{\sum_b^{B_{i,t}} vol_{b,t}} - \sum_{s}^{S_{i,t}} \left(\frac{P_{s,t+3} + \frac{C_s}{4}}{P_{s,t}} - 1 \right) \frac{vol_{s,t}}{\sum_s^{S_{i,t}} vol_{s,t}} \right) \frac{\sum_b^{B_{i,t}} vol_{b,t}}{CLOValue_t} \tag{11}$$

$B_{i,t}$ and $S_{i,t}$ are the set of loans bought and sold by CLO manager i in month t respectively. C is the annual coupon of the respective loan. The volume of purchases and sales does not need to be identical every month. I therefore exclude months in which there were either no sales but purchases or no purchases but sales, calculate the weighted average return for each leg separately, and then scale the difference in the weighted average returns by the purchase volume. If a CLO was not engaging in any trading at all in a given month, then its return is set to zero. The absoulte return is then divided by the face value of all outstanding tranches of the respective CLO and annualised to obtain the annualised relative return.

A4 Additional Empirical Evidence

A4.1 Aggregate Facts

Figure A2: CLO Issuance with and without Refinancing

This figure plots the quarterly issuance of new CLOs that invest primarily in US broadly syndicated loans (in red) and the Cboe Russell 2000 Volatility Index (VIX) (in green) from 2004Q1 to 2020Q4. CLO issuance is the sum of the notional value of all CLO tranches with pricing date in a given quarter. If the pricing date is missing, I use the closing date. The red line excludes CLO tranchess that are refinaces or resets defined by having a ”-R” or ”(R)”. The unit is in billion USD. The VIX is a measure of the expected volatility of the Russell 2000 index and is available on FRED. To construct the quarterly series I take the simple average of the daily VIX. I smooth both series by taking the average of the current and next quarter. To construct the quarterly VIX series I take the simple average of the daily VIX.

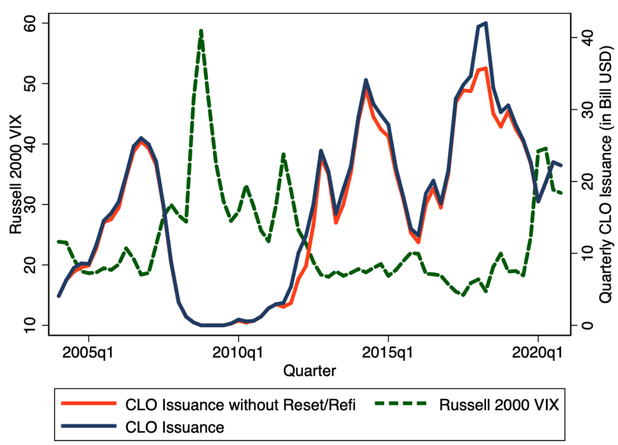


Figure A3: CLO Issuance and Leveraged Loan Issuance

This figure plots the quarterly issuance of new CLOs that invest primarily in US broadly syndicated loans in red and the issuance of new leveraged loans in green from 2004Q1 to 2020Q4. CLO issuance is the total notional value of all CLO tranches with pricing date in a given quarter. If the pricing date is missing, I use the closing date. I smooth both series by taking the average over the current and the next quarter. The units are in billion USD. Leveraged loan issuance are all new originations of institutional term loans (i.e., term loan B-K) that are syndicated in the US, not issued by financial firms (SIC codes 6000-6799, and included in LoanConnector DealScan).

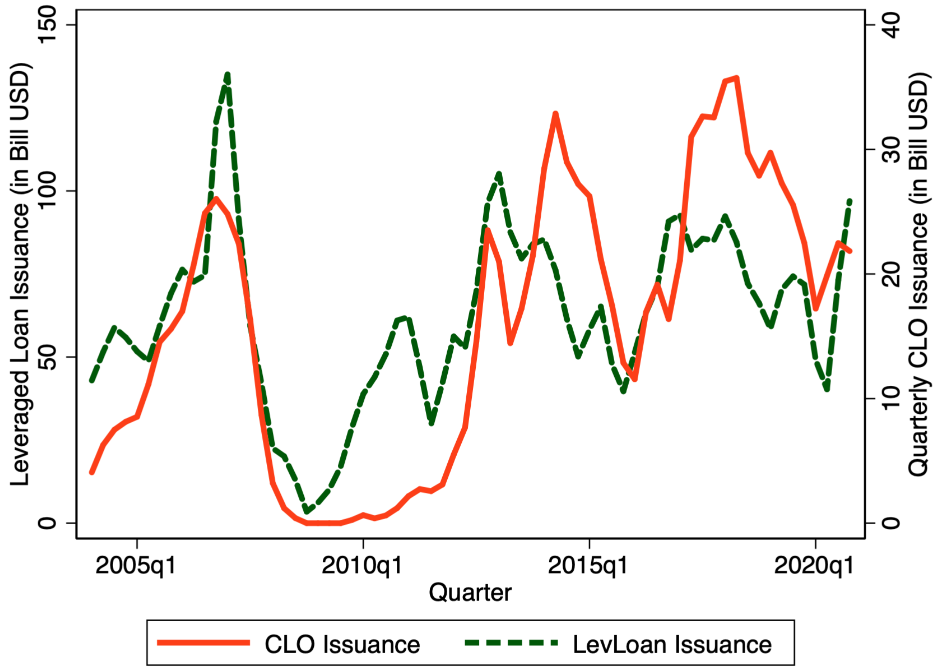
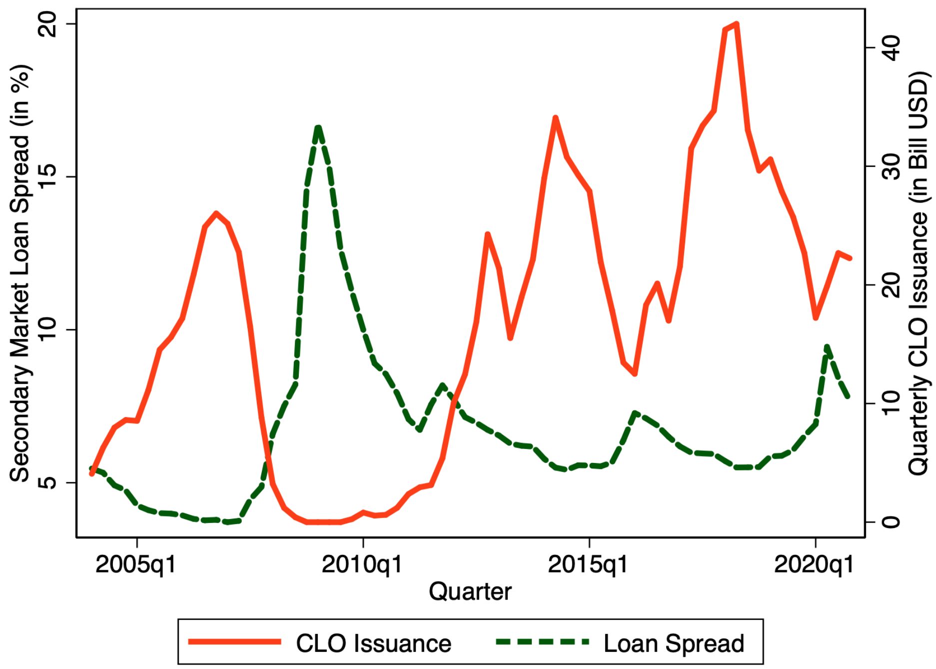


Figure A4: CLO Issuance and Loan Spreads

This figure plots the quarterly issuance of new CLOs that invest primarily in US broadly syndicated loans in red along with the secondary market loan spreads from Saunders, Spina, Steffen, and Streitz (2021) in green from 2004Q1 to 2020Q4. CLO issuance is defined as described in Figure 1.



A4.2 Agency conflict

Table A1: Sales of CCC Loans by Active and Passive CLOs

This table reports the probability of selling a CCC-rated loan for active and passive CLOs and depending on the share invested in CCC-rated loans. The unit of observation is a CLO × Month × Loan triple. The sample contains only CLO × Month × Loan observations for loans that are CCC rated or about to be CCC rated within the following 4 months. The dependent variable that is 100 for CLOs that held the loan in the previous month sold it in the current month, and 0 for CLOs that held the loan in the previous month and still hold it in the current month. The unconditional value of the dependent variable is 3.37%. $CCC\ Share_{t-1}$ is the holdings of CCC rated loans relative to the notional size of the CLO in the previous month measure in percent. *Active* indicates CLOs that are within their reinvestment period. $Price_{t-1}$ is the price of the loan in the previous month measured in cents per dollar of face value. The regression controls for the risk of the portfolio in the previous month by including the weighted average rating factor. Standard errors are clustered on the CLO and Loan × Month level. Significance levels: *(p<0.10), **(p<0.05), ***(p<0.01).

	Prob(CCC Loan Sale)				
	(1)	(2)	(3)	(4)	(5)
Active	0.38***	1.11***	1.07***	1.16***	0.45
	(0.12)	(0.11)	(0.14)	(0.12)	(0.44)
$CCC\ Share_{t-1}$	0.09***	0.06***	0.09***	0.03**	0.05***
	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)
$Active \times Price_{t-1}$					0.01**
					(0.00)
Controls	Y	Y	Y	Y	Y
CLO FE	Y	Y	Y	Y	Y
Year-Month x Manager FE	N	Y	N	N	N
Year-Month x Loan FE	N	N	Y	N	N
Year-Month x Manager x Loan FE	N	N	N	Y	Y
Obs.	1,192,915	1,192,870	1,162,303	1,012,103	806,241
R^2	0.014	0.050	0.206	0.782	0.781

Table A2: Probability of OC Test Failure by Active and Passive CLOs

This table reports the probability of a OC test failure for active and passive CLOs and depending on the share invested in CCC-rated loans. The unit of observation is a CLO × Month pair. *OC Fail* is 100 if the CLO fails the junior OC test in the current month, and 0 if it passes. $CCC\ Share_{t-1}$ is the holdings of CCC rated loans relative to the notional size of the CLO in the previous month measure in percent. *Active* indicates CLOs that are within their reinvestment period. The regression controls for the distance to the junior OC threshold in the previous month, defined as the junior OC test result minus the junior OC test threshold . Standard errors are clustered on the CLO and Month level. Significance levels: *(p<0.10), **(p<0.05), ***(p<0.01).

	OC Fail		
	(1)	(2)	(3)
Active	−3.41***	−2.98***	−2.29***
	(0.96)	(0.78)	(0.77)
Sample Mean OC Fail	4.9	4.7	4.7
Control Lag Distance to Threshold	Y	Y	Y
Control Lag CCC Share	Y	Y	Y
CLO FE	N	N	Y
Year-Month FE	Y	N	N
Year-Month x Manager FE	N	Y	Y
Obs.	51,711	48,503	48,476
R^2	0.404	0.608	0.688

Table A3: Equity Payouts - Active vs Passive CLOs

This table reports the quarterly equity payouts of active and passive CLOs, conditional on the marked-to-market equity ratio being 0. The unit of observation is a CLO $\times$ Month pair. *Quarterly Equity Payouts* is the total amount paid to equity investors measured relative to the notional size of the CLO in basispoints and annualized. *Active* indicates CLOs that are within their reinvestment period. *MtM Equity ratio = 0* indicates whether a CLO currently has a marked-to-market equity ratio that is zero or below. The marked-to-market equity ratio is defined as the total market value of assets minus the face value of outstanding debt tranches, divided by the total market value of assets. The market value of assets is calculated as the market value of all loans held by a CLO plus cash holdings which are assumed to be 3% of the notional CLO size. Standard errors are clustered on the CLO and Month level. Significance levels: *($p<0.10$), **($p<0.05$), ***($p<0.01$).

	Quarterly Equity Payouts		
	(1)	(2)	(3)
Active	−9.60*	−8.97	0.91
	(5.67)	(5.81)	(3.16)
MtM Equity Ratio = 0	−61.26***	−60.64***	−22.50***
	(7.53)	(7.18)	(4.52)
Active × MtM Equity Ratio = 0	23.20***	29.84***	15.58***
	(7.46)	(7.34)	(5.37)
CLO FE	N	N	Y
Year-Month FE	Y	N	N
Year-Month x Manager FE	N	Y	Y
Obs.	18,954	16,130	16,024
R^2	0.383	0.617	0.793

Table A4: Persistence of OC Test Results by Active and Passive CLOs

This table reports the persistence of the OC test result for active and passive CLOs. The unit of observation is a CLO × Month pair. $Distance\,OC\,Test_t$ is the difference between the junior OC test result and the OC test threshold of a CLO in the current month. $Distance\,OC\,Test_{t-1}$ is the equivalent in the previous month. *Active* indicates CLOs that are within their reinvestment period. Standard errors are clustered on the CLO and Month level. Significance levels: *(p<0.10), **(p<0.05), ***(p<0.01).

	$Distance\,OC\,Test_t$			
	(1)	(2)	(3)	(4)
Active	0.03***	0.03***	0.03***	0.04***
	(0.01)	(0.01)	(0.01)	(0.01)
$Distance\,OC\,Test_{t-1}$	0.99***	0.99***	0.98***	0.82***
	(0.01)	(0.01)	(0.01)	(0.02)
$Active \times Distance\,OC\,Test_{t-1}$	−0.03***	−0.03***	−0.03***	−0.04***
	(0.01)	(0.01)	(0.01)	(0.01)
CLO FE	N	N	N	Y
Year-Month FE	N	Y	N	N
Year-Month x Manager FE	N	N	Y	Y
Obs.	56,437	56,437	53,069	53,042
R^2	0.922	0.936	0.954	0.959

A4.3 Trading

Table A5: Riskiness of Trading

This table reports the riskiness of trading by CLOs in relation to the CLO's equity ratio. It contains coefficients from a regreassion of the weighted average rating of bought and sold loans by CLOs, where sold loans receive a negative rating. The unit of observation is a CLO $\times$ Month pair. *MtM Equity ratio = 0* indicates whether a CLO currently has a marked-to-market equity ratio that is zero. The marked-to-market equity ratio is defined as the total market value of assets minus the face value of outstanding debt tranches, divided by the total market value of assets. The market value of assets is calculated as the market value of all loans held by a CLO plus cash holdings which are assumed to be 3% of the notional CLO size. Standard errors are clustered on the CLO and month level. Significance levels: *(p<0.10), **(p<0.05), ***(p<0.01).

	Weighted Average Rating Traded Assets				
	(1)	(2)	(3)	(4)	(5)
MtM Equity Ratio = 0	−10.50***	−8.76***	−4.60***	−4.56***	−2.41**
	(1.66)	(1.95)	(1.10)	(1.12)	(1.03)
CLO FE	N	Y	N	N	Y
Year-Month FE	N	N	Y	N	N
Year-Month x Manager FE	N	N	N	Y	Y
Obs.	48,723	48,688	48,723	45,659	45,629
R^2	0.009	0.094	0.065	0.462	0.511

Table A6: Trading Volumes

This table reports the average purchase (Panel (A)) and sales volume (Panel (B)) of active and passive CLOs. The unit of observation is a CLO × Month pair. Purchase and Sales volumes for a given CLO × Month are measured in percent of the notional CLO size in that month, and annualized by multipling with 12. *Active* indicates CLOs that are within their reinvestment period. CLO × Month observations that fall within the first six months after the CLO's pricing date or within the last six months the CLO is in the dataset are dropped. This ensures that initial loan purchases and portfolio wind-downs after a CLO is called are excluded, and results are based only on trading. The sample period is from 2008/10 to 2020/12.

Panel A - Purchase Volume

	$\frac{\text{Purchase Volume}}{\text{Assets}}$				
	(1)	(2)	(3)	(4)	(5)
Active	25.47***	31.30***	27.19***	27.03***	31.67***
	(1.60)	(2.07)	(1.39)	(1.46)	(1.62)
Constant	17.63***				
	(1.27)				
CLO FE	N	Y	N	N	Y
Year-Month FE	N	N	Y	N	N
Year-Month x Manager FE	N	N	N	Y	Y
Obs.	58,877	58,847	58,877	55,743	55,713
R^2	0.062	0.246	0.255	0.568	0.654

Panel B - Sales Volume

	$\frac{\text{Sales Volume}}{\text{Assets}}$				
	(1)	(2)	(3)	(4)	(5)
Active	9.83***	9.84***	10.51***	10.64***	9.37***
	(0.86)	(0.94)	(0.71)	(0.67)	(0.72)
Constant	10.60***				
	(0.89)				
CLO FE	N	Y	N	N	Y
Year-Month FE	N	N	Y	N	N
Year-Month x Manager FE	N	N	N	Y	Y
Obs.	58,877	58,847	58,877	55,743	55,713
R^2	0.024	0.301	0.094	0.557	0.659

Table A7: Alpha Active vs Passive CLOs - Robustness with Betas

This table reports the risk-adjusted return from trading of CLOs within and outside their reinvestment period in excess of the portfolio beta implied predicted return. The unit of observation is a CLO $\times$ Month pair. The results are from the regression as defined by Equation 2 plus a variable that indicates whether a CLO is currently in its reinvestment period. *Abnormal Return*$^{t\mapsto t+3}$ is the return over the following three months of a long-short portfolio that goes in long in all loans bought and short in all loans sold by a CLO in a given month (desribed in more detail in Appendix A3.1) minus the predicted return of that portfolio. The predicted return is calculated based on the weighted average beta of the long-short period and the realized return of the S&P/LSTA Loan Index from Bloomberg. Portfolio betas are based on loan-level betas from rolling regressions of monthly loan returns on the S&P/LSTA Loan Index return over the prior 12 months with minimum 6 months of data. *Avrg. Rating* is the weighted average rating of the same long-short portfolio in the trading month. *Active* indicates whether a CLO is within its reinvestment period in a given month. Standard errors are clustered on the CLO and month level. Significance levels: *(p<0.10), **(p<0.05), ***(p<0.01).

	Abnormal Return$^{t\mapsto t+3}$ (in BPS)			
	(1)	(2)	(3)	(4)
Avrg. Rating	0.65***	0.68***	0.56***	0.52***
	(0.13)	(0.13)	(0.10)	(0.09)
Active	9.56***	36.38***	18.71***	9.06
	(3.33)	(5.51)	(3.82)	(5.98)
Constant	0.20			
	(2.64)			
CLO FE	N	Y	N	Y
Year-Month x Manager FE	N	N	Y	Y
Obs.	39,359	39,289	36,497	36,418
R^2	0.019	0.083	0.535	0.566

Table A8: Alpha by Equity - Robustness with Betas

This table reports the risk-adjusted return from trading of CLOs based on whethe their marked-to-market equity ratio is zero. The unit of observation is a CLO × Month pair. The results are from the regression as defined by Equation 2 plus a variable that indicates whether a CLO currently has a marked-to-market equity ratio that is zero. $Abnormal\,Return^{t\mapsto t+3}$ is the return over the following three months of a long-short portfolio that goes in long in all loans bought and short in all loans sold by a CLO in a given month (desribed in more detail in Appendix A3.1) minus the predicted return of that portfolio. The predicted return is calculated based on the weighted average beta of the long-short period and the realized return of the S&P/LSTA Loan Index from Bloomberg. Portfolio betas are based on loan-level betas from rolling regressions of monthly loan returns on the S&P/LSTA Loan Index return over the prior 12 months with minimum 6 months of data. *Avrg. Rating* is the weighted average rating of the same long-short portfolio in the trading month. *MtM Equity ratio = 0* indicates whether a CLO currently has a marked-to-market equity ratio that is zero. The marked-to-market equity ratio is defined as the total market value of assets minus the face value of outstanding debt tranches, divided by the total market value of assets. The market value of assets is calculated as the market value of all loans held by a CLO plus cash holdings which are assumed to be 3% of the notional CLO size. Standard errors are clustered on the CLO and month level. Significance levels: *(p<0.10), **(p<0.05), ***(p<0.01).

	Abnormal Return$^{t\mapsto t+3}$ (in BPS)				
	(1)	(2)	(3)	(4)	(5)
Avrg. Rating	0.63***	0.60***	0.63***	0.53***	0.48***
	(0.13)	(0.12)	(0.12)	(0.10)	(0.09)
$MtM\,Equity\,Ratio_t = 0$		−26.47**	−41.61***	−12.28***	−6.50
		(13.03)	(9.90)	(4.41)	(5.05)
Constant	9.59***	11.93***			
	(2.69)	(2.19)			
CLO FE	N	N	Y	N	Y
Year-Month x Manager FE	N	N	N	Y	Y
Obs.	36,134	36,134	36,055	33,642	33,555
R^2	0.017	0.020	0.092	0.558	0.591

Table A9: Abnormal Return from Trading - Robustness Stock Price Betas and Different Horizons

This table reports the risk-adjusted return from trading of CLOs within and outside their reinvestment period and for CLOs with positive and zero marked-to-market equity ratio. The unit of observation is a CLO $\times$ Month pair. The results are from the regression as defined by Equation 2 plus a variable *Active* that indicates whether a CLO is currently in its reinvestment period (Columns (1),(3), and (5)) or the marked-to-market equity ratio (Columns (2),(4), and (6)). $Return^{t \mapsto t+h}$ is the return over the following h months of a long-short portfolio that goes in long in all loans bought and short in all loans sold by a CLO in a given month. The construction of this variable is further detailed in Appendix A3.1. *Avrg. Rating* is the weighted average rating of the same long-short portfolio in the trading month. *Avrg. Stock Price Beta* is the weighted average beta of the same long-short portfolio in the trading month based on unlevered industry-level stock price betas from Aswath Damodaran's website (`https://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/Betas.html`). *MtM Equity ratio = 0* indicates whether a CLO currently has a marked-to-market equity ratio that is zero. The marked-to-market equity ratio is defined as the total market value of assets minus the face value of outstanding debt tranches, divided by the total market value of assets. The market value of assets is calculated as the market value of all loans held by a CLO plus cash holdings which are assumed to be 3% of the notional CLO size. Standard errors are clustered on the CLO and month level. Significance levels: *(p<0.10), **(p<0.05), ***(p<0.01).

	$\text{Return}^{t \mapsto t+1}$ (in BPS)		$\text{Return}^{t \mapsto t+6}$ (in BPS)		$\text{Return}^{t \mapsto t+3}$ (in BPS)	
	(1)	(2)	(3)	(4)	(5)	(6)
Avrg. Rating	0.37***	0.33***	0.95***	0.85***		
	(0.10)	(0.09)	(0.17)	(0.15)		
Avrg. Stock Price Beta					346.10	326.12
					(304.92)	(300.85)
Active	10.58***		11.88***		9.36***	
	(2.43)		(3.95)		(3.56)	
$MtM\,Equity\,Ratio_t = 0$		−21.05*		−54.25***		−39.90***
		(11.09)		(17.42)		(14.09)
Constant	−0.89	11.53***	−5.03*	11.36***	−7.61**	5.82**
	(1.83)	(1.85)	(2.75)	(2.90)	(3.11)	(2.57)
CLO FE	N	N	N	N	N	N
Year-Month x Manager FE	N	N	N	N	N	N
Obs.	44,257	40,624	42,565	39,146	43,370	39,886
R^2	0.014	0.017	0.033	0.040	0.001	0.008

Table A10: Alpha by Equity - Post-Reinvestment Period

This table reports the risk-adjusted return from trading of CLOs outside their reinvestment period based on whether their marked-to-market equity ratio is zero. The unit of observation is a CLO $\times$ Month pair. The results are from the regression as defined by Equation 2 plus a variable that indicates whether a CLO currently has a marked-to-market equity ratio that is zero. *Return*$^{t \mapsto t+3}$ is the return over the following three months of a long-short portfolio that goes in long in all loans bought and short in all loans sold by a CLO in a given month. The construction of this variable is further detailed in Appendix A3.1. *Avrg. Rating* is the weighted average rating of the same long-short portfolio in the trading month. *MtM Equity ratio = 0* indicates whether a CLO currently has a marked-to-market equity ratio that is zero. The marked-to-market equity ratio is defined as the total market value of assets minus the face value of outstanding debt tranches, divided by the total market value of assets. The market value of assets is calculated as the market value of all loans held by a CLO plus cash holdings which are assumed to be 3% of the notional CLO size. The sample is restricted to CLOs that are outside their reinvestment period Standard errors are clustered on the CLO and month level. Significance levels: *(p<0.10), **(p<0.05), ***(p<0.01).

	Return$^{t \mapsto t+3}$ (in BPS)				
	(1)	(2)	(3)	(4)	(5)
Avrg. Rating	0.93***	0.92***	0.90***	0.48*	0.62**
	(0.23)	(0.23)	(0.19)	(0.27)	(0.28)
MtM Equity Ratio = 0		−4.15	−4.59	10.82	6.96
		(4.94)	(6.16)	(10.08)	(10.03)
Constant	−0.26	0.87			
	(2.43)	(2.83)			
CLO FE	N	N	Y	N	Y
Year-Month x Manager FE	N	N	N	Y	Y
Obs.	3,490	3,490	3,411	1,371	1,182
R^2	0.058	0.058	0.249	0.615	0.717

A4.4 Discretion and CLO Cost of Debt

Table A11: Effect of Discretion on CLOs' cost of debt - Portfolio Risk Robustness

This table reports results on the effect of the remaining time of discretionary trading on the spread of deb tranches on the secondary market. The unit of observation is a CLO Tranche × Month pair. The results are from the regression as defined by Equation 1. *Log*(*Spread*) is the secondary market spread of a CLO tranche in a given month as defined in Appendix A3.1. *Years Active Left* is the remaining time in the reinvestment period in years. Column (1) controls for the weighted average return beta of the loan portfolio, where the return beta is based on rolling regressions of monthly loan returns on the S&P/LSTA Loan Index return over the prior 12 months with minimum 6 months of data. Column (2) controls for the weigted average return volatility of the loan portfolio, where the loan-level return volatility is based on monthly returns over the previous 12 months. Column (3) controls for the weighted average beta of the loan portfolio based on unlevered industry-level stock price betas from Aswath Damodaran's website (`https://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/Betas.html`). Column (4) includes all risk measures together, including the weighted average rating factor from the baseline regression. Columns (5) reports the relationship for different values in the Cboe Russell 2000 Volatility Index (VIX). The VIX is standardized over the entire period from 2004 to 2022 to allow for comparison across different samples.The other controls include the current tranche level subordination (=market value assets minus face value of all equally or more senior tranches), the weighted average maturity of loans in portfolio, the weighted average spread of loans in the portfolio, the share of CCC rated loans in the portfolio, the expected remaining maturity, the months since origination, and a dummy that indicates whether the CLO is callable. Standard errors are clustered on the month and CLO level. Significance levels: *(p<0.10), **(p<0.05), ***(p<0.01).

	Log(Spread) × 100				
	(1)	(2)	(3)	(4)	(5)
Years Active Left	3.93**	5.68**	2.98**	5.68**	5.18**
	(1.64)	(2.27)	(1.22)	(2.84)	(2.32)
Years Active Left × R2000 VIX					0.89*
					(0.45)
Risk Measure	Return Beta	Return Vol	Levered Beta	All	All
Controls	Y	Y	Y	Y	Y
Tranche FE	Y	Y	Y	Y	Y
Manager x Month x Seniority FE	Y	Y	Y	Y	Y
Obs.	3,394	3,394	3,400	3,193	3,193
Within R^2	0.032	0.035	0.028	0.033	0.165

Table A12: Effect of Discretion on CLOs' cost of debt - Maturity Robustness

This table reports results on the effect of the remaining time of discretionary trading on the spread of deb tranches on the secondary market. The unit of observation is a CLO Tranche × Month pair. The results are from the regression as defined by Equation 1. *Log*(*Spread*) is the secondary market spread of a CLO tranche in a given month as defined in Appendix A3.1. *Years Active Left* is the remaining time in the reinvestment period in years. Column (1) and (2) include the expected remaining maturity as control, and is equivalent to the baseline model. Column (3) and (4) control for the logarithmic expected remaining maturity. Column (5) and (6) control for the expected remaining maturity as well as the squared expected remaining maturity. Columns (2), (4), and (6) report the relationship for different values in the Cboe Russell 2000 Volatility Index (VIX). The VIX is standardized over the entire period from 2004 to 2022 to allow for comparison across different samples. The remaining controls in each specification include the current tranche level subordination (=market value assets minus face value of all equally or more senior tranches), the weighted average maturity of loans in portfolio, the weighted average spread of loans in the portfolio, the weighted average rating factor of loans in the portfolio, the share of CCC rated loans in the portfolio, the months since origination, and a dummy that indicates whether the CLO is callable. Standard errors are clustered on the month and CLO level. Significance levels: *(p<0.10), **(p<0.05), ***(p<0.01).

	Log(Spread) × 100					
	(1)	(2)	(3)	(4)	(5)	(6)
Years Active Left	3.44***	3.83***	3.66***	3.96***	3.45***	3.63***
	(1.28)	(1.22)	(1.38)	(1.29)	(1.20)	(1.06)
Years Active Left × R2000 VIX		1.11**		1.02*		1.03**
		(0.52)		(0.54)		(0.52)
Form	Linear	Linear	Log	Log	Squared	Squared
Controls	Y	Y	Y	Y	Y	Y
Tranche FE	Y	Y	Y	Y	Y	Y
Manager x Month x Seniority FE	Y	Y	Y	Y	Y	Y
Obs.	3,199	3,199	3,199	3,199	3,199	3,199
Within R^2	0.031	0.037	0.028	0.034	0.031	0.038

Table A13: Effect of Discretion on CLOs' cost of debt - Linear

This table reports results on the effect of the remaining time of discretionary trading on the spread of deb tranches on the secondary market by the Cboe Russell 2000 Volatility Index (VIX). The unit of observation is a CLO Tranche × Month pair. The results are from the regression as defined by Equation 1 but with $Spread_{i,m,f,t}$ as dependent variable plus the interaction of *Years Active Left* with the VIX. $Spread_{i,f,t}$ is the secondary market spread of a tranche f of CLO i managed by m in month t and further detailed in Appendix A3.1. *Years Active Left* is the remaining time in the reinvestment period in years. The VIX is standardized over the entire period from 2004 to 2022 to allow for comparison across different samples. The controls include the current tranche level subordination (=market value assets minus face value of all equally or more senior tranches), the weighted average maturity of loans in portfolio, the weighted average spread of loans in the portfolio, the weighted average rating factor of loans in the portfolio, the share of CCC rated loans in the portfolio, the expected remaining maturity interacted with the VIX, the months since origination, and a dummy that indicates whether the CLO is callable. Standard errors are clustered on the month and CLO level. Significance levels: *(p<0.10), **(p<0.05), ***(p<0.01).

	Spread			
	(1)	(2)	(3)	(4)
Years Active Left	11.67***	18.02	19.02*	40.43**
	(3.61)	(11.27)	(10.89)	(19.00)
Years Active Left × R2000 VIX			3.59	
			(3.34)	
Years Active Left × ELP				37.95*
				(19.40)
Controls	Y	Y	Y	Y
Tranche FE	N	Y	Y	Y
Manager x Month x Seniority FE	Y	Y	Y	Y
Obs.	5,231	3,199	3,199	3,199
Within R^2	0.041	0.040	0.043	0.058

Table A14: Effect of discretion on CLOs' cost of debt - Different expected volatility measures

This table reports results on the effect of the remaining time of discretionary trading on the spread of deb tranches on the secondary market by different aggregate measures of expected volatility. The unit of observation is a CLO Tranche × Month pair. The results are from the regression as defined by Equation 1 plus the interaction of *Years Active Left* with aggregate downgrades-to-upgrades (D/U) (Column (1)), the Excess Loan Premium (ELP) from Saunders, Spina, Steffen, and Streitz (2021) (Column (2)), and aggregate secondary market loan spreads from Saunders, Spina, Steffen, and Streitz (2021) (Column (3)). $Log(Spread)$ is the secondary market spread of a CLO tranche in a given month as defined in Appendix A3.1. *Years Active Left* is the remaining time in the reinvestment period in years. D/U is defined as the ratio of downgraded to upgraded loans among all loans held by CLOs with ratings available in the previous and current month. All three volatility measures are standardized in their respective sample period. The controls include the current tranche level subordination (=market value assets minus face value of all equally or more senior tranches, divided by the market value of assets), the weighted average maturity of loans in portfolio, the weighted average spread of loans in the portfolio, the weighted average rating factor of loans in the portfolio, the share of CCC rated loans in the portfolio, the expected remaining maturity interacted with the respective volatility measure, the months since origination, and a dummy that indicates whether the CLO is callable. Standard errors are clustered on the month and CLO level. Significance levels: *(p<0.10), **(p<0.05), ***(p<0.01).

	Log(Spread) × 100		
	(1)	(2)	(3)
Years Active Left	3.02*	6.66***	3.67***
	(1.56)	(1.58)	(1.21)
Years Active Left × D/U	1.63***		
	(0.48)		
Years Active Left × ELP		5.41***	
		(1.82)	
Years Active Left × Loan Spreads			2.15**
			(1.02)
Controls	Y	Y	Y
Tranche FE	Y	Y	Y
Manager x Month x Seniority FE	Y	Y	Y
Obs.	3,199	3,199	3,199
Within R^2	0.040	0.047	0.039

A5 Additional Theoretical Results

A5.1 Discussion of Assumptions

Optimal Outside Financing In the baseline model, all outside financing is the form debt. Appendix A5.8 contains an extension of the basline model that allows managers to also raise outside equity financing. However, issuing outside equity is costly, which is necessary for financing frictions to matter for issuance. One reason for why outside equity is costly is that outside equity dilutes the manager's incentive to exercise costly effort that improves overall returns (e.g., Jensen and Meckling (1976), Hébert (2018)).

Contracting Environment The model also assumes that contracts cannot be written on the trading by the manager. If the manager and investors could write a contract that only allow the manager to buy undervalued assets and sell overvalued ones, then there would be no agency problem. In practice it seems difficult to write such contracts because the manager is mandated to manage the intermediary for its skill to detect under- and overvalued assets, which outside investors and courts do not possess. Therefore, it is reasonable to assume that for outsiders it is difficult to determine whether a certain trade is value enhancing or destructing. Moreover, in practice, trading returns are not deterministic, which prevents the manager's actions to be perfectly inferable from realized returns.

The ϵ shock in the model represents an aggregate return shock. Di Tella (2017) shows that a contract that compensates the manager of an intermediary relative to an aggregate benchmark can induce the manager to exercise effort, while outside investors absorb aggregate return shocks. Such a contract would prevent the agency problem to depend on the return in $t = 1$. Bad trading by the manager would then be deterministic as in Holmström and Tirole (1997), and only managers with a minimum net worth and depending on the discretion would be financed. [47] In addition, changes in aggregate volatility would not change the equilibrium. In practice, however, CLO managers are not compensated relative to a benchmark. The reasons for this is that part of CLOs' purpose is to create safe assets for outside investors (Cordell, Roberts, and Schwert (2021))) and a proper benchmark might be difficult to create due to the illiquidity of the loan market. Nonetheless, the model's results would remain (under a slightly different interpretation) even if CLO managers were compensated relative to a benchmark as long as ϵ represents idiosyncratic shocks, and uncertainty (i.e., idiosyncratic risk) rises in bad times (Di Tella (2017)).

[47] The manager would engage in good trading iff $\overline{R} + \alpha(f) - D \geq f \cdot B$. Since the manager obtains only financing if any bad trading is impossible, the face value of debt is $(1 - N) \cdot (1 + r^f)$ and only managers with net worth $N \geq \frac{\overline{R}+\alpha(f)-f \cdot B}{1+r^f}$ obtain financing for a given level of discretion.

Short-term Debt The agency problem would also disappear if debt was demandable and at least some investors acquire the necessary information to detect when the manager does not generate alpha (Calomiris and Kahn (1991), Diamond and Rajan (2001))). In this case informed investors could discipline the manager by running on the intermediary. Of course, demandable debt comes at a cost when it leads to runs. In Appendix A5.6 I show that intermediary managers prefer long-term over short-term debt if the liquidation cost of runs on the intermediary are sufficiently high, and restricting the manager's discretion, instead, is feasible. Moreover, Eisenbach (2017) shows that short-term debt might not sufficiently discipline bad trading in good times, and lead to excessive liquidations of the intermediary in bad times reducing its effectiveness as disciplining mechanism. Hence, intermediaries that invest in relatively illiquid assets, such as CLOs investing in syndicated loans, optimally choose non-demandable debt.

A5.2 Detailed Derivations

Payoffs and Trading in t+1:
The payoffs from the portfolio after trading and their distribution between (old and newborn) managers and investors are listed below.

Trading	Portfolio Payout	Manager Payout	Investor Payout
Good	$\overline{R}_t - \sigma_t\epsilon_{t+1} + \alpha(f_t)$	$max\{\overline{R}_t - \sigma_t\epsilon_{t+1} + \alpha(f_t) - D_t, 0\}$	$min\{\overline{R}_t - \sigma_t\epsilon_{t+1} + \alpha(f_t), D_t\}$
Bad	$\overline{R}_t - \sigma_t\epsilon_{t+1} - f_t \cdot \gamma$	$f_t \cdot B + max\{\overline{R}_t - \sigma_t\epsilon_{t+1} - f_t \cdot (\gamma + B) - D_t, 0\}$	$min\{\overline{R}_t - \sigma_t\epsilon_{t+1} - f_t \cdot (\gamma + B), D_t\}$

The manager engages in good trading iff:

$$max\{\overline{R}_t - \sigma_t\epsilon_{t+1} + \alpha(f_t) - D_t, 0\} \geq f_t \cdot B + max\{\overline{R}_t - \sigma_t\epsilon_{t+1} - f_t \cdot (\gamma + B) - D_t, 0\}$$

There are three possible cases:

1. $\overline{R}_t - \sigma_t\epsilon_{t+1} + \alpha(f_t) - D_t > 0$ & $\overline{R}_t - \sigma_t\epsilon_{t+1} - f_t \cdot (\gamma + B) - D_t \geq 0$
   $\Rightarrow$ always generates alpha since $\alpha(f_t) + f_t\gamma \geq 0$
   Note: $\overline{R}_t - \sigma_t\epsilon_{t+1} - f_t \cdot (\gamma + B) - D_t \geq 0$ implies $\overline{R}_t - \sigma_t\epsilon_{t+1} + \alpha(f_t) - D_t > f_t B$

2. $\overline{R}_t - \sigma_t\epsilon_{t+1} + \alpha(f_t) - D_t \geq 0$ & $\overline{R}_t - \sigma_t\epsilon_{t+1} - f_t \cdot (\gamma + B) - D_t < 0$
   $\Rightarrow$ only generates alpha if $\overline{R}_t - \sigma_t\epsilon_{t+1} + \alpha(f_t) - D_t \geq f_t \cdot B$

3. $\overline{R}_t - \sigma_t\epsilon_{t+1} + \alpha(f_t) - D_t < 0$ & $\overline{R}_t - \sigma_t\epsilon_{t+1} - f_t \cdot (\gamma + B) - D_t < 0$
   $\Rightarrow$ never generates alpha

Together, this implies that the manager generates alpha iff:

$$\overline{R}_t - \sigma_t \epsilon_{t+1} + \alpha(f_t) - D_t \geq f_t B$$

This leads to the reservation value in ϵ_{t+1} such that good trading only occurs if ϵ_{t+1} falls below the reservation value, $\widetilde{\epsilon}_t$,

$$\widetilde{\epsilon}_t = \frac{\overline{R}_t - D_t + \alpha(f_t) - f_t \cdot B}{\sigma_t} \tag{12}$$

The t subscript of $\widetilde{\epsilon}_t$ indicates that this value is known by all agents in t.

Investor Problem in t:

Debt investors take the probability of default and bad trading into account when deciding whether to provide debt financing. They price proposed debt contracts with the following equation:

$$G(\widetilde{\epsilon}_t) D_t + \int_{\widetilde{\epsilon}_t}^{\overline{\epsilon}} (\overline{R}_t - \sigma_t \epsilon_{t+1} - f_t \cdot (B + \gamma)) \cdot g(\epsilon_{t+1}) d\epsilon_{t+1} = q_t D_t \cdot (1 + r_t^f), \tag{13}$$

where q_t is the equilibrium price per dollar of promised face value. The manager has to offer a higher face value D_t –which includes both principal and interest payments to debt investors– until it obtains the necessary funds to set up the intermediary $1 - s_t N_t$, where s is the share of the manager's net worth invested in the intermediary. Therefore, set up intermediaries obtain only financing if $q_t D_t = 1 - s_t N_t$. Replacing $q_t D_t$ with $1 - s_t N_t$ and rearranging yields:

$$D_t = \frac{(1 - s_t N_t) \cdot (1 + r_t^f) - (1 - G(\widetilde{\epsilon}_t)) \cdot (\overline{R}_t - f_t \cdot (B + \gamma)) + \sigma_t \int_{\widetilde{\epsilon}_t}^{\overline{\epsilon}} \epsilon_{t+1} g(\epsilon_{t+1}) d\epsilon_{t+1}}{G(\widetilde{\epsilon}_t)}$$

Manager Problem in t:

Given the debt financing costs, and the reservation value, the manager born in t maximizes:

$$\max_{s_t, f_t} \quad \rho \, \mathbb{E}_t[R_{t+1}^M(s_t N_t)] + (1 - s_t) \cdot N_t \cdot (1 + r_t^f)$$

$$\text{with} \quad \mathbb{E}_t[R_{t+1}^M] = G(\widetilde{\epsilon}_t) \cdot (\overline{R}_t + \alpha(f_t) - D_t) - \sigma_t \int_{\underline{\epsilon}}^{\widetilde{\epsilon}_t} \epsilon_{t+1} g(\epsilon_{t+1}) d\epsilon_{t+1} + (1 - G(\widetilde{\epsilon}_t)) \cdot f_t \cdot B$$

$$\text{s.t.} \quad \widetilde{\epsilon}_t = \frac{\overline{R}_t - D_t + \alpha(f_t) - f_t \cdot B}{\sigma_t}$$

$$D_t = \frac{(1 - s_t N_t) \cdot (1 + r_t^f) - (1 - G(\widetilde{\epsilon}_t)) \cdot (\overline{R}_t - f_t \cdot (B + \gamma)) + \sigma_t \int_{\widetilde{\epsilon}_t}^{\overline{\epsilon}} \epsilon_{t+1} g(\epsilon_{t+1}) d\epsilon_{t+1}}{G(\widetilde{\epsilon}_t)}$$

$$f_t \in [0, \overline{f}]$$

Inserting D_t in the expected return to the manager from investing in the intermediary's equity $\mathbb{E}_t[R_{t+1}^M]$ yields:

$$\mathbb{E}_t[R_{t+1}^M] = \overline{R_t} - (1 - s_t N_t) \cdot (1 + r_t^f) + \underbrace{G(\widetilde{\epsilon}_t)\alpha(f_t) - (1 - G(\widetilde{\epsilon}_t)) \cdot f_t \cdot \gamma}_{\text{Expected return from trading}}$$

Therefore, the manager chooses s_t and f_t to maximizes the social return from trading. Hence, the equilibrium is constrained efficient.

Combining the two constraints on D_t and $\widetilde{\epsilon}_t$ yields:

$$\widetilde{\epsilon}_t = \frac{\overline{R}_t - (1 - s_t N_t) \cdot (1 + r_t^f) + G(\widetilde{\epsilon}_t)\alpha(f_t) - (1 - G(\widetilde{\epsilon}_t)) \cdot f_t \cdot \gamma - f_t \cdot B - \sigma_t \int_{\widetilde{\epsilon}_t}^{\overline{\epsilon}} \epsilon g(\epsilon) d\epsilon}{\sigma_t G(\widetilde{\epsilon}_t)}$$

The states of the economy are defined by two variables: the manager's net worth N_t and the volatility of next periods returns σ_t. The two state variables are governed by the following laws of motion:

$$N_{t+1} = (1 - \rho) \left[\int_0^1 R_{t+1}^M(s_{i,t} N_{i,t}, f_t) + (1 - s_{i,t}) \cdot N_{i,t} \cdot (1 + r_f^t) di \right] \tag{14}$$

$$\text{with} \quad R_{t+1}^M(s_{i,t} N_{i,t}, f_t) = \begin{cases} \overline{R}_t - \sigma_t \epsilon_{t+1} + \alpha(f_t) - D_t & \text{if } \epsilon_{t+1} \leq \widetilde{\epsilon}_t \\ f_t \cdot B & \text{if } \epsilon_{t+1} \geq \widetilde{\epsilon}_t \end{cases}$$

$$\sigma_{t+1} = \overline{\sigma} + \eta_1(\sigma_t - \overline{\sigma}) + \eta_2(\sigma_{t-1} - \overline{\sigma}) + \psi \epsilon_{t+1} \tag{15}$$

Next period's net worth depends on the realized return from investing the intermediary's equity, and the share the manager invested in the intermediary. The volatility variable follows a AR(2) process with mean $\overline{\sigma}$ and is exposed to the same shock as the return process.[48] The idea is that bad times are characterized by both an increase in loan defaults that lower the return for the intermediary and a rise in volatility of future returns. This is consistent with Figure **??** in Appendix A4.1, which plots the time-series of CLO issuance along with default rates and a measure of expected volatility for stocks.

First Order Condition:

[48]The Russell 2000 VIX also follows a AR(1) process.

The first order condition from the maximization with respect to f_t is then:

$$G(\widetilde{\epsilon}_t) \cdot \alpha'(f_t) - (1 - G(\widetilde{\epsilon}_t)) \cdot \gamma + g(\widetilde{\epsilon}_t)\frac{\partial \widetilde{\epsilon}_t}{\partial f_t} \cdot (\alpha(f_t) + f_t \cdot \gamma) = 0$$

with $\frac{\partial \widetilde{\epsilon}_t}{\partial f_t} = -\frac{B+\gamma\cdot(1-G(\widetilde{\epsilon}_t))-G(\widetilde{\epsilon}_t)\cdot\alpha'(f_t)}{\sigma_t G(\widetilde{\epsilon}_t)-g(\widetilde{\epsilon}_t)\cdot(f_t\cdot\gamma+\alpha(f_t))}$

$$\Rightarrow \qquad \underbrace{\frac{(\alpha(f_t^*) + f_t^* \cdot \gamma)\, B g(\widetilde{\epsilon}_t)}{\sigma_t G(\widetilde{\epsilon}_t)}}_{\text{Marginal Effect on Probability of Bad Trading and its Costs}} \qquad = \underbrace{G(\widetilde{\epsilon}_t) \cdot \alpha'(f_t^*) - (1 - G(\widetilde{\epsilon}_t)) \cdot \gamma}_{\text{Marginal Expected Return}}$$

The first order condition wrt. s_t is always greater than 0:

$$N_t \cdot (1 + r_t^f) + g(\widetilde{\epsilon}_t)\frac{\partial \widetilde{\epsilon}_t}{\partial N_t}(\alpha(f_t) + f_t \cdot \gamma) - N_t \cdot (1 + r_t^f) > 0$$

with $\frac{\partial \widetilde{\epsilon}_t}{\partial s_t} = \frac{N_t\cdot(1+r^f)}{\sigma_t G(\widetilde{\epsilon}_t)-g(\widetilde{\epsilon}_t)(\alpha(f_t)+f_t\cdot\gamma)} \geq 0$ in equilibrium. Hence, more equity is always valuable because it reduces the agency conflict. Put differently, the cost of debt is larger than the risk-free rate, which is the return required by the manager. From this follows that the manager either chooses to invest its entire net worth in the intermediary or nothing:

$$\Rightarrow s_t^* = \begin{cases} 0 & \text{if } \mathbb{E}[R_{t+1}^M(N_t, f_t))] \leq N_t \cdot (1 + r_t^f) \\ 1 & \text{if } \mathbb{E}[R_{t+1}^M(N_t, f_t)] \geq N_t \cdot (1 + r_t^f) \end{cases}$$

Second Order Condition:

The second order condition for f_t is:

$$SOC = 2g(\widetilde{\epsilon}_t)(\alpha'(f_t) + \gamma)\frac{\partial \widetilde{\epsilon}_t}{\partial f_t} + G(\widetilde{\epsilon}_t)\alpha''(f_t) + g(\widetilde{\epsilon}_t)\frac{\partial^2 \widetilde{\epsilon}_t}{\partial f_t^2}(\alpha(f_t) + f_t\gamma),$$

with $\frac{\partial^2 \widetilde{\epsilon}_t}{\partial f_t^2} = \frac{g(\widetilde{\epsilon}_t)\frac{\partial \widetilde{\epsilon}_t}{\partial f_t}[2(\alpha'(f_t)+\gamma)-\sigma_t\frac{\partial \widetilde{\epsilon}_t}{\partial f_t}]+G(\widetilde{\epsilon}_t)\alpha''(f_t)}{\sigma_t G(\widetilde{\epsilon}_t)-g(\widetilde{\epsilon}_t)(\alpha(f_t)+f_t\gamma)}$

Combining and rearranging yields:

$$SOC = \frac{g(\widetilde{\epsilon}_t)\frac{\partial \widetilde{\epsilon}_t}{\partial f_t}\sigma_t G(\widetilde{\epsilon}_t)2(\alpha'(f_t) + \gamma) - \overbrace{\sigma_t \left(\frac{\partial \widetilde{\epsilon}_t}{\partial f_t}\right)^2 g(\widetilde{\epsilon}_t)^2 \cdot (\alpha(f_t) + f_t\gamma)}^{\geq 0} + \overbrace{\sigma_t G(\widetilde{\epsilon}_t)\alpha''(f_t)}^{\leq 0}}{\sigma_t G(\widetilde{\epsilon}_t) - g(\widetilde{\epsilon}_t)(\alpha(f_t) + f_t\gamma)} \tag{16}$$

If the FOC holds, i.e. the FOC is 0, then $g(\widetilde{\epsilon}_t)(\alpha(f_t^*)+f_t^*\cdot\gamma) = \sigma_t G(\widetilde{\epsilon}_t)\frac{[G(\widetilde{\epsilon}_t)\cdot\alpha'(f_t^*)-(1-G(\widetilde{\epsilon}_t))\cdot\gamma]}{B}$. Therefore: $\frac{\partial \widetilde{\epsilon}_t}{\partial f_t} = -\frac{B}{\sigma_t G(\widetilde{\epsilon}_t)} < 0$ if the FOC holds.

This extremum is therefore only a maximum if:

$$\sigma_t G(\widetilde{\epsilon}_t) - g(\widetilde{\epsilon}_t)(\alpha(f_t) + f_t\gamma) = \sigma_t \frac{G(\widetilde{\epsilon}_t)}{B} \left[B - [G(\widetilde{\epsilon}_t)(\alpha'(f_t) + \gamma) - \gamma]\right] > 0$$

$\Rightarrow B > G(\widetilde{\epsilon}_t)(\alpha'(f_t) + \gamma) - \gamma$ has to be satisfied

The right hand side converges to 0 as f_t approaches ∞ as long as $N_t < 1$. If $N_t = 1$, then the optimal f_t goes to infinity. I exclude that by constraining $f_t < \overline{f}$. If the FOC is satisfied and $G(\widetilde{\epsilon}_t)(\alpha'(f_t) + \gamma) - \gamma < 0$, the lower constraint on f_t binds and $f_t^* = 0$.

Hence, there are three possible equilibria. $f_t^* = 0$, i.e., at the lower bound, if $G(\widetilde{\epsilon}_t)(\alpha'(0) + \gamma) - \gamma \leq 0$. Second, $f_t^* = \overline{f}$ if $G(\widetilde{\epsilon}_t(\overline{f})) = 1$. An interior solution with $f^* \in [0, \overline{f}]$ is attained when the FOC holds.

Market Clearing:

Aggregate Issuance m_t is defined as the total mass of intermediary managers with $s_{i,t}^* = 1$:

$$m_t^* = \int_0^1 \mathbb{1}_{\{s_{i,t}>0\}} di$$

This is pinned down by market clearing: $\overline{R}_t = \overline{R}(m_t)$ where $\overline{R}_t(m_t) = R_0 - \delta^F log(m_t)$ is firms' downward sloping demand curve. If firms have several projects with different return on investment, then for higher financing costs (i.e., higher loan spread) fewer projects are worth being undertaken and therefore loan demand by firms is lower. $\overline{R}_t(m_t)$ represents the expected payment to loan investors, i.e., intermediaries, and can be interpreted as the loan premium in excess of expected losses from loan defaults.

With a mass of identical intermediary managers, the return from investing in intermediary equity and the risk-free asset will be equalized for all managers and managers will be indifferent between investing 100% or 0 of their net worth in the intermediary:

$$\begin{aligned} \mathbb{E}[R_{t+1}^M(N_t, f_t))] &= N_t \cdot (1 + r_t^f) \\ \overline{R}(m_t) &= 1 + r_t^f - G(\widetilde{\epsilon}_t) \cdot \alpha(f_t) + (1 - G(\widetilde{\epsilon}_t)) f_t \gamma \\ \Rightarrow log(m_t) &= \frac{1}{\delta^F} \left[R_0 - 1 - r^f + G(\widetilde{\epsilon}_t) \cdot \alpha(f_t) - (1 - G(\widetilde{\epsilon}_t)) f_t \gamma\right] \end{aligned} \tag{17}$$

Equilibrium:

Combined this gives three equilibrium conditions:

(i) f_t^* is optimal:

$$\begin{cases} f_t^* = 0 & \text{if } N_t \leq \underline{N_t} \\ \frac{Bg(\widetilde{\epsilon}_t^*)(\alpha(f_t^*)+f_t^*\cdot\gamma)}{\sigma G(\widetilde{\epsilon}_t^*)} = G(\widetilde{\epsilon}_t^*)\cdot\alpha'(f_t^*) - (1-G(\widetilde{\epsilon}_t^*))\cdot\gamma & \text{if } N_t \in (\underline{N_t}, \overline{N_t}) \\ f_t^* = \overline{f} & \text{if } N_t \geq \overline{N_t} \end{cases}$$

(ii) $\widetilde{\epsilon}^*$ satisfies the constraint: $\widetilde{\epsilon}_t^* = \frac{N_t\cdot(1+r_t^f)-f_t^*\cdot B-\sigma_t\int_{\widetilde{\epsilon}_t^*}^{\overline{\epsilon}}\epsilon g(\epsilon)d\epsilon}{\sigma_t G(\widetilde{\epsilon}_t^*)}$

(iii) and markets clear: $log(m_t^*) = \frac{1}{\delta^F}\left[R^0 - (1+r_t^f) + G(\widetilde{\epsilon}_t^*)\alpha(f_t^*) - (1-G(\widetilde{\epsilon}_t^*))\cdot f_t^*\cdot\gamma\right]$

Specifically, the constraint $\widetilde{\epsilon}^*$ incorporates both the debt pricing equation and the market clearing condition.

If the marginal expected return from trading is below 0 even at $f_t = 0$, the manager will definitely choose $f_t = 0$. This is the case if $N_t \leq \underline{N_t}$, where $\underline{N_t}$ is such that $G(\widetilde{\epsilon}_t(\underline{N_t}, f_t = 0))\cdot(\alpha'(0)+\gamma)-\gamma \leq 0$, hence $G(\widetilde{\epsilon}(\underline{N}, f=0)) = \frac{\gamma}{\alpha'(0)+\gamma}$. With a uniform distribution for $\widetilde{\epsilon}$ and with market clearing:

$$\underline{N} = \sigma\frac{\left(\frac{\gamma}{\alpha'(0)+\gamma}\right)^2}{2g(\epsilon)(1+r^f)}$$

If the manager's net worth is so high that the probability of bad trading is 0 even at the highest value of $\overline{f}$, then it will choose $\overline{f}$. This is the case if $N_t \geq \overline{N_t}$, where $\overline{N_t}$ is the lowest value of N_t such that $G(\widetilde{\epsilon}_t(\overline{N_t}, f_t = \overline{f})) = 1$. With a uniform distribution for $\widetilde{\epsilon}$ and with market clearing:

$$\overline{N_t} = \left(\frac{\sigma_t}{2g(\widetilde{\epsilon}_t)} + \overline{f}\cdot B\right)\frac{1}{1+r_t^f}$$

For any values of $N_t \in (\underline{N_t}, \overline{N_t})$, there exists a f_t that satisfies the first order condition. However, this f_t can be outside the bounds $[0, \overline{f}]$. The optimal f_t^* is then 0 if the f_t satisfying the first order condition is below 0, and $\overline{f}$ if it is above $\overline{f}$.

A5.3 Proofs

Proposition 1. *There exists an equilibrium.*

Proof: The only non-standard element is the threshold $\widetilde{\epsilon}$. For an equilibrium to exist, there must be a $\widetilde{\epsilon} \in [\underline{\epsilon}, \overline{\epsilon}]$ such that the constraint is satisfied. However, the relevant constraint is not the one stated in the manager's problem but it is in fact a constraint on $G(\widetilde{\epsilon})$. This is sufficient because only $G(\widetilde{\epsilon})$ is used in the constrained optimization. Then, to prove the existence of a $G(\widetilde{\epsilon})$ that satisfies the constraint one can apply a fixed point theorem. Define the constraint on $G(\widetilde{\epsilon})$ as the following mapping $F : [0,1] \to [0,1]$:

$$F(G(\widetilde{\epsilon})) = G\left[\frac{\overline{R} - 1 + N + G(\widetilde{\epsilon})\alpha(f) - (1 - G(\widetilde{\epsilon})) \cdot f \cdot \gamma - f \cdot B - \sigma \int_{\widetilde{\epsilon}}^{\overline{\epsilon}} \epsilon g(\epsilon) d\epsilon}{\sigma G(\widetilde{\epsilon})}\right],$$

where $G()$ is a CDF and therefore $G : R \to [0,1]$. Hence, as long as $G()$ is continuous (which is the case for all standard distributions), F is a continuous mapping from a closed compact space to itself and therefore satisfies the conditions in Brower's fixed point theorem, i.e. there exists at least one $G(\widetilde{\epsilon}) \in [0,1]$ such that $F(G(\widetilde{\epsilon})) = G(\widetilde{\epsilon})$. ■

Proposition 2. *The optimal discretion f_t^* and aggregate new intermediary issuance m_t^* decline (weakly) with σ_t.*

Proof: I drop the t subscript for the proof. The total derivatives for the three equilibrium conditions are:

$$\frac{dm^*}{d\sigma} = \frac{\partial m^*}{\partial f^*}\frac{df^*}{d\sigma} + \frac{\partial m^*}{\partial \widetilde{\epsilon}^*}\frac{d\widetilde{\epsilon}^*}{d\sigma}$$

$$\frac{d\widetilde{\epsilon}^*}{d\sigma} = \frac{\partial \widetilde{\epsilon}^*}{\partial f^*}\frac{df^*}{d\sigma} + \frac{\partial \widetilde{\epsilon}^*}{\partial \sigma}$$

$$\frac{df^*}{d\sigma} = \frac{\partial f^*}{\partial \widetilde{\epsilon}^*}\frac{d\widetilde{\epsilon}^*}{d\sigma} + \frac{\partial f^*}{\partial \sigma}$$

Combining these three equations:

$$\frac{df^*}{d\sigma} = \frac{\frac{\partial f^*}{\partial \sigma} + \frac{\partial f^*}{\partial \widetilde{\epsilon}^*}\frac{\partial \widetilde{\epsilon}^*}{\partial \sigma}}{1 - \frac{\partial f^*}{\partial \widetilde{\epsilon}}\frac{\partial \widetilde{\epsilon}^*}{\partial f^*}}$$

with $\frac{\partial f^*}{\partial \widetilde{\epsilon}^*} = \frac{\sigma g(\widetilde{\epsilon}^*)[2G(\widetilde{\epsilon}^*)(\alpha'(f)+\gamma)-\gamma]}{(\alpha'(f^*)+\gamma)Bg(\widetilde{\epsilon}^*)-\sigma G(\widetilde{\epsilon}^*)^2\alpha''(f)}$, $\frac{\partial \widetilde{\epsilon}^*}{\partial f^*} = -\frac{B}{\sigma G(\widetilde{\epsilon}^*)}$, $\frac{\partial f^*}{\partial \sigma} = \frac{G(\widetilde{\epsilon}^*)[G(\widetilde{\epsilon}^*)(\alpha'(f)+\gamma)-\gamma]}{(\alpha'(f^*)+\gamma)Bg(\widetilde{\epsilon}^*)-\sigma G(\widetilde{\epsilon}^*)^2\alpha''(f)}$, $\frac{\partial \widetilde{\epsilon}^*}{\partial \sigma} = \frac{-\int_{\widetilde{\epsilon}^*}^{\overline{\epsilon}} \epsilon g(\epsilon)d\epsilon - G(\widetilde{\epsilon}^*)\widetilde{\epsilon}^*}{\sigma G(\widetilde{\epsilon}^*)} = -\frac{G(\widetilde{\epsilon}^*)}{2\sigma g(\widetilde{\epsilon}^*)}$ under a uniform distribution with $\mathbb{E}(\epsilon) = 0$, $\frac{\partial m^*}{\partial \widetilde{\epsilon}^*} = m^* \cdot \frac{1}{\delta^F} \cdot g(\widetilde{\epsilon}^*)(\alpha(f^*) + f^* \cdot \gamma)$, and $\frac{\partial m^*}{\partial f^*} = m^* \cdot \frac{1}{\delta^F} \cdot [G(\widetilde{\epsilon}^*)(\alpha'(f) + \gamma) - \gamma]$

If $f^* > 0$ and no corner solution, $\sigma G(\widetilde{\epsilon}^*) - g(\widetilde{\epsilon}^*)(\alpha(f^*) + f^*\gamma) > 0$, $B + \gamma \cdot (1 - G(\widetilde{\epsilon}^*)) - G(\widetilde{\epsilon}^*) \cdot \alpha'(f) > 0$, and $G(\widetilde{\epsilon}^*)(\alpha'(f) + \gamma) - \gamma > 0$ by the second order condition. Therefore, $\frac{\partial f^*}{\partial \widetilde{\epsilon}^*} > 0$, $\frac{\partial \widetilde{\epsilon}^*}{\partial f^*} < 0$, $\frac{\partial m^*}{\partial f^*} > 0$, and $\frac{\partial m}{\partial \widetilde{\epsilon}^*} > 0$. Hence, the denominator is greater than 0 $\left(1 - \frac{\partial f^*}{\partial \widetilde{\epsilon}^*}\frac{\partial \widetilde{\epsilon}^*}{\partial f^*} > 0\right)$.

For $\frac{df^*}{d\sigma} < 0$, the numerator has to be smaller than 0 ($\frac{\partial f^*}{\partial \sigma} + \frac{\partial f^*}{\partial \widetilde{\epsilon}^*}\frac{\partial \widetilde{\epsilon}^*}{\partial \sigma} < 0$):

$$\begin{aligned}\frac{\partial f^*}{\partial \sigma} + \frac{\partial f^*}{\partial \widetilde{\epsilon}^*}\frac{\partial \widetilde{\epsilon}^*}{\partial \sigma} &= \frac{G(\widetilde{\epsilon}^*)[G(\widetilde{\epsilon}^*)(\alpha'(f)+\gamma)-\gamma]}{(\alpha'(f^*)+\gamma)Bg(\widetilde{\epsilon}^*)-\sigma G(\widetilde{\epsilon}^*)^2\alpha''(f)} - \frac{\sigma g(\widetilde{\epsilon}^*)[2G(\widetilde{\epsilon}^*)(\alpha'(f)+\gamma)-\gamma]}{(\alpha'(f^*)+\gamma)Bg(\widetilde{\epsilon}^*)-\sigma G(\widetilde{\epsilon}^*)^2\alpha''(f)}\frac{G(\widetilde{\epsilon}^*)}{2\sigma g(\widetilde{\epsilon}^*)} = \\ &= G(\widetilde{\epsilon}^*)(\alpha'(f)+\gamma)-\gamma-G(\widetilde{\epsilon}^*)(\alpha'(f)+\gamma)+\frac{\gamma}{2} = -\frac{\gamma}{2} < 0\end{aligned}$$

Regarding corner solutions for f^*, the argument is simple if $f^* = \overline{f}$. The optimal discretion is already on the upper bound can only (weakly) decline. If $N < \underline{N}$, then $f^* = 0$. $\underline{N}$ is the value of N such that the marginal return from trading is zero, which under a uniform distributions results in $\underline{N} = \sigma\frac{\left(\frac{\gamma}{\alpha'(0)+\gamma}\right)^2}{2g(\epsilon)(1+r^f)}$. Therefore, also under a higher return volatility, the same level of net worth remains below $\underline{N}$, and thus $f^* = 0$. This concludes the proof that $\frac{df^*}{d\sigma} \leq 0$.

For an interior solution in f^*, combining the total derivative wrt. σ for all three equilibrium conditions and solving for $\frac{dm^*}{d\sigma}$:

$$\frac{dm^*}{d\sigma} = \frac{df^*}{d\sigma}\left(\underbrace{\frac{\partial m^*}{\partial f^*} + \frac{\partial m^*}{\partial \widetilde{\epsilon}^*}\frac{\partial \widetilde{\epsilon}^*}{\partial f^*}}_{=A}\right) + \underbrace{\frac{\partial m^*}{\partial \widetilde{\epsilon}^*}}_{>0}\underbrace{\frac{\partial \widetilde{\epsilon}^*}{\partial \sigma}}_{<0}, \tag{18}$$

where $A = 0$:

$$\begin{aligned}A &= \frac{\partial m^*}{\partial f^*} + \frac{\partial m^*}{\partial \widetilde{\epsilon}^*}\frac{\partial \widetilde{\epsilon}^*}{\partial f^*} = \\ &= m^* \cdot \frac{1}{\delta^F}[G(\widetilde{\epsilon}^*)(\alpha'(f)+\gamma)-\gamma] - \\ &- m^* \cdot \frac{1}{\delta^F}g(\widetilde{\epsilon}^*)(\alpha(f^*)+f^*\cdot\gamma)\cdot\frac{B-[G(\widetilde{\epsilon}^*)(\alpha'(f)+\gamma)-\gamma]}{\sigma G(\widetilde{\epsilon}^*)-g(\widetilde{\epsilon}^*)\cdot(f\cdot\gamma+\alpha(f))} = \\ &= \frac{m^*\cdot\frac{1}{\delta^F}}{\sigma G(\widetilde{\epsilon}^*)-g(\widetilde{\epsilon}^*)\cdot(f\cdot\gamma+\alpha(f))}\underbrace{[\sigma G(\widetilde{\epsilon}^*)[G(\widetilde{\epsilon}^*)(\alpha'(f)+\gamma)-\gamma]-Bg(\widetilde{\epsilon}^*)\cdot(f\cdot\gamma+\alpha(f))]}_{=0 \text{ by FOC for f}} = 0\end{aligned}$$

From this follows that:

$$\frac{dm^*}{d\sigma} = \frac{\partial m^*}{\partial \widetilde{\epsilon}^*}\frac{\partial \widetilde{\epsilon}^*}{\partial \sigma} < 0 \tag{19}$$

For corner solutions in f^*, issuance declines weakly in σ. If $f^* = 0$, then $m^* = exp\left\{\frac{1}{\delta^F}\left[R_0 - 1 - r^f\right]\right\}$. Since in this case discretion remains at zero for a higher value of σ, the expected return from equity and therefore m^* remain constant. If $f^* = \overline{f}$ and $G(\widetilde{\epsilon}^*) = 1$, then issuance remains the same. If $f^* = \overline{f}$ and $G(\widetilde{\epsilon}^*) < 1$, then Equation 18 with

$A = 0$ and Equation 19 apply. Consequently, $\frac{dm^*}{d\sigma} \leq 0$.

$\blacksquare$

Proposition 3. *The optimal discretion f_t^* and aggregate new intermediary issuance m_t^* increase (weakly) with N_t.*

Proof: I drop the t subscript for the proof. The total derivatives of the three equilibrium conditions wrt. N are:

$$\frac{dm^*}{dN} = \frac{\partial m^*}{\partial f^*}\frac{df^*}{dN} + \frac{\partial m^*}{\partial \widetilde{\epsilon}^*}\frac{d\widetilde{\epsilon}^*}{dN}$$

$$\frac{d\widetilde{\epsilon}^*}{dN} = \frac{\partial \widetilde{\epsilon}^*}{\partial f^*}\frac{df^*}{dN} + \frac{\partial \widetilde{\epsilon}^*}{\partial N}$$

$$\frac{df^*}{dN} = \frac{\partial f^*}{\partial \widetilde{\epsilon}^*}\frac{d\widetilde{\epsilon}^*}{dN}$$

with $\frac{\partial \widetilde{\epsilon}^*}{\partial N} = \frac{1+r^f}{\sigma G(\widetilde{\epsilon}^*)}$ Combining the last two equations:

$$\frac{df^*}{dN} = \frac{\frac{\partial f^*}{\partial \widetilde{\epsilon}^*}\frac{\partial \widetilde{\epsilon}^*}{\partial N}}{1 - \frac{\partial f^*}{\partial \widetilde{\epsilon}^*}\frac{\partial \widetilde{\epsilon}^*}{\partial f^*}} > 0$$

Regarding corner solutions: If $N \leq \underline{N}$ and therefore $f^* = 0$, optimal discretion will remain at 0 if for the higher value of N it is still the case that $N \leq \underline{N}$. Otherwise, it will increase. Similarly, if $N \geq \underline{N}$ then a higher net worth will not change f^*. Hence, f^* weakly increases in N.

Combining the first two total derivatives:

$$\frac{dm^*}{dN} = \left(\underbrace{\frac{\partial m^*}{\partial f^*} + \frac{\partial m^*}{\partial \widetilde{\epsilon}^*}\frac{\partial \widetilde{\epsilon}^*}{\partial f^*}}_{=0 \text{ as shown before}}\right)\frac{df^*}{dN} + \frac{\partial m^*}{\partial \widetilde{\epsilon}^*}\frac{\partial \widetilde{\epsilon}^*}{\partial N} = \frac{\partial m^*}{\partial \widetilde{\epsilon}^*}\frac{\partial \widetilde{\epsilon}^*}{\partial N} > 0$$

If $\epsilon_{\widetilde{\epsilon}} > \bar{\epsilon}$, then $G(\epsilon_{\widetilde{\epsilon}}) = 1$, $\frac{dG(\epsilon_{\widetilde{\epsilon}}}{dN} = 0$, and hence $\frac{dm^*}{dN} = 0$. Consequently, $\frac{dm^*}{d\sigma} \leq 0$.

$\blacksquare$

A5.4 Mapping of OC test to model

The OC test states that when $\frac{A^{OC}}{D} < 1+\tau$, all interest payments are directed to pay down principle for debt investors until $\frac{A^{OC}}{D} = 1+\tau$, where A^{OC} is the asset value as calculated for OC test purposes, and $1+\tau$ defines the OC test threshold. To incorporate the OC test in the model more specifically, I extend it by adding another period $t = 3$. After trading in $t = 2$, only parts of the cash flows are distributed between investors. The remainder is distributed in $t = 3$. Denote the value of the assets after the return is realized now as $A = \overline{R} - \sigma\epsilon$. Let w be the interest payments which is the cash flow of the assets paid in $t = 2$, and of which –if there is no OC test violation – s are distributed to debt investors and d to the manager. $A - w$ are the remaining cash flows distributed in $t = 3$.

Suppose that $A < D(1+\tau)$, i.e. without trading the OC test would be violated. The purpose is to illustrate the gross gain from trading against OC test violations for the manager, therefore I ignore the cost, namely *gamma*, in this section. Then, the payoffs would be:

- Payoff to debt investor if **no** trading against OC test failure:
  $\underbrace{s + min\{w - s, D - s - \frac{A}{1+\tau}\}}_{w^D(\tau)} + \beta min\{A - w, D - w^D(\tau)\}$
- Payoff to manager if **no** trading against OC test failure:
  $w - w^D(\tau) + \beta max\{A - w - (D - w^D(\tau)), 0\}$
- Payoff to debt investor if trading against OC test failure:
  $s + \beta min\{A - w, D - s\}$
- Payoff to manager if trading against OC test failure:
  $d + \beta max\{A - w - (D - s) - \gamma, 0\}$,

where β is the common one period discount rate, and $w^D(\tau)$ is the immediate payment the debt investor receives when the OC test is failed. Since when CLOs fail the OC test, interest payments are redirected to debt investors until it does not violate the OC test anymore, the maximum debt investors can receive is either $D - s - \frac{A}{1+\tau}$ or the entire interest payment w.

The gain from trading against the OC test violation for the manager is then:

$$d + \beta max\{A - w - (D - s), 0\} - \big(w - w^D(\tau) + \beta max\{A - w - (D - w^D(\tau)), 0\}\big) \quad (20)$$

If A is sufficiently high, i.e., $A - w - (D - s) \geq 0$, then the entire gain from trading against OC test violation comes from receiving payments earlier:

$$B = (1-\beta) \cdot min\{d, D - s - \frac{A}{1+\tau}\} \tag{21}$$

This means, the value of the assets is sufficiently high to pay all debt obligations. Whether the OC test is failed or not merely determines when debt investors and the manager are paid respectively. If $\beta < 1$, i.e., the manager is impatient, then it will value earlier payments.

If, instead, $A - w - (D - s) \leq 0$, then the gain from trading against the OC test is:

$$B = min\{d, D - s - \frac{A}{1+\tau}\} \tag{22}$$

In the baseline model I focus on the scenario in which $\beta = 1$, i.e. the manager (and debt investors) are patient, and where $1 + \tau$ is sufficiently high such that $D - s - \frac{A}{1+\tau} > d$ for all asset values for which the manager would engage in bad trading to avoid OC test failures. Hence, this case maps to the baseline model with $B = d$.

In Appendix section A5.5, I relax this assumption and let τ be set endogenously.

A5.5 Extension: Risk-shifting and OC test threshold

In this section, I extend the model to incorporate a risk-shifting problem and allow for the OC test threshold to be endogenous. This will provide a prediction regarding the OC test threshold that is consistent with the empirical findings in section 6.2. Note, I summarize the current value of the project, $\overline{R} - \sigma\epsilon$, with the letter A in this section for brevity.

Suppose, there are now three types of portfolios the manager can buy (or three types of trading it can engage in), which have the following payoffs:

1. Alpha portfolio: $A + \alpha(f)$
2. Trading against OC test portfolio: $A - f\gamma$
3. Risk-shifting portfolio: $A - f\Gamma$,

where Γ¿γ. The problem is as before, but now the risk-shifting portfolio provides a third option for the manager. Importantly, I assume the risk-shifting problem is more socially more costly than trading against the OC test which is designed to disincentivize risk-shifting. This seems reasonable, given that the OC test is voluntarily included in the contract by the manager.

The respective payoffs to the equity investors are therefore:

1. Alpha portfolio: $max\{A + \alpha(f) - D, 0\}$

2. Trading against OC test portfolio: $max\{A - f\gamma - fB - D, fB\}$

3. Risk-shifting portfolio: $max\{A - f\Gamma - fb - D, fb\}$,

where b represents the value transfer from debt investors to the manager (i.e. the equity investor). One way to think about risk-shifting is through the perspective of option pricing since the manager's equity claim resembles a call option on the assets with strike price D, and the debt claim a short-put option with the same strike price Merton (1974). Increasing the risk of the underlying assets increases the value of the call option and reduce the value of the short-put option equivalently. b then represents the increase in the option value of the equity claim, or equivalently the decline in the debt claim's option value.

The optimal trading by the manager generates alpha iff: $A + \alpha(f) - D \geq max\{fB, fb\}$. I now allow the manager to endogenously set the value for B when designing the contract in $t = 0$. Since risk-shifting is more inefficient, and its costs ultimately borne by the manager, it will set B high enough to prevent risk-shifting, but then as low as possible to induce as much trading in the alpha portfolio as possible. Hence, it will set $B = b$. Therefore, the manager will never engage in risk-shifting but trade against the OC test if $A + \alpha(f) - D \leq f \cdot B$.

One way for the manager to set B, i.e. the manager's gain from trading against the OC test, is to set the OC threshold. As shown in Appendix section A5.4, the benefit B from not violating the OC test is weakly increasing in τ, the OC threshold. Intuitively, upon failing the OC test, a higher OC threshold increases the cash flows debt investors receive before the manager obtains any payment because it takes more payments to debt investors to be in compliance with the OC test again. Therefore, it becomes more attractive for equity investors not to fail the OC test.

If in bad times the attractiveness of risk-shifting b increases, for instance because there are more risky assets to trade in, then the manager optimally increases (weakly) the OC threshold to increase the attractiveness of trading against OC test violations. Hence, an increase of the risk-shifting problem can rationalize the higher OC threshold of newly originated CLOs in bad times as shown in Figure 8.

A5.6 Extension: Short-term Debt

A large literature studies theoretically the advantages of short-term debt in disciplining intermediary managers (e.g., Calomiris and Kahn (1991), Diamond and Rajan (2001), Eisenbach (2017)).

Suppose, the manager can also choose to finance itself with short-term debt in order to provide itself with incentives to generate alpha instead of diverting value away from debt investors in default states. Informed investors can threaten to run on the intermediary if the manager does not generate alpha, which eliminates the any value the manager receives from bad trading. In such case, the manager engages in good trading iff:

$$max\{\overline{R} - \sigma\epsilon + \alpha(f) - D, 0\} \geq 0, \tag{23}$$

which is always satisfied.

However, short-term debt is costly. It requires that at least some investors invest in information acquisition in order to detect as soon as the manager starts trading at the expense of debt investors. Calomiris and Kahn (1991) shows that this creates a free-rider problem where each investor has the incentive to rely on others to provide the disciplining service. In case the liquidation of the intermediary is costly because long-term assets have to be sold at a discount, this free-rider problem is solved by a sequential-servicing constraint, which provides those investors that invested in information with a higher payoff because they run first. However, this leads to multiple equilibria with the possibility of inefficient "panic" runs (Diamond and Dybvig (1983)).

I add short-term debt as additional optional contract in the model to uncover the necessary condition for why CLO managers (and other long-term financed intermediaries with agency frictions) prefer long-term funding, and what distinguishes them from short-term funded intermediaries such as open-end mutual funds.

For a run by informed creditors to be credible it most be optimal. Suppose, $\epsilon > \widetilde{\epsilon}$ and the manager with full discretion would divert cash flows from debt investors if not disciplined. Running on short-term is only credible iff:

$$\begin{aligned} \overline{R} - \sigma\epsilon - \overline{f} \cdot (B + \gamma) &\leq \overline{R} - \sigma\epsilon - \lambda \\ \lambda &\leq \overline{f} \cdot (B + \gamma) \end{aligned} \tag{24}$$

The liquidation costs, λ must be lower than the costs of misbehaving by the manager.

Moreover, even if a run is credible, long-term debt is optimal if information acquisition costs and the expected liquidation costs through "panic" runs are higher than the agency costs –the cost of not generating all possible alpha in all states. Consider a scenario in which with probability p investors panic and force a costly liquidation before the manager can engage in any trading. Moreover, investors need to pay in all states κ to acquire information about the manager's trading. The manager –who optimally maximizes the social welfare of the debt contract – chooses long-term debt as long as:

$$\alpha(\overline{f}) - G(\widetilde{\epsilon}) \cdot \alpha(f^*) + (1 - G(\widetilde{\epsilon}))f^*\gamma \leq p\lambda + \kappa \tag{25}$$

Hence, the optimal debt maturity is long-term if $\lambda \geq max\left\{\overline{f} \cdot (B+\gamma), \frac{\alpha(\overline{f}) - G(\widetilde{\epsilon}) \cdot \alpha(f^*) + (1-G(\widetilde{\epsilon}))f^*\gamma - \kappa}{p}\right\}$. Intermediaries that invest in illiquid assets, such as CLOs, prefer long-term debt because the liquidations costs would be too high. In particular, when the agency costs can be limited to $\alpha(\overline{f})$ in the worst case by reducing the discretion.

A5.7 Extension: Refinancing

Clearly, managers would like to restrict their ability to engage in bad trading to lower their ex-ante financing costs. The agency problem would disappear if one could force the manager to generate alpha, which is difficult to achieve without perfect contracts. One form of improvement, however, would be to take discretion away from managers (without any cost) as soon as they have the incentive to engage in bad trading. Writing a contract with state contingent discretion seems not possible because managers could trade to change the not perfectly defined "state" as they do in the case of the OC test. An alternative that can nonetheless provide state-contingent discretion are refinancings/reset. CLOs typically have the option to be refinanced/reset, where managers approach their investors to –for instance– extend the reinvestment period. However, this is costly because one needs to hire an investment bank and lawyers to approach investors and change the terms, and obtain an updated rating from a rating agency. Denote this cost c.

I now introduce a refinancing option in the model, and derive how the initial choice of discretion and issuance changes. I mark the choices under the refinancing model with a superscript r and for now I drop the t subscript. I assume that when refinancing, the manager obtains full discretion. With the refinancing option, the manager sets the initial discretion optimally to zero because in the good state the gain from using the refinancing option – $\alpha(\overline{f}) - c$ – is independent of the initial discretion, while the degree of bad trading in the bad state is minimized with initial discretion $f^r = 0$. In this sense, the refinancing option allows to implement state-dependent discretion.

Investors only allow the manager to refinance if the manager subsequently generates alpha:

$$\overline{R} - D^r + \alpha(\overline{f}) - c - \sigma\epsilon \geq \overline{f}B$$

$$\widetilde{\epsilon}^r = \frac{\overline{R} - D^r + \alpha(\overline{f}) - c - \overline{f}B}{\sigma}$$

The manager's expected return when setting $f^r = 0$ and including a refinancing option in the contract is:

$$\mathbb{E}_t[R^{M,r}_{t+1}] = \overline{R_t} - (1 - N_t) \cdot (1 + r^f_t) + G(\widetilde{\epsilon}^r_t)(\alpha(\overline{f}) - c)$$

Alternatively, the manager can choose the optimal discretion and earn in expectation:

$$\mathbb{E}_t[R^M_{t+1}] = \overline{R_t} - (1 - N_t) \cdot (1 + r^f_t) + G(\widetilde{\epsilon}_t)\alpha(f_t) - (1 - G(\widetilde{\epsilon}_t)) \cdot f_t \cdot \gamma$$

Clearly, if $G(\widetilde{\epsilon}_t{}^*$ is sufficiently low, then setting $f = 0$ and including a refinancing option in the contract has the higher expected return. Similarly, if $G(\widetilde{\epsilon}_t{}^*$ is sufficiently high, and thus also f^*, then choosing $f^* > 0$ and never refinance because $\alpha(f^*_t) > \alpha(\overline{f}) - c$ is optimal. Thus, for a given σ, there exists a level $\widetilde{N}$, s.t. choosing the refinancing option is optimal only if $N \leq \widetilde{N}$.

Therefore, with the refinancing option, the equilibrium is then:

1. As the baseline equilibrium if $N_t \geq \widetilde{N}(\sigma_t)$

2. Otherwise, the manager chooses initial $f^r_t = 0$, and refinances with $f^r_{t+1} = \overline{f}$ at cost c if $\epsilon_{t+1} \leq \widetilde{\epsilon}^r_t$. The constraint and level of issuance under this choice are:

   (i) $\widetilde{\epsilon}^r_t = \frac{N_t \cdot (1+r^f_t) - G(\widetilde{\epsilon}^r_t)\overline{f}B) - \sigma_t \int_{\widetilde{\epsilon}^r_t}^{\overline{\epsilon}} \epsilon_{t+1} g(\epsilon_{t+1}) d\epsilon_{t+1}}{\sigma_t G(\widetilde{\epsilon}^r_t)}$

   (i) $log(m^r_t) = \frac{1}{\delta^F}\left[R_0 - 1 - r^f_t + G(\widetilde{\epsilon}^r_t) \cdot \big(\alpha(\overline{f}) - c\big)\right]$

A5.8 Extension: Outside Equity Issuance

This extension allows CLO managers to issue outside equity financing at cost $c(\Delta E_t) = k(\Delta E_t)^2$, where $\Delta E_t = E_t - N_t$ is the amount of equity that is issued, E_t is the total (i.e., inside + outside) equity financing of the intermediary, and k is a parameter for the cost of outside equity issuance. There are several reasons why outside equity financing is costly. For instance, outside equity dilutes the manager's incentive to exercise costly effort that improves overall returns (e.g., Jensen and Meckling (1976), Hébert (2018)).

I assume that the issuance cost is paid to the outside equity investors who in addition need $\Delta E \cdot (1 + r^f)$ as compensation. The resulting share of total equity payments paid to the manager is denoted π_t

Optimal trading in t+1:

The manager engages in good trading iff:

$$\pi_t \cdot (\overline{R}_t - \sigma_t \epsilon_{t+1} + \alpha(f_t) - D_t) \geq \pi_t \cdot f_t \cdot B$$

$$\Rightarrow \widetilde{\epsilon}_t = \frac{\overline{R}_t - D_t + \alpha(f_t) - f_t \cdot B}{\sigma_t}, \tag{26}$$

which is the same cut-off value $\widetilde{\epsilon}_t$ as before.

The manager's problem in t then becomes:

Manager problem in t:

$$\max_{s_t, f_t, E_t} \; \rho \left(\pi_t \cdot \mathbb{E}_t[R^E_{t+1}(E_t)] + (1 - s_t) \cdot N_t \cdot (1 + r^f_t) \right)$$

$$\widetilde{\epsilon}_t = \frac{\overline{R}_t - (1 - E_t) \cdot (1 + r^f_t) + G(\widetilde{\epsilon}_t)\alpha(f_t) - (1 - G(\widetilde{\epsilon}_t)) \cdot f_t \cdot \gamma - f_t \cdot B - \sigma_t \int_{\widetilde{\epsilon}_t}^{\overline{\epsilon}} \epsilon g(\epsilon) d\epsilon}{\sigma_t G(\widetilde{\epsilon}_t)}$$

$$f_t \in [0, \overline{f}]$$

The notation already takes into account that $s^* = \{0, 1\}$, i.e. that a manager setting up a CLO invests the entire net worth in the CLO, and so the entire equity invested in the CLO is comprised of the manager's net worth and the raised outside equity: $E_t = N_t + \Delta E_t$

The profit share π_t that the manager receives is determined by outside investors' required expected return, which compensates them with the risk-free rate and the equity issuance costs:

$$(1-\pi_t) \left(\overline{R}_t - (1 - E_t) \cdot (1 + r^f_t) + G(\widetilde{\epsilon}_t)\alpha(f_t) - (1 - G(\widetilde{\epsilon}_t)) \cdot f_t \cdot \gamma \right) = \Delta E_t \cdot (1+r^f) + k(\Delta E_t)^2$$

From this one can rewrite manager's expected return from their intermediary investment – and thus their objective function conditional on investing in the intermediary – as:

$$\max_{f_t, E_t} \; \overline{R}_t - (1 - N_t) \cdot (1 + r^f_t) + G(\widetilde{\epsilon}_t)\alpha(f_t) - (1 - G(\widetilde{\epsilon}_t)) \cdot f_t \cdot \gamma - k(\Delta E)^2$$

Thus, the manager now maximizes the sum of the expected return from trading $G(\widetilde{\epsilon}_t)\alpha(f_t) - (1 - G(\widetilde{\epsilon}_t)) \cdot f_t \cdot \gamma$ and equity issuance costs $-k(\Delta E)^2$. **FOCs:**

For f, the FOC is as before, which leads to the following expression for optimal f_t^*:

$$\underbrace{\frac{\left(\alpha(f_t^*) + f_t^* \cdot \gamma\right) Bg(\widetilde{\epsilon}_t^*)}{\sigma_t G(\widetilde{\epsilon}_t^*)}}_{\text{Marginal Effect on Probability of Bad Trading and its Costs}} = \underbrace{G(\widetilde{\epsilon}_t^*) \cdot \alpha'(f_t^*) - (1 - G(\widetilde{\epsilon}_t^*)) \cdot \gamma}_{\text{Marginal Expected Return}}$$

For ΔE, the FOC is:

$$g(\widetilde{\epsilon}_t)(\alpha(f_t) + f_t\gamma)\frac{\partial \widetilde{\epsilon}_t}{\partial E_t} - 2k(\Delta E_t) = 0$$

with $\frac{\partial \widetilde{\epsilon}_t}{\partial E_t} = \frac{1+r_t^f}{\sigma G(\widetilde{\epsilon}_t) - g(\widetilde{\epsilon}_t)(\alpha(f_t)+f_t\gamma)}$

$$\Rightarrow \Delta E_t^* = \frac{\left(\alpha(f_t^*) + f_t^* \cdot \gamma\right) g(\widetilde{\epsilon}_t^*)(1 + r_t^f)}{\left[\sigma_t G(\widetilde{\epsilon}_t^*) - \left(\alpha(f_t^*) + f_t^* \cdot \gamma\right) g(\widetilde{\epsilon}_t^*)\right] 2k}$$

Market Clearing:

Managers need to break even, which determines aggregate issuance:

$$\overline{R}_t - (1 - E_t) \cdot (1 + r_t^f) + G(\widetilde{\epsilon}_t)\alpha(f_t) - (1 - G(\widetilde{\epsilon}_t)) \cdot f_t \cdot \gamma - \Delta E \cdot (1 + r^f) - k(\Delta E_t)^2 = N_t \cdot (1 + r^f)$$

$$\Rightarrow \overline{R}(m_t) = 1 + r^f - G(\widetilde{\epsilon}_t)\alpha(f_t) + (1 - G(\widetilde{\epsilon}_t)) \cdot f_t \cdot \gamma + k(\Delta E_t)^2$$

with the loan demand function $\overline{R}_t(m_t) = R_0 - \delta^F log(m_t)$ this becomes:

$$\Rightarrow log(m_t^*) = \frac{1}{\delta^F}\left[R^0 - 1 - r_t^f + G(\widetilde{\epsilon}_t^*) \cdot \alpha(f_t^*) - (1 - G(\widetilde{\epsilon}_t^*))f_t^*\gamma - k(\Delta E_t^*)^2\right]$$

Combining the market clearing condition with the constraint on $\widetilde{\epsilon}_t$:

$$\widetilde{\epsilon}_t^* = \frac{E_t^* \cdot (1 + r_t^f) + k\Delta E_t^{*2} - f_t^* \cdot B - \sigma_t \int_{\widetilde{\epsilon}_t^*}^{\overline{\epsilon}} \epsilon g(\epsilon) d\epsilon}{\sigma_t G(\widetilde{\epsilon}_t^*)}$$

Profit share for the manager:

The manager's profit share is then:

$$\pi_t = \frac{\overline{R}_t - (1 - N_t) \cdot (1 + r_t^f) + G(\widetilde{\epsilon}_t)\alpha(f_t) - (1 - G(\widetilde{\epsilon}_t)) \cdot f_t \cdot \gamma - k(\Delta E_t)^2}{\overline{R}_t - (1 - E_t) \cdot (1 + r_t^f) + G(\widetilde{\epsilon}_t)\alpha(f_t) - (1 - G(\widetilde{\epsilon}_t)) \cdot f_t \cdot \gamma}$$

with the market clearing condition, this becomes:

$$\pi_t^* = \frac{N_t^* \cdot (1 + r^f)}{E_t^* \cdot (1 + r^f) + k(\Delta E_t^*)^2}$$

Equilibrium Conditions:

This results then in the following equilibrium conditions:

1. $\Delta E_t^* = \frac{(\alpha(f_t^*)+f_t^*\cdot\gamma)g(\widetilde{\epsilon}_t^*)(1+r_t^f)}{[\sigma_t G(\widetilde{\epsilon}_t^*)-(\alpha(f_t^*)+f_t^*\cdot\gamma)g(\widetilde{\epsilon}_t^*)]2k}$

2. $\frac{(\alpha(f_t^*)+f_t^*\cdot\gamma)Bg(\widetilde{\epsilon}_t^*)}{\sigma_t G(\widetilde{\epsilon}_t^*)} = G(\widetilde{\epsilon}_t^*)\cdot\alpha'(f_t^*) - (1-G(\widetilde{\epsilon}_t^*))\cdot\gamma$

3. $\widetilde{\epsilon}_t = \frac{E_t^*\cdot(1+r_t^f)+k\Delta E_t^{*2}-f_t^*\cdot B-\sigma_t\int_{\widetilde{\epsilon}_t^*}^{\overline{\epsilon}}\epsilon g(\epsilon)d\epsilon}{\sigma_t G(\widetilde{\epsilon}_t^*)}$

4. $log(m_t^*) = \frac{1}{\delta^F}\left[R^0 - 1 - r_t^f + G(\widetilde{\epsilon}_t^*)\cdot\alpha(f_t^*) - (1-G(\widetilde{\epsilon}_t^*))f_t^*\gamma - k(\Delta E_t^*)^2\right]$

A6 Calibration Details

A6.1 Volatility calibration

The model implies the following CLO debt pricing equation from the perspective of debt investors:

$$q \cdot FV = G(\widetilde{\epsilon}) \cdot FV \cdot (1+c) + \int_{\widetilde{\epsilon}}^{\overline{\epsilon}} (\overline{R} - \sigma\sqrt{T}\epsilon) g(\epsilon) d\epsilon - (1 - G(\widetilde{\epsilon}))(B+\gamma)f, \qquad (27)$$

$$\text{with } \epsilon_{\widetilde{\epsilon}} = \frac{\overline{R} - FV \cdot (1+c) - fB + \alpha(f)}{\sigma\sqrt{T}}$$

where q is the price per dollar of face value FV, c is the promised coupon payment, σ is the annual volatility of returns, and T is the maturity.

Rewriting the price in terms of promised cash flows discounted at a spread s plus a risk-free rate r^f, yields:

$$\begin{aligned} q \cdot FV &= \frac{FV \cdot (1+c)}{(1+s)^T} \\ \Rightarrow s &= \left(\frac{1+c}{q}\right)^{\frac{1}{T}} - 1 \end{aligned} \qquad (28)$$

For the indirect inference of the volatility, I start by defining an equal-spaced grid for the volatility σ with 500 values ranging from 0 to 0.3. For each σ, I solve for the spread as in equation 28 for 300 different values in f ranging from 0.8 to 4.9 (the 10th and 90th percentile for the remaining length in the reinvestment period in the spread panel (Table 1)), and add a pricing error $u \sim N(0, 0.001)$. I set c to the average coupon (275.5 bps), $\overline{R} - FV$ to the average equity ratio (6%) and T to the average maturity (2.17 years) in the spread sample (see Table 1). All parameters are calibrated as in Table 7. After calculating the spread, I add the difference between the average spread in the data sample (414 bps as in Panel (C) of Table 1) and the average spread of the model sample, which ensures that the average spreads are identical in the two samples. Moreover, I transform the spreads in basis points and take the logarithm, equivalent to the empirical analysis. After that, I regress the log-spreads on the level of f to obtain the coefficient $\beta(\sigma)$, equivalent to the empirical regression specified in equation 1. For the initial volatility, I select σ_0 such that $\beta(\sigma_0)$ equals the reduced-form coefficient from Column (3) in Table 3 for a value in the VIX of -0.05 – the average quarterly standarized VIX in the period 2004Q1-2020Q4, for which origination data is available. This results in $\beta(\hat{\sigma}_0) = 4.34 + 0.94 \cdot (-0.05)$. Note, I standardize the VIX over its entire period from 2004Q1-2020Q4 throughout the paper to make it comparable across different sample periods. For the volatility in the first period after the shock, and thus the change in the volatility caused by the shock, I select the volatility σ_1 that corresponds to a 1 standard deviation higher VIX. Specifically, I match the regression coefficient to the reduced-form coefficient for a value of $-0.05+1 = 0.95$ in the standardized VIX: $\beta(\sigma_1) = 4.34 + 0.94 \cdot (-0.05 + 1)$.

Another factor to consider is the maturity. The calibration of the shock takes into account the maturity of CLO bonds and provides the change in the expected annual volatility (see above). When calculating the model implied issuance, I also take into account the maturity of loans by (a) replacing the total volatility in the model with the annual volatility times the maturity: $\sigma_t \cdot \sqrt{T}$, and (b) replacing firms' total loan demand elasticity with the annual elasticity times the maturity: $\delta_F \cdot T$. I set T to the typical leveraged loan maturity of 5 years.