The Externalities of Fire Sales: Evidence from Collateralized Loan Obligations*

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Shohini Kundu†

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Abstract

I investigate how covenants, intrinsic to *Collateralized Loan Obligation* (CLO) indentures, provide a mechanism through which idiosyncratic shocks may be amplified, imposing negative externalities on other firms in the CLO portfolio. To this aim, I exploit cross-sectional variation in CLO exposure to the Oil & Gas (O&G) industry, as well as the timing of the O&G bust in 2014 to study how non-O&G firms in CLO portfolios are affected. I find that when CLOs are subject to idiosyncratic shocks that push them closer to their covenant constraints, they fire-sell unrelated loans in the secondary loan market to alleviate these constraints. The ex-post, secondary market spread becomes the effective cost of capital for these innocent bystanders, as the expected rate of return across debt instruments is equalized in market equilibrium. In response, firms make financial and real adjustments. These adjustments are most pronounced for riskier firms held in CLO portfolios, whose loans are marked at market prices, as selling mark-to-market loans can generate greater slack in the covenant constraints. As the sample period for this study is 2012-2017, a relatively benign macroeconomic period, the effects may be significantly larger during times of stress such as Spring of 2020, at the outset of the COVID-19 pandemic.

JEL Classification: E44, G23, E32, E22, G33, G14, G18

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†Shohini Kundu is at the University of Chicago Booth School of Business. email: skundu@chicagobooth.edu

1 Introduction

Financial contracts include provisions intended to align incentives and mitigate capital market imperfections. However, some provisions in contracts may also catalyze fire sales and trigger amplification, fomenting instability. In this paper, I demonstrate how covenants that are intrinsic to managerial Collateralized Loan Obligation (CLO) contracts may kindle fire sales after adverse shocks, impacting firms whose creditworthiness is orthogonal to the shocks themselves. Covenants fulfill critical objectives of mitigating agency frictions and allocating control rights, facilitating the expansion of credit in the economy, ex-ante. However, covenants may also introduce and amplify fire sale risk in some states of the world, reducing the amount of credit in these states, ex-post.

CLOs are the largest purchasers of leveraged loans and constitute an increasingly prominent source of credit to risky firms. In quest to devolve risk in the post-GFC era, banks have shifted from an "originate-to-retain" model to "originate-to-distribute," diversifying credit and liquidity risks to a gamut of investors, chiefly, CLOs.[1] CLOs purchased nearly 75% of all syndicated institutional leveraged loans in 2019 and held 25% of all outstanding leveraged loans (pro rata and institutional) in 2020 (Leveraged Commentary and Data (2019); International Monetary Fund (2020)). However, greater diversification has also contributed to the opacity and complexity of interconnections between the traditional banking and rising shadow banking sectors. The Federal Reserve recently warned that the secondary market for leveraged loans is not liquid and during times of stress, price declines from CLO loan sales may be excessive (Board of Governors (2019)).[2] The Bank of England outlined the risk to financial institutions, emphasizing the high concentration of leveraged loans among bank and non-bank institutions with uncertain implications on firm financing (Financial Policy Committee (2019)).[3] The Financial Stability Board has raised questions about the risk to borrowers, stating that: *Shocks arising from outside of the leveraged loan and CLO markets that place intermediaries under financial strain, could impair the supply of capital to leveraged borrowers or cause other intermediaries in the market to become unable to offload exposures to leveraged borrowers* (Federal Stability Board (2019)). Understanding the externalities of covenants is critical from a policy perspective for informing regulatory intervention and developing targeted and well grounded guidelines (Stein (2013)).

Underlying the CLO market is a set of legal indentures, mutually agreed upon by the core trinity of CLO participants: arranger, manager, and trustee. A CLO indenture governs the operations and activities a CLO manager may undertake. Broadly, CLO liabilities are of two

[1] I refer readers to Kundu (2020*a*) for a comprehensive overview of the leveraged loan and CLO markets.

[2] *Investors in CLOs ... face the risk that strains within the underlying loan pool will result in unexpected losses ... The secondary market is not very liquid even in normal times, and liquidity is likely to deteriorate in times of stress, which could amplify any price declines. It is hard to know with certainty how today's CLO structures and investors would fare in a prolonged period of stress* (Board of Governors (2019)).

[3] "Globally, banks account for more than half of the financial system's exposure to leveraged loans...Non-bank investors also have significant holdings of leveraged loans. Leveraged loan holdings by open-ended investment funds are significantly higher than pre-crisis, and large-scale redemptions during stress could amplify price falls. In a stress, the leveraged loan and high-yield corporate bond markets may not be sufficiently liquid to meet demand from borrowers, potentially restricting corporates from accessing funds. "

forms: debt tranches and equity tranches. Without any contractual embellishments, the inherent structure of a CLO produces agency frictions. The manager's interests are most aligned with the equity class; their compensation consists of a fixed fee and subordinated fees that are proportional to the residual interest available to the equity class. The manager may maximize her revenue by shifting investment decisions in favor of the equity class at the expense of debtholders. Hence, covenants intrinsic to managerial contracts serve as disciplining devices to curtail against risk-shifting behavior and protect debtholders, reducing conflicts of interest. Specifically, violation of coverage covenants – which ensure that there is a specific level of coverage and subordination relative to the covenant triggers for each tranche – can be punitive, as proceeds intended for junior tranches, management fees, and equity distributions may be diverted towards prematurely paying down liabilities in order of seniority, or, the purchase of higher-quality collateral, until the CLO is in compliance with its constraints. Therefore, covenants also provide a mechanism for allocating control rights between debt and equity investors. Unlike in other settings, covenants in CLO indentures are not renegotiable, reducing the potential for hold-up of investment decisions, ex-ante (Gârleanu and Zwiebel (2009)).

The objective of this paper is twofold: *(1)* to study whether contracts have externalities on asset prices, and if so, *(2)* to explore the mechanism through which firm distress can propagate to other firms. I postulate that shocks can propagate through capital markets via CLO fire sales. The elements are as follows. First, markets for loans and corporate debt are illiquid. Second, while CLO covenants are largely effective tools in addressing agency frictions, in some states of the world, they can generate forced sales. Third, forced sales reduce prices of debt securities that are sold, even if the issuer of the debt's creditworthiness is unchanged. The secondary market spread becomes the effective cost of capital for these issuers. As a result, these firms make financial and real adjustments. Hence, covenants transmit shocks to innocent bystanders, firms that have no direct exposure to the shocks.

For illustration of the mechanism through which idiosyncratic risk may amplify to systemic risk, consider the following microcosm of the empirical setting, as presented in Figure 1. Firms and CLO intermediaries can be conceived as a web. In the network, CLOs purchase loans issued by firms which are represented by the outer circles, and firms are connected to other firms through the CLO. The spokes are bidirectional because firm performance affects cash flows to CLOs, and, intermediary distress may also transmit to firms (left figure). If a firm experiences extreme distress, as represented by the red outer circle, a CLO may be pushed against its constraints as represented by the pink color (center figure). In this event, I posit that the CLO manager will take two actions. First, the manager will preemptively sell loans issued by the distressed firm to eliminate the risk of becoming further constrained. By selling a loan at a discount relative to the current book value, a CLO may move closer to its constraint in the present, but avoid violation in the future. Hence, the red firm is disconnected from the CLO. Second, the manager will sell *other* risky loans to generate more slack in the constraints – represented by the pink firms with dashed connections to the CLO (right figure). Thus, financial constraints may potentially create a cycle. If a firm becomes distressed and a CLO is pushed against its constraints, the manager will sell the distressed loan as well as sell loans issued by other innocent bystanders. This can alleviate CLO constraints. However, it may also ultimately sow the seeds of future distress (bottom figure). In this paper, I focus on how innocent bystanders are affected by actions the CLO manager takes.

I begin by exploring several scenarios of how a manager may respond to capital constraints. As a CLO approaches the covenant triggers, it can improve its covenant performance by selling loans at prices above book values. Alternatively, a CLO may improve its covenant performance by taking advantage of disparate accounting rules for different assets. Because assets that are distressed, defaulted, or, rated CCC/Caa1 or below, are not always marked at par value, I posit that CLOs sell these assets to alleviate their constraints and verify that this is true in my sample.

To study the externalities of fire sales, I use a Bartik-style difference-in-differences identification strategy, exploiting the timing of the oil price plunge in 2014, as well as cross-sectional variation in the oil and gas exposure of CLOs to study how characteristics of non-oil and gas firms held in CLO portfolios are affected. Before the oil price plunge, CLOs with high oil and gas exposure experience looser capital constraints relative to CLOs with low oil and gas exposure. However, after the oil price plunge, CLOs with high oil and gas exposure experience a tightening in their capital constraints, relative to CLOs with low oil and gas exposure. In the ideal thought experiment, I compare the differences in outcomes between two virtually identical innocent bystanders, held in different CLO portfolios with varying oil and gas exposures, after the oil and gas price plunge. This empirical design largely circumvents concerns about non-random matching between CLOs and portfolio firms.

I proceed in several steps. First, I study the effects on asset prices. I find that a one percentage point increase in a CLO's exposure to oil and gas is associated with a 8-14 bps increase in the secondary loan spread of non-oil and gas portfolio firms after the shock. In addition, for firms that seek new bank loans, I study how the legacy of their CLO creditors, measured by exposure to the oil and gas industry from three months prior, affects the spread of new loans. Concretely, a one percentage point increase in a CLO's exposure to oil and gas is associated with an additional 1.2-4.7 bps increase in the spread of new loans issued by non-oil and gas firms, after the shock. Moreover, a one percentage point increase in a CLO's exposure to oil and gas is also associated with an additional 0.8-2.4 bps increase in the credit spreads of bonds issued by non-oil and gas firms, after the shock. The increase in the spreads of different forms of debt is explained through a variation of a no-arbitrage argument, that connects fire sales to credit crunch effects. In market equilibrium, the expected rate of return for any form of debt issued by a firm is equalized, therefore, for affected innocent bystanders, firms' effective cost of capital may increase.

Second, I study the real effects to firms. I examine how non-oil and gas portfolio firms respond – innocent bystanders. On average, firm liquidity declines. In addition, firms make financial adjustments, reducing spending across operations as well as borrowing. Further, employment, investment, net leverage and Tobin's Q decline. How do these effects occur? CLOs that are more constrained drastically reduce their monthly net purchase of loans issued by non-oil and gas firms. In efforts to derisk, constrained CLOs reduce their share of loans rated

CCC/Caa1 and below, and hold loans that are less risky, i.e., loans that pay lower interest rates and have lower remaining maturity. Specifically, CLOs derisk by divesting themselves of loans that are marked at market.[4] Results yielded from subsample and difference-in-difference-in-differences analyses indicate that, indeed, the effects are more pronounced for firms whose assets are rated CCC/Caa1 or below – one category of loans that are marked at market. The pricing effects are at least three times larger for riskier firms. In addition, these firms experience larger declines in size, debt growth, employment, investment, and net leverage.

The sample period for this study is 2012-2017 – a relatively benign macroeconomic period. Hence, the effects may be significantly larger during times of stress, as financial market liquidity dissipates. As 90% of CLOs are exposed to the top 50 US borrowers, and 80% are exposed to the top five borrowers, simultaneous default may have disastrous implications (Federal Stability Board (2019)). One lesson from the financial crisis of 2008 tendered by the American Bankers Association (ABA) to the Securities Exchange Commission in a letter in 2008 is: "The problems that exist in today's financial markets can be traced to many different factors. One factor that is recognized as having exacerbated these problems is fair-value accounting" (Ellul et al. (2015)). For external validity, I replicate the baseline result in the analysis, using the COVID-19 shock. I find that the results are roughly five times as large. Hence, this channel has consequential effects. The finding that intermediaries which operate in a market setting may serve as a linchpin between financial markets and real economic activity is novel.

The roadmap for the paper is as follows. I begin with a review of the literature in Section 2. I provide a description of the institutional background in Section 3. The formulation of hypotheses is presented in Section 4. I describe the data sources used in this study in Section 5. I present the results in Section 6. The mechanism underlying the main findings are discussed in Section 7. In addition, I discuss the magnitude of the effect in Section 8. Lastly, I conclude in Section 9.

2 Literature Review

This paper is one in a series of papers on CLOs, including Kundu (2020*a*,*b*), which describe the mechanics of the CLO market, as well as sources of potential risk. In particular, Kundu (2020*a*,*b*) introduce several fire sale facts. First, CLO managers are not passive buy and hold investors in the sense that there is selection of loans, monitoring, and turnover. Second, CLO managers sell loans issued by distressed firms before the firms file for bankruptcy, introducing fire sale. Third, this is primarily driven by covenant considerations; the propensity to sell risky loans most strongly varies with distance to the capital constraint while the intensive margin – the amount – is explained by distance to the liquidity constraint. Fourth, a CLO's size increases in the *threshold* of covenant constraints.[5] Equity distributions increase in distance to the liquidity constraint. Fifth, there is price pressure around bankruptcy defaults with stark differences in returns for capital constrained and unconstrained managers, as well as for other character-

[4] That is: "Asset prices are determined by the total available liquidity or in other words by the 'cash in the market"' (e.g., Allen and Carletti (2008*b*); Allen and Gale (1994)).

[5] A more stringent threshold proffers more protection to debtholders.

istics, including rating and maturity. In this paper, I describe how diffuse idiosyncratic shocks can amplify and affect real firm outcomes through CLO intermediaries. This paper provides an explanation for how fire sale risk may transpire.

In addition, the foundation for this work is set upon four pillars of the extant literature, namely, credit supply shocks, role of intermediary balance sheet, fire sales, and the structure of CLOs.

First, this paper contributes to the existing literature by providing evidence of how a source of market financing can affect firm financial decisions through covenants, standing in contrast to a rich literature base on credit supply shocks that has focused on bank lending relationships. Bank intermediaries are known to be more efficient at resolving informational asymmetries than the market by developing unique relationships with firms, allowing for close monitoring. If a bank collapses, naturally, dependent borrowers may also be in distress. Theoretical work has emphasized how shocks to bank capital can affect real economic outcomes through the credit channel (e.g., Bernanke and Blinder (1988); Bernanke and Gertler (1989); Holmstrom and Tirole (1997)). Empirical work, exploiting variation through the use of instruments and natural experiments has investigated how changes in bank credit supply affect real economic outcomes with varying deductions (e.g., Kashyap, Lamont and Stein (1994); Gerlter and Gilchrist (1994); Kashyap and Stein (2000); Peek and Rosengren (2000); Khwaja and Mian (2008); Paravisini (2008); Ivashina and Scharfstein (2010); Chava and Purnanandam (2011); Benmelech, Bergman and Seru (2011); Schnabl (2012); Chodorow-Reich (2014); Huber (2018); Amiti and Weinstein (2018); Kundu and Vats (2020)). CLOs, in contrast are at arms-length. They are institutions that hold bank loans. CLOs are not directly involved with firms, nor do they possess any firm-specific private information about fundamentals (Kundu (2020*b*)). Thus, the finding that frictions in capital markets can transmit to firms is a novel contribution.

Second, this paper is related to work on the role of intermediary balance sheet, which has studied on how binding intermediary capital constraints may reduce their risk-bearing capacities, and affect asset prices by extension (e.g., Froot and O'Connell (1999); He and Krishnamurthy (2012); He and Krishnamurthy (2013); Adrian, Etula and Muir (2014); Ivashina, Scharfstein and Stein (2015); Koijen and Yogo (2015); He, Kelly and Manela (2017); Du, Tepper and Verdelhan (2018); Du, Hébert and Huber (2019); Boyarchenko, Fuster and Lucca (2019))). This paper contributes to the growing literature on intermediary asset pricing, showing how shocks to the balance sheet of a different financial firm can affect asset prices. However, in contrast to the extant literature which has shown how regulatory capital constraints or shocks from financial crises can affect intermediaries, I provide evidence of how *covenants* can affect CLO demand for assets in a relatively unexplored setting: the secondary loan market.

Third, this paper is related to the literature on fire sales, which examines various contexts and mechanisms through which fire sale risk can materialize and study its impact (e.g., Shleifer and Vishny (1992); Shleifer and Vishny (2012); Pulvino (1998); Coval and Stafford (2007); Mitchell, Pedersen and Pulvino (2007); Caballero and Simsek (2013); Jotikasthira, Lundblad and Ramadorai (2012); Campbell, Giglio and Pathak (2011)). An advantage of using the CLO setting to analyze fire sales is the availability of frequently observed transaction market prices – both purchases and sales by CLO entities. In addition to fire sales, *price pressure* can cause prices to diverge from the informationally efficient values because of unanticipated demand shocks (Scholes (1972)). When this occurs, risk-averse liquidity providers must be additionally compensated, which causes the price to deviate. In the context of this project, covenants may be interpreted as uninformed shocks which impact constrained CLO managers. Prospective buyers, including vulture funds, open-ended funds, structured credit funds, and unconstrained managers are compensated for providing liquidity. à la Ellul, Jotikasthira and Lundblad (2011), I argue that both the price pressure and fire sales hypotheses are at play; price pressure can occur around negative credit events including bankruptcies and missed interest/principal events, while fire sales are induced when the affected loans are held disproportionately by relatively constrained CLOs. In addition to proffering another example of fire sales, I provide evidence of real effects of the fire sales. Specifically, I show that the pricing dislocation in the secondary loan market persists long enough to affect real outcomes of firms. Persistence arises from financial frictions which can magnify the time for the price to recover and the magnitude of deviation.[6]

Fourth, this paper builds on nascent research on the CLO market that has focused on the role of securitization in credit markets. CLOs facilitate the extension of credit in the overall economy through more borrower-friendly loan contracts, characterized by lower spreads, and weaker and standardized covenants (e.g., Nadauld and Weisbach (2012); Shivdasani and Wang (2011); Ivashina and Sun (2011); Becker and Ivashina (2016); Bozanic, Loumioti and Vasvari (2018); Ivashina and Vallee (2019))). There are two seemingly incongruous conclusions drawn from past work. On the one hand, it has been argued that there is very limited evidence of adverse selection in CLO securitizations. Loans are syndicated to banks and institutional investors, thereby dispersing the role of screening. In addition, lead banks often have "skin in the game," retaining a fraction of the original loan for their own balance sheet, mitigating agency frictions (Benmelech, Dlugosz and Ivashina (2012*a*)). However, the growing incidence of "cov-lite" loans and standardized contracts, coupled with the originate-to-distribute model of bank lending, along with the increasing presence of institutional investors, suggests that incentives of banks to screen and monitor borrowers may be limited. Further, Kundu (2020*b*), Elkamhi and Nozawa (2020), and Loumioti and Vasvari (2019) provide evidence, demonstrating that CLOs are not "passive" unlike other securitizations, as risk-taking constraints, as well as other considerations, including, reputation can affect the structure of CLOs. Kundu (2020*b*) provides prima-facie evidence of CLOs screening and monitoring their underlying investments. In summary, the existing literature has shown that structural aspects of securitization have fueled an increase in credit alongside a degradation in contractual terms, with unclear ramifications regarding systemic risk. In this paper, I document the role of CLO managers in amplifying idiosyncratic risk through the compliance of contractual obligations, set ex-ante by investors.

The closest theoretical analogue of this work is He and Xiong (2012) and He and Milbradt (2014). Broadly, in these models, a deterioration in liquidity of debt markets can cause firms to

[6]Encumbrances to liquidity provision can arise from search costs or slow-moving capital (e.g., Duffie, Gârleanu and Pedersen (2007); He and Krishnamurthy (2012); Duffie and Strulovici (2012); Acharya, Shin and Yorulmazer (2009); Brunnermeier and Pedersen (2009)).

incur losses from rolling over existing, maturing debt. Equity holders continue rolling over and diluting the existing shares as long as the equity value remains positive. As equity holders bear rollover losses, firms default at a higher threshold, thereby demonstrating the link between liquidity risk and credit risk. In this paper, I show a similar effect. CLO forced sales in the relatively illiquid secondary loan market can increase firms' effective cost of capital. This can have deleterious effects on innocent bystanders.

3 Institutional Background

A CLO operates as a *special purpose vehicle* that issues tranched asset-backed securities or notes, and uses the proceeds to finance the purchase of the underlying portfolio of leveraged loans. From a balance sheet perspective, the loans of a CLO consist of leveraged loans, and, the liabilities consist of notes that are issued to investors. In this section, I provide a pithy summary of how CLOs function. For a more detailed discussion, I refer the readers to Kundu (2020*a*).

CLOs are tranched. Higher-rated tranches have lower risk and pay out lower returns relative to lower-rated tranches which have higher risk and higher returns. There are two categories of tranches: debt tranches and equity tranches. Debt tranches are paid a fixed spread above LIBOR based on seniority whereas the equity tranche receives the remaining spread after proceeds from the underlying loans have been distributed towards senior liabilities. The objective of the CLO is to maximize the excess spread.

The financial interests of a CLO manager are most aligned with the equity class; a manager's compensation consists of a fixed fee and subordinated fees that are proportional to the residual interest available to the equity class.[7] Debt investors do not benefit from excess risk or returns because they are paid a fixed spread above LIBOR based on seniority. From the perspective of debt investors, monitoring a manager's investment decisions and verifying cash flows can be costly. For this reason, there are covenants to curtail risk-shifting tendencies.

Covenants interact with the distribution of cash flows, ensuring that there is a specific level of coverage and subordination relative to the covenant triggers for each tranche. Cash flows are distributed according to two waterfalls: interest waterfall and principal waterfall. The interest (principal) waterfall stipulates the conditions for distributing interest (principal) payments to specific classes of debtholders, based on priority; cash flows are distributed according to seniority, while losses are borne starting from the subordinated or lowest rated tranches. Covenants serve as disciplining devices for managers to adequately screen and monitor their investments, and exert control when incentives conflicts. There are two classes of covenants: quality covenants and coverage covenants. Quality covenants are maintain-or-improve constraints which do not directly prescribe any action on the managers in the event of a breach. In event that a quality covenant is triggered, the manager must maintain portfolio credit quality and cannot make trades that will worsen the quality of the portfolio. However, neither management fees nor equity distributions are affected. On the other hand, if coverage

[7] If managers are residual claimants, i.e., have skin-in-the-game, managers may have even greater incentives to risk-shift in favor of the equity class to maximize revenue.

covenants are triggered, proceeds may be diverted from junior tranches, junior management fees and equity distributions towards either paying down liabilities in order of seniority, prematurely, or towards the purchase of "higher-quality" collateral. Coverage covenants can be financially costly to the manager in several ways. Fees and payments may be siphoned off from the manager and other junior stakeholders, impairing the manager's ability to operate the portfolio. Investors may also lose confidence in the manager's ability to administer the CLO portfolio, causing a leftward shift in demand. If CLO failures persist, i.e., the manager serially breaches contractual provisions, the manager may be dismissed. Furthermore, if assets default, equity holders may elect to not exercise the call until the defaulted assets rebound in price. These ramifications may cause a CLO to operate well-beyond its expected call date until legal maturity and hurt a manager's career prospects as well as future deals.

There are three types of coverage covenants that CLOs are typically subject to: Overcollateralization (OC) covenants, Interest Diversion (ID) covenants, and Interest Coverage (IC) covenants. The OC and ID covenants are *capital constraints*, which ensure that there is sufficient coverage and subordination of tranches relative to the tranche-specific triggers. They are akin to measures of the leverage ratio. The OC and ID covenants are measured similarly, with two caveats. First, the ID covenant has a lower threshold, so it is triggered before any of the OC covenants. Second, if the ID covenant is breached, proceeds are diverted towards the purchase of high-quality, value-increasing loans to eliminate the opportunity for asset substitution, in contrast to the OC covenants which force deleveraging. The IC covenants are similar to the OC covenants, insofar as they can also cause the manager to pay down liabilities early. Interest coverage covenants ensure that there is a specific level of coverage for interest due on tranches relative to the triggers. These are *liquidity constraints*. Broadly, covenants create first-loss tranches, cushions for principal losses for more senior tranches.

$$\begin{aligned} OC/ID = {} & \frac{\text{Par value of collateral+Defaulted collateral value}}{\text{Principal balance of tranche and all senior tranches}} + \\ & \frac{\text{Purchase price of discounted collateral-'CCC/Caa1' excess adjustment}}{\text{Principal balance of tranche and all senior tranches}} \end{aligned} \tag{1}$$

$$IC = \frac{\text{Interest from collateral}}{\text{Interest due on tranche and senior tranches}} \tag{2}$$

For the most part, loans are marked at par value and are not subject to market volatility unless one of three things occurs: the asset experiences default, it is downgraded to CCC/Caa1 or below, or is a discount obligation. In these cases, the loan is marked to lower of market value or recovery value, marked to market value, or marked to purchase price, respectively. A CLO faces a limit on collateral rated CCC/Caa1 or below, typically set to 7.5%. The loans in excess of this percentage are subject to mark-to-market accounting. These categories are not mutually exclusive – a loan that is downgraded to CCC/Caa1 may also be a discount obligation and treated as such, even if the CLO operates below its 7.5% concentration limit. Regardless, there is a "cliff effect" as loans become distressed, impairing CLOs.

This hypothesis is consistent with several theoretical and empirical papers which contend that mark-to-market accounting and cash-in-the-market pricing can caused distressed sales which may exacerbate spirals of price pressure and illiquidity (e.g, Allen and Carletti (2008*a*), Plantin and Shin (2008), Sapra (2008), Merrill et al. (2008)). Hence, mark-to-market accounting may be a source of contagion across markets, and, pose risks to financial instability.

4 Formulation of Hypotheses

In this three-period model, the manager starts out with a portfolio of non-distressed loans. In period t = 1, a fraction of loans are downgraded but the manager does not experience any constraint. With probability π, the downgraded assets default in the subsequent period at t = 2. Once default is realized, the defaulted loans do not yield anything to the manager and the Interest Diversion ratio binds. To alleviate the constraint, the CLO manager must sell non-distressed loans. The CLO manager's objective includes a quadratic measure of price pressure which captures mispricing. Price impact is convex; if more is sold, the cost increases by a disproportionately larger amount. To avoid selling a greater amount at t = 2, CLO managers sell distressed loans, ex-ante, at t = 1. The predictions generated from this model are largely consistent with the theoretical predictions of a static version of the model with no uncertainty in Appendix C. The prices γ_{dt} and γ_{nt} are endogenous functions of quadratic price pressure.[8]

4.1 t = 0

At t = 0, the CLO manager starts with A_0 loans in her portfolio. All loans are non-distressed. Nothing happens in this period.

4.2 t = 1

At t = 1, x_1 fraction of loans in the CLO experience distress. $(1 - x_1)$ share of loans are non-distressed. Upon experiencing distress, e.g., downgrades, the CLO manager's Interest Diversion constraint does not bind.

That is, the constraint at the start of $t = 1$ satisfies the following condition.

$$\frac{x_1 A_0 \gamma_{dt} + (1 - x_1) A_0}{L} \geq \rho \tag{5}$$

where γ_{dt} is the price for all distressed loans at time t, and ρ is the exogenous constraint.

Non-distressed loans pay out fixed return Y_n while distressed loans pay out a fixed return of Y_d that is greater than Y_n. These returns are exogenous. These returns may be thought of as equity distributions to the CLO manager. The managers faces quadratic price pressure.

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[8]Suppose the fundamental values of a distressed loan and non-distressed loan at time t are F_{dt} and F_{nt}, respectively. The prices γ_{dt} and γ_{nt} are then:

$$\gamma_{dt} = F_{dt} - \beta_2((x_1 - z_d)A_0)^2 - \beta_1((x_1 - z_d)A_0) \tag{3}$$

$$\gamma_{nt} = F_{nt} - \beta_2((1 - x_1 - z_n)A_0)^2 - \beta_1((1 - x_1 - z_n)A_0). \tag{4}$$

These are modeled quadratically. In this period, the manager chooses new amounts z_d and z_n of the distressed and non-distressed loans, respectively.

$$
\begin{aligned}
max_{z_d,z_n}(1-\pi)[z_dA_0Y_d+z_nA_0Y_n]+\pi V(x_2,A)-\beta_2((x_1-z_d)A_0)^2 \\
-\beta_2((1-x_1-z_n)A_0)^2-\beta_1((x_1-z_d)A_0)-\beta_1((1-x_1-z_n)A_0).
\end{aligned} \tag{6}
$$

The new shares, z_d and z_n do not need to add up to 1, as the total amount of assets may not remain A_0. Hence, assets and portfolio share of distressed assets are defined as follows.
Dynamics of State Variables:

$$A = z_dA_0 + z_nA_0 \tag{7}$$

$$x_2 = \frac{z_d}{z_d+z_n} \tag{8}$$

4.3 t = 2

The state variables are (x_2, A) as defined above. x_2 denotes the portfolio share of distressed assets. Total portfolio assets are A. At t = 2, the distressed loans default and yield 0 to the manager. I assume that when defaults are realized, the CLO manager's Interest Diversion constraint binds. Default causes the price of the asset to be $\gamma_{dt} = 0$. At zero price, the manager cannot sell any defaulted loans; the manager may only sell defaulted loans at positive price.[9] The zero price stands in for the severe fire sale when default occurs, i.e., zero price conveys that γ_{dt} is significantly below the long-run value. This simplification illustrates the main predictions of the model. I refer readers to Appendix E for a version of the model that does not make the simplification above.[10]

The quadratic model of price pressure is then applied over the entirety of the defaulted share x_2. Proceeds from sales of non-distressed loans are used towards paying down liabilities to satisfy the binding constraint. Therefore, the maximization is over a single choice variable, x_n – the amount of new non-distressed loans, subject to the Interest Diversion constraint.

$$V(x_2,A) = \max_{x_n} x_nAY_n - \beta_2((1-x_2-x_n)A)^2 - \beta_2(x_2A)^2 - \beta_1((1-x_2-x_n)A) - \beta_1(x_2A) \tag{9}$$

s.t.

$$\frac{x_nA}{L-(1-x_2-x_n)A\gamma_{nt}} \geq \rho \tag{10}$$

[9] This assumption is needed to eliminate arbitrage opportunities which may allow prospective buyers to purchase at zero price and generate infinite returns upon recovery.
[10] The model of Appendix E yields unwieldy expressions, making interpretation difficult.

4.4 Solution:

I start with the solution to the $t = 2$ problem. I assume that the constraint is binding. Then:

$$x_n^* = \frac{\rho(L - A\gamma_{nt} + x_2 A\gamma_{nt})}{A(1-\gamma_{nt}\rho)}. \tag{11}$$

After making substitutions for x_n, x_2, and A, the maximum value is:

$$V(x_2, A) = \frac{\rho(L - z_n A_0 \gamma_{nt})Y_n}{1-\rho\gamma_{nt}} - \beta_2(\frac{z_n A_0 - \rho L}{1-\rho\gamma_{nt}})^2 - \beta_2(z_d A_0)^2 - \beta_1(\frac{z_n A_0 - \rho L}{1-\rho\gamma_{nt}}) - \beta_1(z_d A_0). \tag{12}$$

The t = 1 constrained optimization problem may be written as:

$$\begin{aligned}\mathcal{L} &= (1-\pi)[z_d A_0 Y_d + z_n A_0 Y_n] + \pi V(x_2, A) - \beta_2((x_1 - z_d)A_0)^2 \\ &- \beta_2((1 - x_1 - z_n)A_0)^2 - \beta_1((x_1 - z_d)A_0) - \beta_1((1 - x_1 - z_n)A_0).\end{aligned}$$

This yields the following solutions:

$$\boxed{z_d^* = \frac{x_1}{1+\pi} + \frac{(1-\pi)(Y_d + \beta_1)}{2\beta_2 A_0(1+\pi)}} \tag{13}$$

$$\boxed{z_n^* = \frac{(Y_n + \beta_1)(1-\rho\gamma_{nt})^2 - \pi(Y_n+\beta_1)(1-\rho\gamma_{nt})}{2\beta_2 A_0((1-\rho\gamma_{nt})^2 + \pi))} + \frac{\rho L \pi}{A_0((1-\rho\gamma_{nt})^2+\pi))} + \frac{(1-x_1)(1-\rho\gamma_{nt})^2}{((1-\rho\gamma_{nt})^2+\pi))}} \tag{14}$$

Note the following. The CLO manager will sell distressed loans, ex-ante, i.e., at t = 1, $x_1 - z_d > 0$ if:

$$x_1 > \frac{(1-\pi)Y_d}{2\beta_2 A_0 \pi}. \tag{15}$$

As A_0 is large, this is likely to hold when β_2 and π take non-trivial values.
The CLO manager will *not* sell non-distressed loans, ex-ante, i.e., at t = 1. If the manager were to sell non-distressed loans, ex-ante, then $1 - x_1 - z_n > 0$, or:

$$1 - x_1 > \frac{(Y_n + \beta_1)(1-\rho\gamma_{nt})^2}{2\beta A_0 \pi} - \frac{(Y_n - \beta_1)(1-\rho\gamma_{nt})}{2\beta_2 A_0} + \frac{\rho L}{A_0}. \tag{16}$$

As A_0 is large, the first two terms approximate to 0 if β_2 and π take non-trivial values. Assuming that $L = A_0$, the RHS of the inequality approximates to ρ. ρ must be greater than or equal to 1, as the value of the underlying assets must be at least as large as the total value of liabilities. As x_1 is non-negative, under these assumptions, the inequality is not satisfied. Therefore, managers do not sell non-distressed loans, ex-ante.

Predictions:

1. Holding onto distressed assets through adverse credit events, such as bankruptcy defaults, may tighten the Interest Diversion constraint.

2. To avoid the risk of selling a greater amount of assets when distress realizes as default, managers sell distressed assets, ex-ante.

3. Sectoral shocks, e.g., oil and gas price plunge, effectively tighten ρ, hence, CLOs that are more exposed to the source of the shock experience a lower ρ after the shock, and the effects are more pronounced.

4. Selling risky assets that are mark-to-market assets can improve the Interest Diversion constraint. The manager will sell higher value assets before selling lower value assets to maximize improvements to the Interest Diversion constraint.[a]

[a] There is a pecking order to CLO distressed sales. CLOs will sell loans in order of descending market value to maximize improvements to the Interest Diversion constraint. That is, if x amount of distressed loans is sold at prices γ_1 and $\gamma_1^{'}$, the following relation holds if $\gamma_1 > \gamma_1^{'}$:

$$\frac{A(1 - x\gamma_1)}{L - x\gamma_1 A} > \frac{A(1 - x\gamma_1^{'})}{L - x\gamma_1^{'} A}. \tag{17}$$

Hence, selling a given amount of loans that are marked to a higher price can increase a CLO's distance to the Interest Diversion constraint by a larger margin than selling the same amount of loans at a lower price.

In this paper, I hypothesize that expectations of future constraint can cause CLO managers to fire sell risky loans that are marked at market value, ex-ante, to generate more slack in the constraint.[11] Covenant considerations provide the original impetus for fire sales in the secondary loan market, increasing the effective cost of capital for affected firms, which are then forced to make financial and real adjustments, shown in Section 6. Oil and gas price shocks can magnify these effects.

Lastly, of noteworthy mention is that CLOs do not internalize the externalities of their actions. The covenant calculations do not incorporate the unintended consequences a manager's trading decisions may have on the market.

5 Data

There are a number of data sources used in this project, ranging from financial data to firm fundamental data. In this section, I describe the datasets used in this project.

The primary data source is the *CreditFlux CLO-i Database*, which provides information on over 35,000 trustee reports, prospectuses, and covers over 1,200 CLOs in the US. CreditFlux provides granular data on CLO transactions and their associated prices, holdings, covenants, tranches, and equity distributions. In 2019, the CLO-i database covered 67-76% of the market, while in earlier years the coverage seems to have been between 46-65% of the market (Kundu

[11] Kundu (2020*b*) provides empirical tests of 1 and 2, showing that CLO managers divest themselves of distressed loans prior to default, driven by covenant considerations.

(2020*a*); Benmelech, Dlugosz and Ivashina (2012*b*)). Additional information on coverage and characteristics of the data are described in the Data section of Kundu (2020*b*).

To supplement the data on transaction prices reported in the CreditFlux CLO-i database, I collect additional financial data from WRDS-Thomson-Reuters' LPC DealScan and WRDS Bond Returns. I use data on new loans from the WRDS-Thomson-Reuters' LPC DealScan, or, Loan Pricing Corporation Deal Scan database. This database contains extensive and comprehensive data on the terms of loan pricing contracts that is sourced from both SEC filings and directly from lenders and and borrowers. I restrict my analysis to deals in which the lead arranger can be identified. In addition, I use the WRDS Bond Database which provides comprehensive coverage of all traded corporate bond issues. This database sources corporate bond transactions data from TRACE.

For firm characteristics, I use two databases from S&P Capital IQ: Compustat North America (Compustat) and Capital Structure. Compustat provides data on firm fundamentals from balance sheets, statements of cash flows, income statements, and supplemental data items. I describe the construction of firm-level variables in Section B. A limitation of my analysis is that Compustat only reports data for publicly held companies, whereas CLOs hold loans issued by both private and public firms, thereby restricting the coverage of firm variables. I use the Capital Structure database to study dynamics in firm liquidity through data on Lines of Credit. This data is sourced from press releases, company websites, and stock exchanges as well as through direct feeds from SEC, SEDAR, ASX, and RNS. When applicable, I cross-referenced the Roberts Dealscan-Compustat Linking Database (Chava and Roberts (2008)).

There is no identifying code in the Creditflux CLO-i database that allows for easy matching across databases. For this reason, I manually encode the data and generate several crosswalks between the CLO-i database and other datasets and databases. As mentioned in Kundu (2020*a*), case sensitivity, abbreviations, inconsistent syntax, punctuation, and the conflation of subsidiaries and holding companies are some of the issues which hinder automatic matching.

Lastly, I use data on WTI crude oil data from FRED. This data is used to track the start of the oil price plunge as well as price movements. The sample period for the main analysis in this paper is 2012-2017.

6 Results

6.1 Motivation

To motivate the objective of this study, I present two pieces of evidence that demonstrate how covenant performance may determine trading decisions with unintended price effects.

First, I examine the relation between the propensity to sell mark-to-market or risky assets and covenant performance in Table D.1. Risky assets are defined as assets rated CCC/Caa1 or below in excess of the CCC/Caa1 limit, discount obligations or defaulted loans. I use a linear probability model, exploiting variation within manager-year to examine how distance to the covenant threshold affects the likelihood of a risky sale. The outcome variable takes a value of 1 if the CLO sells risky assets, and 0 otherwise. I find that a one standard deviation loosening in the capital constraints – shown in Columns 3, 5, and 7 for the Interest Diversion, Junior OC, and Senior OC covenants, respectively – relative to the mean, is associated with a 3% decline in the likelihood of selling risky assets, after accounting for structural aspects of CLOs through additional arranger and trustee fixed effects. In addition, the R^2 of the Interest Diversion constraint, the largest among any covenant at 14%, suggests that the Interest Diversion constraint explains most variation in the likelihood of a CLO sale of risky assets. Hence, greater distance to the covenant thresholds is associated with a lower likelihood of selling risky assets.[12] The results from this exercise inform the choice to restrict the analysis to the capital constraints, and in particular, the Interest Diversion covenant. This is because the Interest Diversion covenant is the most stringent among the coverage covenants; the median CLO operates within 3% of this covenant threshold.[13]

Second, I examine heterogeneity in price pressure around Chapter 11 bankruptcy defaults. In Figure 3, I plot the price pattern around bankruptcy defaults for three categories of loans: the cumulative abnormal average returns (CAAR) for loans that are issued by distressed firms and held by constrained CLOs ("Dist. Constrained," shown in red), loans issued by distressed firms and held by unconstrained CLOs ("Dist. Unconstrained," shown in blue), and, non-distressed firms held by constrained CLOs ("Non-dist., Constrained," shown in red) around firm bankruptcy.[14] A CLO is constrained if its performance on the Interest Diversion constraint is below the median.[15] *Non-dist., Constrained* loans are loans that are issued by non-distressed firms and held by constrained CLOs. I match this set of non-distressed firms to distressed firms that *do* file for Chapter 11 bankruptcy based on similar industry and size characteristics. The *Non-dist., Constrained* set of firms present a counterfactual of how non-O&G non-risky firms held by constrained CLOs perform relative to non-O&G risky firms held by constrained CLOs. The average abnormal returns are normalized to 0, five quarters before bankruptcy default.

I find that distressed firms held by unconstrained CLOs as well as non-distressed firms held by constrained CLOs exhibit virtually no impairment around firm bankruptcy. However,

[12]The *propensity* of selling risky loans is most strongly associated with performance on the capital constraints (OC and ID covenants), while the *amount* exhibits greatest sensitivity to the liquidity constraints (IC covenants), as shown in Kundu (2020*b*). For a comprehensive examination of competing hypotheses and detailed discussion of the relation between covenants and trading patterns, I refer readers to Kundu (2020*b*).

[13]For a complete table of summary statistics, see Table D.2.

[14]The specification is

$$ln(\frac{P_{i,t}}{P_{i,t-1}}) \approx \alpha + \beta Z_{i,t-1,t} + \gamma_0(Q_{i,t} - Q_{i,t-1}) + \gamma_1(Q_{i,t}ln(S_{i,t}) - Q_{i,t-1}ln(S_{i,t-1})) + \epsilon_{i,t-1,t}$$

where $P_{i,t}$ of loan i on date t is a function of the $E_t(V_i)$, $Q_{i,t}$, and $A_{i,t}$ which denote the fundamental value, purchase indicator (-1 for sale), and half spread (spread around the fundamental loan value), change in fundamental value is Z, a function of the following: (1) 5-Year Treasury Constant Maturity Rate (match duration of average leveraged loan); (2) Barclay's Corporate IG Index Return; (3) Barclay's Corporate HY Index Return; (4) S&P 500 Index Return; (5) S&P/LSTA Leveraged Loan Index Return. $Z_{i,t-1,t}$ denotes the vector of these components from $t-1$ to t. Identifying assumptions are: $E(\nu_{i,t-1,t}) = 0$ and $\epsilon_{i,t-1,t} = \nu_{i,t-1,t} + Q_{i,t}\eta_{i,t} - Q_{i,t-1}\eta_{i,t-1}$. Origins of this specification are described in Section 4.1 of Kundu (2020*b*).

[15]Loans that fall in the Constrained category are analogous to loans issued by WidgetCo B held by CLO B. Loans that fall in the Unconstrained category are analogous to loans issued by WidgetCo A held by CLO A using the empirical framework of Section 6.2.

distressed firms that are held by constrained CLOs exhibit price pressure with a significant decline and reversal around default. At its trough, loans held by constrained CLOs experience a 5% cumulative abnormal average return, relative to the return five quarters before default.[16] CLOs trade at fire sale prices upon experiencing capital constraints. The reversal is explained by subsequent positive abnormal returns that compensate liquidity providers.[17] These stylized facts motivate the study of how trading decisions and price patterns may be mechanical reactions of innocent bystanders in response to forced sales by CLO managers who encounter unrelated idiosyncratic shocks. This may provide a potential mechanism for contagion and serial correlation in defaults.

Thus far, I have provided two pieces of motivating evidence to convey that *(1)* covenants produce trading effects, and, *(2)* covenants produce price effects around bankruptcy default. That is, covenants affect how managers manage risk. This often stems from the distressed segment of firms. However, in the subsequent sections, I study the externalities of fire sales, taking an agnostic approach in investigating which types loans are sold as it is unclear, ex-ante, how incentives and portfolio constraints may manifest in managerial decisions, i.e., it is plausible that managers may divest themselves of either the most illiquid loans in the portfolio, or, the most liquid loans.

6.2 Empirical Methodology

The ultimate objective of this paper is to identify how CLO covenants determine the transmission of shocks. However, reliance on explicit measures of CLO health through performance measures, including distance to the Interest Coverage, Interest Diversion, and Overcollateralization thresholds may raise concerns about non-random matching between CLOs and firms. To circumvent these selection concerns, I exploit cross-sectional variation in CLO exposure to the oil and gas (O&G) industry as a measure of risk that directly affects the capital constraint. In addition, I exploit the timing of the O&G price plunge to analyze the impact of the shock.

To understand the analysis, consider the following thought experiment. There are two CLOs: CLO A and CLO B. CLO A does not hold any firms operating in the O&G industry. CLO B has a sizeable exposure to firms in the O&G industry. With the exception of O&G exposure, suppose that both CLOs both hold a similar portfolio of loans issued by comparable firms in their respective portfolios. When the O&G price plunge occurs, CLO A is unaffected as CLO A is not exposed to O&G. However, CLO B will operate closer to its covenant thresholds, as many O&G firms may be in distress and fall back on interest/principal payments. If CLO A contains a loan issued by WidgetCo A and CLO B contains a loan issued by WidgetCo B – both of which are vulnerable to being fire sold – the main objective of this paper is to study if there are differential effects for WidgetCo A as compared with WidgetCo B, simply based on differences

[16] Quarterly CAARs are likely to be smaller than monthly CAARs. Taking the average across a larger time horizon attenuates the influence of anomalous and egregiously abnormal trades.

[17] A common hypothesis is that information revelation explains these findings. If information revelation informed selling behavior, the price would fall to a new level and stabilize there. The lack of "flattening" in prices suggests that trades are not driven by new information. Other hypotheses as well as implications are discussion in Kundu (2020*b*).

in the distance to covenant triggers. Broadly, how do idiosyncratic shocks propagate to other portfolio firms through CLO intermediaries?

6.3 Specification

The baseline specification for causal inference is of the following form. I use this specification to investigate the externalities of shocks.

$$\begin{aligned} Y_{c,f,t} &= \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t \\ &\quad + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_{i,r} + \epsilon_{c,f,t} \end{aligned} \tag{18}$$

where c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. Z is a vector of firm controls and X is a vector of CLO controls. For simplicity, I refer to the *Oil Shock* variable as *Post*, hereafter. In addition, I use *firm* and *issuer* interchangeably, depending on context. [18]

Summary statistics for this empirical analysis are provided in Table 2. The median (mean) CLO has 2.8% (3.56%) of the portfolio invested in O&G. The 25^{th} and 75^{th} percentile values are 1.76% and 4.34%, respectively. The standard deviation associated with the O&G share is 4.77%. Summary statistics for outcome variables are reported in Table 2. I report the number of observations, the 25^{th} percentile, median, 75^{th} percentile, mean, and standard deviations.

In the subsequent sections, I will first validate that the O&G exposure is a reasonable measure of risk that affects performance on the Interest Diversion constraint. Then, I will address common concerns with the identification strategy, namely, exogeneity and selection.

6.3.1 Validating O&G as a Measure of Risk

First, I validate a CLO's exposure to O&G as a relevant proxy for performance on the capital constraints. In Table 1, I study the relation between a CLO's share in the O&G industry, and its

[18]There is precedence for using this type of empirical design. Autor, Dorn and Hanson (2013) use an IV strategy, instrumenting changes in import share for the US, using contemporaneous changes in import share for high income countries. Concretely, I am interested in estimating the following structural equation:

$$y_{lt} = D_{lt}\rho + B_{lt}\delta_2 + \epsilon_{lt}.$$

This is similar to equation 1.1 in Goldsmith-Pinkham, Sorkin and Swift (2020), where l indexes the CLO, t index the time period, y_{lt} denotes an outcome variable, D_{lt} is a vector of controls that may include fixed effects, B_{lt} is the Bartik instrument – an inner product of CLO-O&G shares and O&G-period growth rates, ϵ_{lt} is a structural error term. For identification under the shares interpretation of Goldsmith-Pinkham, Sorkin and Swift (2020), $\epsilon_{l,t} \perp\!\!\!\perp z_{l,t}$ – shares must be exogenous. In my estimation, there is an additional linear term:n $z_{l,t}$, such that

$$\epsilon_{lt} = \delta_1 z_{lt} + \epsilon^*_{lt}.$$

If δ_1 is constant – $\delta_1 z_{lt}$ is a linear function of z_{lt}, the identifying assumption is that $z_{l,t} \perp\!\!\!\perp \epsilon^*_{l,t}$. The use of contemporary values provides a closer approximation to the data-generating process of the real world. If there is a concern that CLOs with high O&G exposure sell O&G loans, and resemble CLOs with low O&G exposure after the shock, the point estimates will be understated towards a null effect.

distance to the Interest Diversion threshold.[19] As indicated by the coefficient associated with *Oil & Gas*, before the price plunge occurs, CLOs with greater O&G exposure experience more slack in their capital constraints – the distance from the threshold increases. According to a CLO manager, this is because loans issued by O&G firms offered higher yields, during this period. CLOs with greater O&G exposure may be thought of as CLOs that are reaching-for-yield relative to their constraints, or have some degree of precautionary demand. I corroborate this in Section 6.3.5, in which I examine the dynamic relation between O&G exposure and performance on the Interest Diversion covenant. After the oil price plunge occurs, risk is realized and firms with greater exposure to O&G perform worse on their capital constraints, as indicated by the coefficient on the *Oil & Gas* $\times$ *Post* variable. From Columns 1-5, I include successive levels of CLO controls and year fixed effects, intended to control for structural aspects of CLOs and aggregate shocks. Column 1 does not include any controls. Column 2 includes a size control. Column 3 includes size and performance control.[20] Column 4 includes size, performance, and age controls. Column 5 includes year fixed effects, intended to control for common shocks. Concretely, using the most conservative estimate in Column 5, a one percentage point increase in the share of O&G is associated with an additional decline in the performance of the Interest Diversion constraint by 0.23 standard deviations, relative to the mean. The magnitude of the point estimate from Columns 1-5 increases with the addition of controls. Standard errors are two-way clustered by CLO manager and month-year.[21]

Hence, O&G is a relevant proxy for risk, and by extension, a CLO's performance on its capital constraints. In addition, in Figure A.5, I present the results from an alternate specification. I fix the cross-sectional shares of O&G exposure, and exploit variation in oil price deviation. Because the coefficient of interest is an interaction of two continuous variables, namely, the price deviation and the share, I plot the marginal effects – the slope of the distance to the Interest Diversion threshold on the price deviation, while holding the value of the O&G share constant between 0 and 1.[22] The findings from this figure corroborate the hypothesis that CLOs with higher O&G share experience loosening in the Interest Diversion constraint when the price of oil is higher.

6.3.2 Concern #1 with Strategy: Exogeneity

A common concern with difference-in-differences specifications for causal inference is the exogeneity of shocks. If the shock is not exogenous, the policy may be correlated with the errors, causing inconsistency of the estimators. I argue that the Oil & Gas price plunge is exogenous. Figure 4 exhibits the average crude oil price ($ per barrel) from 1960 through 2020. The price precipitously dropped starting from June 2014 through 2016 – one of the three largest

[19]This is measured as a ratio of $\frac{Result}{Threshold}$.

[20]Performance refers to the annualised equity distribution.

$$\text{Equity Distribution} = \frac{\text{Interest payment} \times \frac{12}{\text{Payment frequency}}}{\text{Par value of equity}} \times 100 \tag{19}$$

[21]Small sample size explains limited of statistical significance.

[22]Oil price deviation$_t = ln(\frac{P_t}{70})$. $70 is set as a benchmark for the cost of extracting oil.

declines since World War II, and the longest-lasting since the supply-driven price plunge of 1986 (Stocker, Baffes and Vorisek (2018)).[23]

There are several major factors that contributed to the oil price plunge. First, booming shale production in the US and improvements in fracking technology reduced break-even prices of shale production; post-crisis financing conditions facilitated improvements in oil extraction through hydraulic fracking and horizontal drilling.[24] Given the shorter life cycle of these projects and lower capital costs relative to conventional extracting methods, shale oil is more elastic to oil price changes than crude oil (e.g., Baffes et al. (2015); Krane and Agerton (2015); McCracken (2015)). Second, OPEC announced a shift in policy, renouncing price targeting, partly, in response to the increasing shale share of global oil supply. Third, receding geopolitical tensions allowed oil production to function without disruption or conflict – hence, supply remained steady. Fourth, the appreciation of the dollar from June 2014 and June 2015 increased the local cost of oil in countries where the currency was not pegged to the dollar. This contributed to "weaker oil demand in those countries and greater supply from non-US dollar producers" (Baffes et al. (2015)). While some contemporaneous demand shocks also occurred contemporaneously, e.g., stock market turbulence experienced in China, consensus has formed around supply-driven factors as dominant contributors of the oil price plunge (e.g., Arezki and Blanchard (2014); Hamilton (2014)). Regardless, the main point is that the sources of the shock are outside of the leveraged loan and CLO markets.

6.3.3 Concern #2 with Strategy: Selection

The second concern with the proposed identification strategy is that matching between CLOs and firms may not be *as good as random*. In other words, CLOs with higher O&G exposure may be structurally different from CLOs with lower O&G exposure. Specifically, there may be a concern that CLOs with higher O&G exposure employ different hedging strategies than CLOs with lower O&G exposure or purchase different loans. This can manifest as differences in observable characteristics of portfolio firms, as well as differences in the concentration of investment across industries and geographies. I refer to a CLO with *high O&G* exposure if its portfolio share in the O&G industry is above median – it has *low O&G* exposure otherwise.

In Table A.1, I compare characteristics of firms that are held by CLOs with high O&G exposure to firms that are held by CLOs with low O&G exposure, before the shock. The distribution of characteristics across firms held by CLOs with high O&G exposure is comparable to that of firms held by CLOs with low O&G exposure in several dimensions, including, payout, capital expenditures, research and development, acquisitions, cash flow (operating income), employment growth, investment (capital stock growth), net leverage, and Tobin's Q. Moreover, in Figure A.2, I compare the industry distribution for CLOs with high O&G exposure to CLOs with low O&G exposure. Differences in the distribution are limited; the industry Herfindahl-Hischman Index (HHI) is 0.0497 for CLOs with low O&G exposure and 0.0491 for

[23] A plot of monthly crude oil prices from 2012-2018 is available in Figure A.4.

[24] Further, increased biofuel production and extraction from Canadian oil sands also coincided with the price plunge.

CLOs with high O&G exposure. Furthermore, in Figure A.3, I compare the geographic concentration of investment for CLOs with high O&G exposure to CLOs with low O&G exposure. The location of the firm is identified using Compustat headquarter information. This yields a 10% match. The difference in the geographic Herfindahl-Hirschman Index is less than 0.05.[25] Hence, concerns about selection across these dimensions appears limited.

I conduct two additional tests to directly test the sensitivity to oil. First, I study whether non-O&G firms held by CLOs with high O&G exposure have the same dependency on the price of oil as compared to firms held by CLOs with low O&G exposure. Second, I study whether it can forecasted which CLO a non-O&G firm will be held by, based on the covariance between the firm's profitability and oil price. These results are presented in Tables A.2 and A.3. I do not find any statistically significant relation between a firm's profitability and the oil price deviation, nor does this relation differ for firms held by CLOs with low O&G share. Using a probit model, I also do not find evidence of forecasting CLO selection based on the covariance between price and profitability. Thus, I rule out concerns about portfolio hedging with regard to O&G exposure.

I conclude that CLO assignment of non-O&G firms is as good as random.

6.3.4 Parallel Trends

In this section, I assess pre-trends to study if the first stage result is driven by pre-trends before the price plunge. For identification, the parallel trends assumption states that the relation between the secondary loan spread of a non-O&G issuer and CLO exposure to the O&G industry would have followed common trends across CLOs both before and after the price plunge in the absence of the price plunge. However, I cannot assess the counterfactual scenario of what would have occurred in the absence of the price plunge. Therefore, I assess whether there is divergence between CLOs with greater O&G exposure relative to CLOs with lesser O&G exposure before to the shock – do they trend in parallel?

In Figure 5, I study two features of the data. First, I study if pre-trends are parallel prior to the shock. Second, I study if the relation between the secondary loan spread of non-O&G issuers and CLO O&G exposure differs *after* the shock occurs. Specifically, for a given CLO, I chart the relation (point estimate) between the secondary loan spread of non-O&G issuers in the portfolio and its O&G exposure, in six month increments surrounding the shock. I plot the estimated coefficients of β_i and the associated 95% confidence interval from the following regression specification.

$$S_{c,f,t} = \sum_{\substack{i=-24 \\ i=i+6 \\ i\neq 0}}^{30} \beta_i \mathbb{1}_{i\leq t<i+6} \times (\text{O\&G Exposure})_{c,t} + \sum_{\substack{i=-24 \\ i=i+6 \\ i\neq 0}}^{30} \delta_i \mathbb{1}_{i\leq t<i+6} +$$
$$\theta_1 \text{O\&G Exposure}_{c,t} + \alpha_{i,r} + \alpha_c + \epsilon_{c,f,t} \qquad (20)$$

[25]For CLOs with low O&G exposure, the Herfindahl-Hirschman Index is 0.1867, while it is 0.1447 for CLOs with high O&G exposure.

where c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, i denotes the industry and r denotes the rating. $S_{c,f,t}$ is the secondary loan spread of a loan issued by firm f, held in CLO c, at time t. $O\&G\ Exposure_{c,t}$ measures the O&G share of a CLO at a given point in time. The regression specification includes leads and lags of the shock as well as their respective interactions with CLO O&G exposure. I exclude the last pre-treatment month to avoid perfect multicollinearity. The coefficients, β_i, encapsulate the relation between the secondary loan spread of non-O&G issuers and the associated CLO's O&G exposure before and after the shock. The estimator is a within rating-industry estimator that includes CLO fixed effects to absorb all unobserved time-invariant heterogeneity. In Figure 5, the x-axis represents months around the O&G price plunge. The y-axis represents the secondary loan spread in bps of non-O&G issuers.

The β_i estimates prior to the shock are akin to placebo treatments; each of the β_i coefficients is a placebo test for whether the treatment has an effect. Under the parallel trends assumption, there should not be an effect before the treatment occurs. The findings are consistent with the assumption that prior to the shock, the relation between the secondary loan spread of non-O&G issuers and CLO O&G exposure is statistically indistinguishable from the last pre-treatment period – the 95% confidence intervals include the null.[26]

After the shock occurs, the relation between secondary loan spread of non-O&G issuers and CLO exposure to O&G exhibits a marked change – the magnitude of β_i becomes economically meaningful, stable, and statistically significant.[27] Hence, I reject the hypothesis that the relation between secondary loan spread of non-O&G issuers and CLO O&G exposure is driven by pre-trends. As the shock does not exhibit similar effects before and the shock, I attribute any variation after the event to the price plunge itself.

In the context of the thought experiment, these findings suggest that before the price plunge, loans of WidgetCo B held by CLO B with high O&G exposure did not trade at a statistically distinguishable secondary loan spread. However, after the shock, the WidgetCo B's loans trade at a higher spread – not driven by pre-trends.

6.3.5 Interest Diversion Covenant and O&G Exposure

I study the dynamic relation between O&G exposure and Interest Diversion covenant in Figure 6. The x-axis represents the months around the O&G price plunge. The y-axis represents the distance to the Interest Diversion threshold. CLOs are segmented based on O&G exposure; CLOs with above median Interest Diversion performance have *high O&G* exposure, while CLOs with below median Interest Diversion performance have *low O&G* exposure. I plot the median distance to the Interest Diversion threshold for these two groups of CLOs. It is is plotted in red for CLOs with high O&G exposure, and blue for CLOs with low O&G exposure. This plot is presented with standard errors in Figure A.1.

Before the shock occurs, there is considerable difference in the distance to the Interest Diversion for CLOs with low O&G exposure as compared to CLOs with high O&G exposure.

[26] See Figure A.4 for the monthly crude oil price trend.

[27] The relation is statistically significant one year after the shock.

CLOs with high O&G exposure outperform CLOs with low O&G exposure, consistent with the supposition that prior to the O&G shock, loans issued by O&G firms offered higher yields relative to their ratings – CLOs with higher O&G exposure experienced larger risk premia, evinced in the subsequent empirical analysis presented.[28] This can explain how constraints may ease with higher O&G exposure in the absence of selling pressure and recorded sales. Concretely, the discrepancy provides an explanation for the subsequent results, in which I document a strong relation between characteristics of financial assets and firms, and, CLO O&G exposure, before the shock.[29] After the price plunge occurs, the risk associated with greater O&G exposure materializes with time, as performance of CLOs with high O&G exposure on the capital constraints deteriorates.[30] Eventually, almost 20 months after the price plunge, CLOs with high O&G exposure perform worse than CLOs with low O&G exposure. Thus, CLOs with higher O&G exposure are relatively unconstrained before the shock, and, relatively more constrained after the shock.

In contrast to CLOs with high O&G exposure, CLOs with low O&G exposure do not exhibit much temporal variation with regard to their performance on capital constraints; the distance to the Interest Diversion covenant oscillates between 1.03 and 1.035 across time.

I report this plot with 95% confidence intervals in Figure A.1.

6.4 First Stage: Implications for Asset Prices

In this section, I discuss the first stage results – how asset prices of various types of debt are affected by the degree of a CLO's constraints.

The sample period of interest traces the boom and bust of O&G. Before the price plunge, when crude oil prices are high and relatively stable, O&G firms profit as they do not experience extreme headwinds or unanticipated aggregate shocks (See Figure A.4). During this period, CLOs are also better capitalized. The combination of low default/distress rates as well as high yields from the underlying pool of loans manifests as improvements to CLO capital constraints, which are acutely sensitive to cash flow and distress. CLOs with higher O&G exposure are not subject to selling pressure to satisfy their covenants before the shock, thus, they recover higher prices for loans issued by portfolio firms relative to CLOs with lower exposure. Therefore, I expect β_1 from Equation 18 to be positive. Given the boom and bust nature of O&G, pre and post shock, the appropriate benchmark of comparison is the interaction term, β_3 from Equation 18.[31] Throughout these specifications, standard errors are two-way clustered by CLO and month-year.[32]

[28] Note that CLOs operate within 3% of the interest diversion covenant threshold (see Table D.2), therefore even CLOs with higher O&G exposure are *relatively* unconstrained.

[29] Had CLOs with low O&G exposure and high O&G exposure performed similarly on the Interest Diversion covenant, i.e. the blue and red lines were superimposed, the dynamic relation between characteristics of financial assets and firms, and, CLO O&G exposure, is expected to be nonlinear. For specific evidence of this, I refer readers to Section 8.1.

[30] Presumably, after the price plunge, marginal O&G firms become distressed.

[31] The "boom" is not witnessed for the hotels, motels, inns, gaming and leisure (HMIGL) sector before the COVID-19, therefore the effect before the shock is statistically negligible.

[32] Observations are identified at a CLO month-year level. This clustering strategy allows residuals of firms which belong to the same CLO or observations within the same time dimension to be correlated.

First, I study how the secondary loan spread of loans that are issued by non-O&G firms in a CLO's portfolio changes with a CLO's exposure to O&G after the O&G price plunge. I impute the secondary loan spread from the observed transaction prices of CLO sales.[33] The results are presented in Table 3. Regressions include rating-industry fixed effects. This is consistent with the thought experiment of comparing two similar firms, in terms of industry and rating across CLOs, which only differ by the O&G exposure of their CLO creditors.[34] I include CLO and issuer controls in Columns 2-5, and Columns 3-5, respectively. CLO controls consist of CLO size, annualized equity distribution, and age. Issuer controls consist of firm size, leverage, and tangibility. The addition of controls substantially reduces the sample size because Compustat reports firm fundamental information only for publicly held companies, whereas a sizeable share of leveraged loan issuers are mid-market companies, and private firms.

The coefficient of interest is the coefficient of Oil & Gas $\times$ *Post*, which signifies how changes in financial constraints experienced by CLOs affects the secondary loan spread. The most conservative estimate of Column 5, which accounts for common shocks and loan type through month-year and term loan fixed effects, respectively, suggests that a one percentage point increase in a CLO's exposure to O&G is associated with an additional 14 bps increase in the spread in the secondary loan market after the shock. Across all specifications, the estimate remains stable – between 8-14 bps – economically meaningful, and statistically significant at the 5% level. Thus, secondary loans issued by non-O&G firms trade at a larger spread if the CLO has greater exposure to O&G after the shock. In the least conservative specification of Column 1, the R^2 is 0.4204, hence, the model explains a sizeable amount of variation in the dependent variable. For robustness, I assess whether this relation holds with issuer fixed effects in Table A.4. In Column 1 of Table A.4, I do not include any control variables. The point estimate from the within issuer estimator is comparable to the point estimate from the within rating-industry estimator in Column 1 of Table 3. Using the within issuer estimator, a one percentage point increase in a CLO's exposure to O&G is associated with an additional 8.67 bps increase in the spread of the secondary loan market after the shock, compared to 8.14 bps from Column 1 of Table 3. The most conservative estimate of the within issuer specification, presented in Column 3, includes month-year fixed effects, industry and rating $\times$ term loan fixed effects. This column suggests that a one percentage point increase in a CLO's exposure to O&G is associated with an additional 18 bps increase in the spread in the secondary loan market after the shock. Thus, the estimates yielded from the within issuer estimator are comparable, albeit slightly larger, to those from the within industry-rating estimator.

How do these price effects materialize? After the price plunge, higher CLO O&G exposure is associated with lower monthly net purchase of loans issued by non-O&G firms as shown in Table 9; a one percentage point increase in a CLO's exposure to O&G is associated with an additional decline in the monthly net purchase of non-O&G loans by 0.052-0.068 standard deviations, relative to the mean. This is mostly driven by sales of risky firms, as explained in Section 7.2. Findings on the mechanism are expounded in Section 7.

[33] The spread, in bps, is computed as $(100 - P) \times 100$, as the price is reported per \$100 notional par.

[34] I refer to the CLOs a firm's debt is held by as its "CLO creditors."

Second, I study how the legacy of a non-O&G firm's previous CLO creditors affect the terms at which the firm obtains new credit. Specifically, for firms that seek new bank loans, I study how the exposure of their CLO creditors to O&G from three months prior, impacts the *all-in-drawn spread* associated with new term loans B+. The all-in-drawn spread is defined as the total annual spread above LIBOR for each dollar drawn from a loan. This includes both fees and interest payments. I interpret this measure as the cost of financing. Further, I restrict my analysis to the set of deals conducted by lead banks.[35] The estimator is a within rating-industry estimator, presented in Table 4. I include CLO controls and issuer controls in Columns 2-5 and Columns 3-5, respectively. In addition, I control for a loan's maturity as well as whether it is secured or not in Columns 3-5. I include year fixed effects in Column 5 to control for common shocks. I find that a one percentage point increase in a CLO's exposure to O&G is associated with an additional 1.2-4.7 bps increase in the all-in-drawn spread. These point estimates are statistically significant and economically meaningful across all specifications. In the least conservative specification of Column 1, the R^2 is 0.3223, hence, the model explains a sizeable amount of variation in the dependent variable. There is limited suggestive evidence of O&G exposure of CLOs affecting the *quantity* of new term loans after the shock, presented in Table A.5. In Table A.5, the outcome variable is the natural log of the loan volume.

While CLOs typically purchase term loans B+ (See Table 5 of Kundu (2020*a*)), banks hold onto revolving lines of credit and term loans A. This gives rise to the following question: how do the changes for these credit facilities compare to the changes for institutional term loans? In Table A.6, I replicate Table 4 for the all-in-drawn spread associated with new revolving lines of credit facilities. I find that a one percentage point increase in a CLO's exposure to O&G is associated with an additional 0.6-2.3 bps increase in the all-in-drawn spread of revolving credit facilities, after the shock. Hence, the change in the all-in-drawn spread for revolving lines of credit is less aggressive than the change in the all-in-drawn spread for term loans B+. However, Table A.7 reports that a one percentage point increase in a CLO's exposure to O&G is associated with an additional decline of 1.04-2.94 standard deviations in the *volume* of new credit facilities, relative to the mean. The additional decline is statistically significant across all specifications, unlike in Table A.5, and larger in magnitude as compared to term loans B+. Thus, the O&G exposure of a firm's previous CLO creditors tangibly affects the terms at which a firm obtains new loans by affecting both the cost of financing, as well as the volume of new financing. The increase in the cost of financing is larger for term loans B+, as compared to revolving lines of credit. However, the additional decline in the volume of new credit is larger for revolving lines of credit as compared with term loans B+. These results suggest that banks substantially reduce credit, typically retained on their balance sheets, to firms whose CLO creditors have a larger exposure to the O&G industry.

Third, I examine the sensitivity of credit spreads of non-O&G traded corporate bonds to the O&G exposure of CLOs before and after the shock. Past work has shown that banks are the main source of funding for riskier and more opaque firms, as banks have the ability to

[35] I use the *Lead Arranger Credit* variable to define lead banks, consistent with Sufi (2007). As a robustness exercise, I have also replicated this analysis by manually encoding lead arrangers, and the results are effectively unchanged.

monitor borrowers (e.g., Diamond (1984); Diamond (1991); Petersen and Rajan (1994); Petersen and Rajan (1995); Bolton and Freixas (2000)). It is also well established that upon experiencing an aggregate shock, firms substitute from bank debt to public debt (e.g., Kashyap, Stein and Wilcox (1993); Adrian, Colla and Shin (2013); Becker and Ivashina (2014)). In Columns 1-4, the point estimate associated with the *Post* variable is negative, consistent with the established literature on substitution of firms' external financing sources. However, I find that credit spreads of traded corporate bonds widen, after the idiosyncratic or sectoral shock, for firms that are held by CLOs with greater O&G exposure. This is shown in Table 5. I use a within rating-industry estimator, controlling for CLO characteristics (Columns 2-5), and bond characteristics (Columns 2-5) which include maturity controls (Columns 3-5) and fixed effects for bond type, convertibility, investment grade, high-yield, secured status, and issuer characteristics (Columns 5). I include quarter fixed effects, and, quarter and year fixed effects in Column 4 and Column 5, respectively, to control for seasonality and common shocks. I find that a one percentage point increase in a CLO's share of O&G is associated with an additional 0.8-2.4 bps increase in the credit spread of bonds issued by non-O&G issuers after the shock. The point estimates are statistically significant and economically meaningful across all specifications. In the least conservative specification of Column 1, the R^2 is 0.5088, hence the model explains a sizeable amount of variation in the dependent variable.

In summary, a one percentage point increase in a CLO's share of O&G is associated with 8-14 bps increase in the secondary loan spread, 1.2-4.7 bps increase in the primary loan spread (all-in-drawn spread), and 0.8-2.4 bps increase in the credit spread of corporate bonds for non-O&G portfolio firms.

6.5 Second Stage: Real Effects on Corporate Decisions

In this section, I examine how innocent bystanders respond – the second stage of the analysis. For ease of comparison, I standardize the outcome variables. Standard errors are two-way clustered according to CLO and quarter-year in this section.[36]

I consider how non-O&G firms' liquidity is affected based on the exposure of their CLO creditors to the O&G industry. I report these results in Table 6 for the intensive margin, in which I restrict the sample to firms which have access to a line of credit. In Columns 1 and 3, the outcome variable is the ratio of a firm's total line of credit to the aggregate of total line of credit and, cash and cash equivalents. In Columns 2 and 4, the outcome variable is the ratio of a firm's undrawn line to the aggregate of the undrawn line and, cash and cash equivalents. In Columns 1 and 2, I do not include any controls. In Columns 3 and 4, I include both CLO and issuer controls to control for investor and firm heterogeneity. In addition, I include quarter

[36]The frequency of observations for real outcomes occurs quarterly. This allows residuals of firms which belong to the same CLO to be correlated, or observations within the quarter-year to be correlated. As the number of clusters are limited, I conduct wild bootstrapped-based tests for assessing statistical significance of the interaction term. High correlation within a small number of clusters can lead to low statistical power in the estimators, hindering inference. I report the wild bootstrapped results in Table A.10, A.11, and A.12, respectively. The differences are negligible in the t-statistics and p-values. I do not manually compute standard errors, per Roodman et al. (2019), as using the imputed standard errors for inference rely on the asymptotic normality of $\hat{\beta}$ which is not applicable when large-sample theory does not apply.

fixed effects, to control for seasonality. I find that within rating-industry, a one percentage point increase in a CLO's exposure to the O&G industry is associated with an additional 0.013-0.016 standard deviations decline in a firm's liquidity ratio, relative to the mean, after the shock. This estimate is stable, economically meaningful, and statistically significant across all columns. Hence, the liquidity of portfolio firms with access to an existing line of credit, experience deterioration in firm liquidity as their CLO creditors become more constrained. In Table A.8, I report the results from the extensive margin, demonstrating that the results are robust even when considering firms that do not have access to an existing line of credit. In addition, the results are robust to an alternative definition of total line of credit as shown in Table A.9, in which the outcome variable is defined as the ratio of total line of credits to lagged assets (standardized). Across the tables, the estimates are of similar magnitudes and statistically significant.

Next, I study whether non-O&G firms make financial adjustments in Table 7. I use a within rating-industry estimator to look at how firms' debt growth is affected in Column 1, payout in Column 2, capital expenditures in Column 3, research and development in Column 4, acquisitions in Column 5, and cash flow in Column 6. I include CLO and issuer controls and account for common shocks through year fixed effects. The construction of firm variables is described in Section B. As CLOs become more constrained, their portfolio firms make financial adjustments, experiencing declines in aggregate debt growth and cash flows, as well as expenditures related to payout, capital, research and development, and acquisitions. Concretely, a one percentage point increase in a CLO's exposure to O&G is associated with additional declines in the debt growth by 0.008 standard deviations, payout by 0.023 standard deviations, capital expenditures by 0.034 standard deviations, research and development by 0.015 standard deviations, acquisitions by 0.012 standard deviations, and cash flow by 0.007 standard deviations, relative to their respective means. These point estimates are statistically significant.

In addition to financial adjustments, non-O&G firms also make real adjustments. In Table 8, I study how employment growth, various measures of investment, and investment growth, net leverage, and Tobin's Q are affected, using a within rating-industry.[37] I include CLO and issuer controls, as well as year fixed effects to control for common shocks across all columns. After the price plunge, portfolio firms contained in more constrained CLOs make real adjustments: employment growth, investment, investment growth, net leverage and Tobin's Q decline. In addition, larger firms – relative to the median – experience sizeable declines in employment growth. This is because larger firms constitute a larger share of a CLO's assets.[38] Concretely, a one percentage point increase in a CLO's exposure to O&G is associated with additional declines in employment growth by 0.012 standard deviations for large firms, investment by 0.014-0.034 standard deviations, investment growth by 0.040 standard devia-

[37] *Investment*, without further qualification, hereafter, refers to capital stock growth.

[38] If *large* firms are firms with size above the median firm size, while *small* firms are firms with size below the median, the estimate share of a CLO's assets attributed to large firms is 58.0070%, while the estimated share of a CLO's assets attributed to small firms is 44.3498%. The difference between these two groups is -13.657%. A t-test rejects the equality of means.

tions, net leverage by 0.001 standard deviations, and Tobin's Q by 0.009 standard deviations, relative to their respective means. On average, the size of non-O&G portfolio firms is not affected by CLO O&G exposure, after the shock, therefore, not reported. However, there is a statistically significant relation between firm size and CLO O&G exposure for the subset of subset of non-O&G risky firms, discussed in Section 7.2.

6.6 Discussion

How do these price effects occur across asset classes? I explain these phenomena by a variation of a no-arbitrage argument. Suppose that there is a distinct group of prospective buyers who want to purchase risky debt and gain exposure to a certain firm. The prospective buyer may purchase any form of debt – secondary issuance, primary issuance, bonds, etc.. CLOs constitute marginal investors in the secondary loan market which is illiquid relative to other capital markets. When they become constrained, CLOs sell loans issued by innocent bystanders – shown in Section 7 – to generate slack in their constraints. As the spread associated with secondary loans widens, other forms of debt also experience a widening of spreads. In market equilibrium, the expected rate of return for any form of debt issued by a firm is equalized. For the affected innocent bystanders, the secondary market spread becomes the effective cost of capital. Thus, the real costs of fire sales can exacerbate credit crunches by contracting credit as described in Diamond and Rajan (2011).

Stein (2013) argues that the forced sale of an asset below its long-run fundamental valuation is not sufficient for regulatory intervention. However, when a fire sale creates externalities or welfare effects, it may merit regulatory intervention.[39] In the context of CLOs, the interaction of covenants with idiosyncratic or sectoral shocks can lead to the shrinkage of CLOs' balance sheets. As stated, the secondary loan market is relatively illiquid, forced sales in this market can increase the rate of return for other markets in equilibrium, which can affect firms' credit quality by extension. Naturally, this gives rise to two questions: (1) how persistent is the dislocation? (2) why do other investors not step in to eliminate excess returns? I address these questions next.

6.6.1 How persistent is the shock?

In this section, I address concerns on the plausibility in the link between financial market dislocations and real effects. To do this, I study the dynamic effects of CLO O&G exposure on the secondary loan spread of loans issued by a non-O&G issuers. I also examine the dynamic effects of CLO O&G exposure on several firm-level financial and real variables. These results shed light on the persistence of the shock and the transmission of market imperfections to the firm-level.

Contemporaneous Effects: In Figure 7, I present the contemporaneous effects of O&G exposure on the secondary loan spread for loans issued by non-O&G firms for each quarter-year. The point estimate is plotted along with the 95% confidence interval, based on standard

[39] Hanson, Kashyap and Stein (2011) propose a *macroprudential* approach to *control the social costs associated with excessive balance sheet shrinkage on the part of multiple financial institutions hit with a common shock.*

errors computed from two-way clustering on CLO and quarter-year. Before the O&G price plunge, demarcated by the dotted vertical gray line, sales of secondary loans issued by non-O&G issuers are associated with lower spreads. From late-2012 until mid-2014, the point estimate is negative, statistically distinguishable from 0, and stable. This suggests that during this period, loans issued by non-O&G firms that are held by CLOs with higher O&G exposures, retrieve higher prices in the secondary loan market, relative to comparable loans by rating and industry, held by CLOs with lower O&G exposures. Hence, innocent bystanders in CLO portfolios with large O&G exposure benefited during the boom period. After the oil price plunge begins in mid-2014, this relation changes. The point estimate increases above the pre-2014 levels, reaching a peak in 2016. That is, loans issued by non-O&G firms that are held by CLOs with higher O&G exposure retrieve significantly lower prices in the secondary loan market relative to comparable loans by rating and industry, held by CLOs with higher O&G exposures. The point estimate after the O&G price plunge is larger in every year, as compared to the average point estimate before the plunge. Therefore, even when the point estimate is not statistically distinct from zero, the spread of a loan traded in the secondary market is effectively larger than that traded during the boom period, before the plunge in mid-2014. Hence, the firm experiences a relative increase in the cost of refinancing. Furthermore, the point estimates are positive and statistically significant from zero for approximately four quarters, starting from 2015Q3.

Additionally, I present the contemporaneous effects of O&G exposure on a panel of (standardized) firm real outcomes for each quarter-year for risky, non-O&G firms.[40] This is presented in Figure A.8, in which I plot the point estimate, along with the 95% confidence interval, based on standard errors computed from two-way clustering on CLO and quarter-year. The pre- and post- plunge effects are demarcated by the dashed vertical gray line. The contemporaneous effects are presented for debt growth (Figure A.8a), cash flow (Figure A.8b), payout (Figure A.8c), Tobin's Q (Figure A.8d), investment (Figure A.8e), and employment (Figure A.8f) – all variables are standardized. The contemporaneous effects reflect that declines in real activity coincide around the timing of the secondary market spike in 2016. While the point estimate exhibits rebounding, a temporary hemorrhage may still have debilitating effects in the long-term.

Impulse Responses: In addition to studying the contemporaneous effects of the shock, I present a Jordà (2005) style linear projection of the regression for 24 months to study the dynamics of the secondary loan spread for loans issued by non-O&G firms, in response to oil price shocks. In Figure A.6, I present the response of the secondary loan spread to oil price shocks for CLOs with high O&G exposure, relative to the median. The specification is as follows.

$$Y_{c,f,t} = \beta_0 + \beta_1 (ln(OilPrice))_t + +\alpha_{i,r} + \epsilon_{c,f,t} \tag{21}$$

where $Y_{c,f,t}$ is the secondary loan spread, c denotes the CLO, f denotes the portfolio firm

[40] A firm is considered to be *risky* if has a rating below CCC/Caa1.

($f \in c$), t denotes the time, i denotes the industry, r denotes the rating, and $ln(OilPrice)$ denotes the oil price. All variables are standardized. The effects shown in Figure A.6 are statistically significant and economically meaningful. I find that the response is largest at t = 0 as a one standard deviation increase in the oil price is associated with 0.2 standard deviations decline in the secondary loan spread of non-O&G portfolio firms. The effects endure, albeit monotonically decline in magnitude until t = 15 – that is, 15 months after the initial impact. This baseline finding is robust to the addition of control variables. Furthermore, I refer readers to the discussion on parallel trends in Section 6.3.4, describing the findings of a trend-analysis that exploits variation from O&G exposure and the timing of the O&G price plunge. This corroborates persistence.

In addition, I present the cumulative impulse response functions (IRFs) of non-O&G firm characteristics on oil price shocks in Figure A.7. These plots present the cumulative IRFs for firms held by CLOs with high O&G exposure, estimated from a panel VAR(1) model. The contemporaneous effects are presented for debt growth (Figure A.7a), size (Figure A.7d), cash flow (Figure A.7b), payout (Figure A.7c), investment (Figure A.7e), and employment (Figure A.7f) – all variables are standardized. I find that all variables respond gradually and endure even eight quarters after the initial impulse. Thus, a temporary episode of distress can damage firms for a longer-term – an externality of "short-termist" damage control.

6.6.2 Why do other investors not step in to eliminate excess returns?

In this section, I address the question of why other investors do not step in to eliminate excess returns, manifesting from CLO forced sales in the secondary loan market. First, a large body of literature has found that lending market risk aversion increases in the aftermath of shocks (e.g., Malmendier and Nagel (2011); Malmendier, Tate and Yan (2011); Malmendier and Nagel (2015); Koudijs and Voth (2016)). The results from Table 10 suggest that after the O&G shock, the average remaining maturity of loans in CLO portfolios declines – invariant to the degree of constraint (discussed in detail in Section 7). In addition, CLOs that are more constrained purchase loans with lower interest rates. This is consistent with lending market risk aversion increasing. Secondly, relatively unconstrained CLOs with spare balance sheet capacity *do* substitute their portfolios towards riskier assets. Figure 9 shows that CLOs with low O&G share have a higher share of B1-B3 rated assets after the shock and a lower share of Ba1-Ba3 rated assets, compared to before. This suggests that unconstrained CLOs increase purchase of riskier loans after the shock. Further, Table 9 shows that CLOs which are unconstrained purchase more than CLOs that are constrained However, the total amount of purchasing may be insufficient to offset the price decline. Other potential buyers, including banks, insurance and pension companies may be subject to other regulatory and risk-based capital constraints preventing them from purchasing risky loans.[41] This may explain the findings of Table A.7 and Table A.6, which show that revolving lines of credit, typically retained on banks' balance sheets, are sensitive to the O&G exposure of firms' CLO creditors. In instances of large shocks

[41] Figure 6 of Kundu (2020*a*) shows the purchasers of leveraged loans and CLOs. Section 4.3 and 4.4 of Kundu (2020*a*) discuss the treatment of CLOs for banks' balance sheets.

impairing banks, which are also large purchasers of leveraged loans, bank capital may be immobile because of debt overhang. Debt overhang can prevent banks from making positive net present value investments by raising new equity funding. This is because new equity is essentially a transfer to more senior debt claimants, making it more difficult for banks to recapitalize (Myers (1977)).

6.6.3 Robustness

I conduct a battery of robustness tests to check if the results are robust to alternative specifications, measures, weights, definitions, periods, and empirical strategies, in addition to the supplemental results suggested in the previous sections. In this section, I provide a brief summary of the main findings.

First, I run two placebo tests: *(1)* I randomize the date of the oil price plunge from a uniform distribution, and *(2)* I randomize the O&G share from a uniform distribution. These placebo tests address whether the timing of the O&G price plunge is a meaningful indicator. In addition, the findings ensure that the baseline results are not driven by omitted variable bias, as long as the structure of omitted variables is identical across CLOs. The point estimate of the interaction term from 1,000 Monte-Carlo simulations of the baseline regression, without any CLO or issuer controls is presented in Figure A.9. In this regression, the outcome variable is the transacted secondary loan price, P. The histograms show that the estimate is centered around 0. The "true" estimated point estimates lie outside of the graph. The null results suggest that omitted variables do not drive the results – the timing of the O&G price plunge, as well as CLO exposure to O&G are both critical determinants of the results.

Second, I study whether the result is robust to alternative empirical specifications. I study whether the results differ if the initial O&G shares are fixed before the price plunge occurs, according to the following specification.

$$\begin{aligned} y_{c,f,t} = \beta_0 + \beta_1 \text{O\&G Exposure}_c + \beta_2 \text{Oil Shock}_t + \beta_3 (\text{O\&G Exposure}_c \times \text{Oil Shock}_t) + \\ + \gamma_0' X_c + \gamma_1' Z_f + \alpha_{i,r} + \epsilon_{c,f,t} \end{aligned} \tag{22}$$

where c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, i denotes the industry and r denotes the rating. $y_{c,f,t}$ denotes the dependent variable. *O&G Exposure*$_c$ fixes the O&G share of a CLO to before the shock, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. Z is a vector of firm controls and X is a vector of CLO controls. I present the results in Table A.13. A one percentage point increase in a CLO's exposure to O&G is associated with additional increases in the secondary loan spread, primary loan spread or all-in-drawn spread, and bond credit spread by 5.3 bps, 1.6 bps, and 2.6 bps, respectively. In addition, debt growth and investment exhibit sensitivity to CLOs' O&G exposures in a statistically significant manner.

In Figure A.10, I consider a variant of this specification, in which I fix O&G exposure to the initial shares, and exploit time variation in the price deviation of WTI crude from $70 – Oil Price Deviation$_t = ln(\frac{P_t}{70})$. $70 is arbitrarily selected within the range of the cost of extracting a barrel of crude worldwide. The regression specification is as follows.

$$\begin{aligned} Y_{c,f,t} &= \beta_0 + \beta_1 \text{O\&G Exposure}_c + \beta_2 \text{Oil Price Dev.}_t + \beta_3 (\text{O\&G Exposure}_c \times \text{Oil Price Dev.}_t) + \\ &+ \gamma_0' X_c + \gamma_1' Z_f + \alpha_{i,r} + \epsilon_{c,f,t} \end{aligned} \tag{23}$$

where c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, i denotes the industry and r denotes the rating. $y_{c,f,t}$ is the dependent variable. *O&G Exposure*$_c$ measures the initial O&G share of a CLO. The cross-sectional shares of O&G exposure are fixed. Temporal variation comes from the oil price deviation$_t$ $= ln(\frac{P_t}{70})$. Z is a vector of firm controls and X is a vector of CLO controls. Because the coefficient of interest is an interaction of two continuous variables, namely, the price deviation and the share, I plot the marginal effects – the slope of various outcome variables on price deviation, while holding the value of the O&G share constant between 0 and 1. I produce these plots for the secondary loan spread (top left), bank loan spread (top right), bond credit spread (middle left), debt growth (middle right) and investment (bottom). As the crude price deviation is positive and larger, it is expected that CLOs with greater O&G exposure will perform farther from their covenant thresholds. Conversely, when the crude price deviation is negative and larger in magnitude, it will push these CLOs closer to their covenant thresholds. The plots of Figure A.10 are consistent with these hypotheses. When the oil price deviation is higher, CLOs with larger O&G exposure experience lower spreads, higher debt growth, and investment. When the oil price deviation is lower, CLOs with smaller O&G exposure experience higher spreads, lower debt growth, and investment. Furthermore, in Table A.14, I bin CLOs based on exposure to the O&G industry. CLOs in *Bin #4* are those with O&G exposure above the 75^{th} percentile across all CLOs, CLOs in *Bin #3* are CLOs with O&G exposure between the 50^{th} and 75^{th} percentiles, CLOs in *Bin #2* are CLOs with O&G exposure between the 25^{th} and 50^{th} percentiles, and CLOs in *Bin #1* are CLOs with O&G exposure below the 25^{th} percentile. As expected, I find that the coefficient of the interaction is most economically meaningful for CLOs in Bin #4. The point estimates exhibit ordinal ranking in significance. The secondary loan spread, primary loan spread, bond spread, debt growth, and investment exhibit greatest sensitivity to CLOs with large O&G exposures – before and after the shock. The relation weakens for CLOs with smaller O&G exposures.

Third, I consider how alternative measures of CLO health affect financial amplification as a sanity check. In Table A.15, I examine how the all-in-drawn spread for term loans B+ is affected by alternative measures of CLO health between 2013-2017, using the least conservative specification. This provides a basic check of whether the fire sale effect spreads to other markets. In this table, *Unhealthy #1* takes a value of 1 if a CLO's distance to the Interest Diversion threshold is below the median, and is assigned 0, otherwise. *Unhealthy #2* takes a value of 1 if a CLO *fails* the Interest Diversion threshold, i.e., it operates below the threshold, and is assigned 0, otherwise. Columns 1 and 2 suggest that after the price plunge occurs, the loans issued by a CLO's portfolio firms trade at a higher spread if the CLO is constrained. Neither of these measures consider distance to the threshold, a measure of the extent to which a CLO is healthy or unhealthy. For this reason, in Columns 3 and 4, I use a continuous measure of distance to the Interest Diversion constraint. In Column 4, *CLO Post* takes a value 1 if the CLO experiences any O&G defaults and is assigned a value of 0 otherwise. This is a CLO specific measure. Columns 3 and 4 suggest that after the shocks are realized, firms belonging to CLOs that perform better on their Interest Diversion constraints, i.e., are farther from their covenant thresholds, obtain more favorable terms for new loans – lower all-in-drawn spreads. However, all specifications rely on explicit measures of CLO performance on the Interest Diversion covenants. I do not directly use these measures of covenant performance as the main measure in this empirical analysis, because these direct measures of CLO health are plagued by a myriad of selection concerns between CLOs and portfolio firms.

In addition, I replicate the baseline results using alternative weights, weighing firm observations based on their relative weight in a CLO. I also use a secondary identification strategy, using the share of a firm's debt held by constrained CLOs to instrument for the firm's exposure to constrained CLOs.[42] In the interest of parsimony and concision, I do not report these results in this paper.

These results suggest that intermediary distress can tangibly affect firms. In the subsequent section, I will analyze the mechanism through which these effects can transpire, and test whether non-O&G risky firms may be most susceptible to being innocent bystanders, as suggested by the hypotheses presented in Section 4.

7 Mechanism

7.1 CLO Management

How do CLO managers manage their portfolio? How do the asset pricing, financial, and real effects materialize for non-O&G portfolio firms? In this section, I examine the actions CLO managers take with regard to their portfolios, and further dissect which types of loans are most vulnerable to forced sales.

CLOs that are more constrained drastically reduce their monthly net purchase of loans issued by non-O&G firms. This is presented in Table 9. A one percentage point increase in a CLO's exposure to O&G is associated with an additional decline in the monthly net purchase of non-O&G loans by 0.052-0.068 standard deviations, relative to the mean. The range of point estimates is economically meaningful, statistically significant at the 10% level, and very stable.

[42]This exact measure is susceptible to endogeneity concerns. The firm may contribute to the liquidity result, plaguing identification by reverse causality. Furthermore, CLOs may select based on unobservable characteristics of the firm. In this instance, reliance on the liquidity result can produce biased estimates, stemming from endogeneity. To address this, I use an instrument that is constructed as follows. For each firm f, I recompute the distance to the covenant threshold without accounting for firm f. This ensures that the firm's cash flow and financial performance do not contribute to the constraint. The removal of f from the calculation ensures that the results are not driven by characteristics of the firm, rather than the constraint. I classify a CLO, c, as *constrained* if its adjusted distance-to-threshold is below or equal to the median adjusted distance-to-threshold – the results are robust to other thresholds, as well. Then, for each firm, I compute the share of debt held by constrained CLOs as:

$$\text{Share of debt held by constrained CLOs}_f = \frac{\sum_{c=1}^{N} \mathbb{1}_{\text{c is constrained}} \times Holdings_{cf}}{\sum_{c=1}^{N} Holdings_{cf}}$$

Standard errors are two-way clustered by manager and month-year in parentheses. The large-scale forced sales can generate price declines and large spreads in the secondary loan market, as described in Section 6.4, and in Kundu (2020*b*).

While the purported aims of the covenants are to ensure that CLOs which operate close to their covenant thresholds appropriately derisk, it is ambiguous whether constrained CLOs actually do derisk, or gamble for resurrection. One way I study this is by comparing the industry composition of constrained and unconstrained CLOs at different points in time. In Figure 8, I study the difference in the amount transacted for each industry for a CLO with low O&G exposure before the shock to a CLO with high O&G exposure after the shock. The difference between the two groups is within 3% across industries. Moreover, the industry concentration is largely invariant to the shock or CLO O&G exposure. The industry HHI of holdings is 0.0557 for CLOs with low O&G exposure before the shock, 0.0588 for CLOs with low O&G exposure after the shock, 0.0590 for CLOs with high O&G exposure before the shock, and 0.0533 for CLOs with low O&G exposure after the shock. If CLOs were gambling for resurrection, I would expect to see diversion of funds *towards* the O&G sector. In the absence of any distinguishable change in concentration, I rule out that CLOs gamble for resurrection upon becoming constrained.

To further assess risk, I study how the remaining maturity and coupon rate associated with non-O&G portfolio loans is affected by a CLO's exposure to O&G. I use a within issuer-term loan estimator for investigating how characteristics of loans within a given issuer and loan type vary with the CLO constraint. Standard errors are two-way clustered by manager and month-year in parentheses. In Columns 1 and 3 of Table 10, I explicitly control for the size and age of the CLO, while in Columns 2 and 4, I include CLO fixed effects to adjust for all CLO-specific, unobserved time-invariant heterogeneity. The main findings are as follows. First, after experiencing a shock, loans tend to have lower remaining maturity. After the O&G shock, unconditional on the degree of constraint, loans held by CLOs have an average remaining maturity that is 0.013-0.029 months below that of loans held by CLOs before the shock. This is signified by the point estimate of the *Post* variable. Second, remaining maturity does not exhibit sensitivity to the exposure of CLOs to O&G, *Oil & Gas Share* $\times$ *Post* – the degree of constraint, in a robust or statistically significant manner. Third, the coupon rate declines in a CLO's exposure to O&G, however. Specifically, a one percentage point increase in a CLO's exposure to O&G is associated with an additional decline in the interest rate by 0.011-0.014%. The estimates are stable and statistically significant. Together, these results suggest that upon experiencing a shock, CLOs tend to hold loans that are more liquid in nature – loans that are of shorter maturity and have lower rates. I investigate this further by studying how the composition of ratings in the portfolio changes before and after the shock for CLOs with differential exposures to the O&G industry.

In Figure 9, I present the ratings composition of CLO portfolios for CLOs with high O&G exposure and low O&G exposure, before and after the shock. After the shock, CLOs with high O&G exposure have a larger share of B1-B3 rated loans in their portfolio and a smaller share of loans that are rated CCC/Caa1 or below, relative to before the shock. Hence, constrained CLOs exhibit substitution from loans that are lower-rated to loans that are higher-rated. In contrast, CLOs with low exposure to O&G exhibit substitution from loans rated Ba1-Ba3 before the shock, towards loans rated B1-B3 after the shock – evidence of taking on additional risk.

Thus far, I have provided evidence, showing that after a shock occurs, constrained CLOs tend to reduce net purchase of loans, hold loans that tend to be of shorter maturity with lower interest rates, and hold fewer loans that are rated below CCC/Caa1. This suggests that CLOs divest themselves of loans that are riskier, consistent with the hypotheses presented in Section 4. In the next section, I will show evidence suggesting that riskier firms are disproportionately affected. This can provide an explanation for how price pressure around bankruptcy defaults can occur, as described in the motivation for the empirical analysis. An idiosyncratic shock can trigger a fire sale for risky innocent bystanders with real effects for these firms, including the choice to liquidate.

7.2 Risky Firms as Innocent Bystanders

To alleviate their constraints, I posit that constrained CLOs sell assets marked at market, subject to cash-in-the-market pricing. Assets are identified as mark-to-market or risky assets if they have a rating of CCC/Caa1 or below, are discount obligations or defaulted loans. First, I will provide descriptive evidence in support of this hypothesis. Second, I will examine if the risky subset of firms, defined as firms with a rating below CCC/Caa1, are disproportionately affected by the CLO constraints.

I begin by characterizing sales. I compute the net amount transacted for each firm, after the shock occurs, and categorize firms by rating. I find that CLOs are net purchasers in every rating category above CCC/Caa1, and net sellers in every rating category CCC/Caa1 and below. Hence, net sales are concentrated among the lowest rating category of loans. Further, using individual loan transaction data, I study the concentration of loan sales in a more granular fashion. I find that among the category of loans rated CCC/Caa1 or below, 48.3% of sales are for loans rated Caa1, 22.5% for loans rated Caa2, 17.5% for loans rated Caa3, 10.1% for loans rated Ca, and the remaining for loans rated C or D. Furthermore, the mean transacted price monotonically declines with a decline in ratings; loans trade at a mean value of \$86.7/\$100 for loans rated Caa1, \$80.92/\$100 for loans rated Caa2, \$78.07/\$100 for loans rated Caa3, \$72.92/\$100 for loans rated Ca, \$72.76 for loans rated C, and \$66.56 for loans rated D. Hence, this descriptive exercise suggests that, *(1)* sales are concentrated for lower rated loans, *(2)* among lower rated loans (CCC/Caa1 or below), sales are concentrated for loans that are higher rated, and *(3)* loans that are higher rated recover higher prices than loans that are lower rated.[43] Taken together, these three pieces of evidence corroborate the hypotheses presented in Section 4; CLOs first sell mark-to-market assets that recover a higher dollar value before those

[43] Among loans held by CLOs and rated CCC/Caa1 or below, the vast majority are rated Caa1, followed by Caa2, Caa3, Ca, C, and D. Relative to the benchmark – the percentage of loans by rating for loans rated below CCC/Caa1C – sales are still disproportionately concentrated for the upper segment. That is, the difference between the percent of sales of Caa1-Caa3 rated loans and holdings of Caa1-Caa3 loans is +3.5%. This difference for Ca is 4%. Thus, the initial holdings differences cannot fully explain differences in the concentration of sales.

that recover a lower dollar value, to maximize improvements to the constraint. Hence, in the subsequent analysis, I will focus on risky loans and real effects to their issuers.

First, I study how the change in a CLO's share of risky loans is affected by CLO constraint. In Table 11, I find that after the shock, a one percentage point increase in a CLO's exposure to O&G is associated with an additional reduction in the change of a CLO's share of risky loans by 0.15 standard deviations, relative to the mean, accounting for CLO control variables. That is, an increase in a CLO's exposure to O&G is associated with a decline in the subsequent amount of transacted risky assets, after the shock. This estimate is stable even with the addition of various time fixed effects. It is also economically meaningful and statistically significant. Hence, the result suggests that upon experiencing constraints, CLOs divest themselves of risky loans to generate slack in their covenant constraints.

Next, I study the price effects to non-O&G risky firms in Table 12 – a replication of Table 3 for the subset of loans that are rated below B3. The coefficient of interest is the coefficient of Oil & Gas $\times$ *Post*, which signifies how changes in financial constraints experienced by CLOs affects the secondary loan spread. The most conservative estimate of Column 5, which accounts for common shocks and loan type through month-year and term loan fixed effects, respectively, suggests that a one percentage point increase in a CLO's exposure to O&G is associated with an additional 40 bps increase in the spread in the secondary loan market after the shock. Across all specifications, the estimate remains stable – between 40-78 bps – economically meaningful, and statistically significant at the 1% level in all columns, except Column 1. Evidently, the price effects are significantly larger when restricting the sample to the set of non-O&G risky firms, which are more likely to be sold first; the effect is between 3-7 times as large.[44]

Furthermore, I exploit a difference-in-difference-in-differences (DDD) design to study the effect of the oil price plunge on asset prices and real effects of the riskier subset of issuers associated with CLO portfolios. I apply this empirical strategy to account for unobserved differences in trends in the outcome variables for risky and non-risky firms across CLOs with different O&G exposure. The regression specification is the following.

$$\begin{aligned}
Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \\
+ \beta_4(\text{Risky Firm}_{c,f,t}) + \beta_5(\text{Risky Firm}_{c,f,t} \times \text{Oil Shock}_t) \\
+ \beta_6(\text{Risky Firm}_{c,f,t} \times \text{O\&G Exposure}_{c,t}) + \\
+ \beta_7(\text{Risky Firm}_{c,f,t} \times \text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \\
+ \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_i + \epsilon_{c,f,t}
\end{aligned} \tag{24}$$

where the notation is the same as in equation 18. Risky firm denotes whether the issuer or firm f of a loan in CLO c has a rating below B3 – a subset of non-O&G firms that are marked to market. The coefficient of interest is β_7 which captures the treatment effect of CLO O&G exposure on outcome variables observed for non-O&G, risky firms relative to non-risky firms,

[44] I do not include issuer fixed effects to ensure that the sample size is large.

after the shock, within industry.

In Table 13, I study whether the real effects disproportionately affect non-O&G risky firms. The dependent variables are size in Column 1, debt growth in Column 2, employment growth for large firms in Column 3, investment in Column 4, and net leverage in Column 5. Greater CLO O&G exposure is associated with smaller firm size, lower debt growth, investment, and net leverage for non-O&G risky firms relative to non-risky firms after the price plunge. This is indicated by the coefficient of Risky Firm$_{c,f,t}$ $\times$ O&G Exposure$_{c,t}$ $\times$ Oil Shock$_t$. Specifically, I find that after a shock occurs, a one percentage point increase in a CLO's exposure to O&G is associated with additional declines in size, debt growth, employment growth, investment, and net leverage by 0.071, 0.080, 0.093, 0.035, and 0.108 standard deviations for risky firms, relative to their respective means.[45] Thus, the real effects are more pronounced for this subset of firms.[46] This is robust to the addition of issuer controls, presented in Table A.17.[47] For confirmation of the fire sale effect spreading to other markets, I report the price effects for the risky subset of non-O&G firms using the DDD specification in Table A.16.[48]

These findings may explain the price pattern around negative credit events, including bankruptcy defaults, motivating this inquiry. As hypothesized in Section 4, constrained CLOs sell loans issued by innocent bystanders that are marked at market value, subject to cash-in-the-market pricing, according to price. That is, mark-to-market assets are sold in descending order of market value to maximize improvements to the capital constraints. This trading strategy can distort the effective cost of capital for innocent bystanders. Loans issued by innocent bystanders may trade at a significantly larger spread in the secondary loan market than their firm fundamentals may suggest. As evidence suggests, this distortion can make it difficult for the affected firms to obtain external financing. Subsequently, these firms may resort to making financial and real adjustments. Hence, marginal firms may file for liquidation.

8 Magnitude of Effect

How large are these magnitudes? In Sections 6.4 and 6.5, the regression specifications yielded point estimates from averaging over the entire pool of non-O&G portfolio firms. However,

[45] While a concern may be that trading behavior may reflect firm fundamental changes as I identify "risky" assets using ratings, this concern is only plausible if the timing of the shock coincides with the timing of the fundamental events.

[46] The point estimate associated with employment growth is statistically significant for firms in the fourth size quartile.

[47] As the number of clusters is limited, I conduct wild bootstrapped-based tests for checking statistical significance. These results are reported in Table A.18 for the triple interaction term. The differences are negligible.

[48] I use a within industry estimate and control for CLO characteristics and seasonality through quarter fixed effects. The outcome variables are: secondary loan spread, primary loan spread (all-in-drawn spread), and credit spread in Columns 1-3, respectively. I find that the coefficient of Risky Firm$_{c,f,t}$ $\times$ O&G Exposure$_{c,t}$ $\times$ Oil Shock$_t$ is economically meaningful across all three Columns, and statistically significant in Columns 1 and 3. Specifically, I find that after a shock occurs, a one percentage point increase in a CLO's exposure to O&G is associated with additional increases in the spreads of secondary loans, primary loans, and bonds, between 7-111 bps for risky issuers. Hence, these results suggest that loans that are lower rated experience larger changes in asset prices, contingent on the degree of constraint.

these point estimates may severely understate the magnitude of the true effect for several reasons.

First, not all non-O&G portfolio firms are innocent bystanders. As explained in Sections 4, 7.2, CLOs can generate more slack in their constraints by selling assets that are marked at market. The analysis of Section 7.2 replicates the baseline results, finding that this subset of firms, which are more likely to be innocent bystanders, experience pronounced effects. However, even these estimates may be understated; I rely on ratings as an approximation for determining assets that may be marked to market price. It is plausible that not all firms that are rated CCC/Caa1 or below are marked at market. Selecting issuers based on their secondary market price after the oil price plunge and studying the real effects may provide more precise estimates of the size of the channel. However, there are several difficulties with this approach. Statistical power is limited given the sample size during this relatively uneventful macroeconomic period. In addition, disentangling the oil price shock from other firm-specific events that may affect firm fundamentals presents another challenge.

Second, the estimates yielded from the baseline specifications are across CLO effects. If the average CLO is exposed to O&G, all CLOs may experience a tightening in their constraints after the shock. In this case, the effect that is measured is the effect of additional tightening by more exposed CLOs. With heterogeneous effects across CLOs, the aggregate impact may be larger than the point estimates yield, depending on the average O&G exposure of the average CLO. Third, the empirical methodology of Sections 6.4 and 6.5 measure the reduced-form/intention-to-treat (ITT) effects. This assumes that the assignment of treatment is exogenous. However, it can ignore noncompliance, deviations, or attrition post-randomization. While the ITT is the "causal effect of being assigned to treatment," if the treatment assigned differs from the treatment itself, the intention-to-treat, it can often lead to the underestimation or dilution of the true effects (Angrist and Pischke (2014)).

Lastly, I conduct my analysis for a relatively benign macroeconomic period – from 2012-2017. This is a period when financial markets were calm and relatively liquid. While the effects emanating from a financially tranquil period may be temperate, it raises concerns of what may occur when markets become more illiquid during times of stress. 90% of CLOs are exposed to the top 50 US borrowers, and 80% are exposed to the top five borrowers (Federal Stability Board (2019)). Default can impose negative externalities on other firms held in the CLO portfolio or the same industry. This can have especially deleterious effects if issuers simultaneously default. Elkamhi and Nozawa (2020) project that with small shocks, as many as 44% of CLOs may fail their Junior OC tests.[49] I replicate the first stage using the COVID-19 shock for external validity and to study how the magnitude may change with more adverse shocks.

[49]Specifically, Elkamhi and Nozawa (2020) claim that if the top 10 borrowers default, 70% of CLOs would violate their Junior OC test restriction during the COVID-19 global pandemic in 2020 – up from 44% in Dec. 2019.

8.1 First Stage Replication: COVID-19 Shock

Thus far, I have shown how idiosyncratic or sectoral shocks may amplify through covenants that constrain CLO managers. When managers become constrained, they sell loans issued by innocent bystanders, unrelated to the original source of distress. This increases the effective cost of capital for these issuers, which may make financial and real adjustments in response. I test whether this mechanism can be externally validated using a recent shock: the global COVID-19 pandemic.

In Table 14, I replicate the first stage analysis. I use the secondary loan spread as the outcome variable, exploit cross-sectional variation in CLOs' exposure to the *hotels, motels, inns, gaming and leisure* (HMIGL) industries, as well as the timing of the COVID-19 shock. From Table 2, the median (mean) CLO has 6.08% (5.78%) of the portfolio invested in HMIGL. The 25^{th} and 75^{th} percentile values are 4.24% and 7.89%, respectively. The standard deviation associated with HMIGL share is 2.64%.

I use a within rating-industry estimator. I find that a one percentage point increase in the share of HMIGL share is associated with an additional increase in the spread of secondary loans issued by non-HMIGL firms by 42-52 bps. This estimate is roughly five times larger than the baseline result presented in Table 3. Across all specifications, the estimates are stable, economically meaningful, and statistically significant at the 1% level. Furthermore, unlike the baseline results, I note that the coefficient associated with *HMIGL Share* is neither statistically significant, nor as large in magnitude as the coefficient associated with the interaction term. In Figure A.11, I present the dynamic relation between CLOs' HMIGL exposure and distance to the Interest Diversion covenant, showing that that CLOs with high HMIGL exposure performed worse on their Interest Diversion constraint than CLOs with low HMIGL exposure, prior to the shock – not the case with O&G exposure around the O&G shock as shown in Figure 6. In other words, anecdotally, CLOs with higher HMIGL exposure do not have experience greater slack in their capital constraints. Hence, I do not expect other, unrelated loans held in CLO portfolios with greater HMIGL exposure to recover a higher price, relative to CLOs with lower HMIGL exposure, before the shock.

Given the recency of the event, there is currently insufficient data to replicate the main analyses using the COVID-19 shock. As the data is updated, I will be able to conduct a complete replication of the main analyses using the COVID-19 shock. Nonetheless, the first stage results are promising and provide a check for external validity. They also suggest that the point estimates may be much larger during periods of financial stress.

9 Conclusion

Covenants provide a mechanism for diffuse, idiosyncratic or sectoral shocks to snowball into larger shocks through CLO intermediaries. This poses systemic concerns. When CLOs experience shocks, they may be pushed closer to their operating constraints. In response, CLOs may sell unrelated, riskier loans, i.e., loans that are mark-to-market, to alleviate covenant constraints. Given the illiquidity in corporate debt markets, including the secondary loan market, forced sales may have outsize effects to firms. Thus, fire sales originating from the CLO market can exacerbate credit crunches, by propagating shocks through capital markets. With difficulties in obtaining external credit, innocent bystanders may make financial and real adjustments, reducing spending, employment, and investment. Potential bystanders may also be pushed to liquidate. Thus, I provide a potential explanation for the price pattern of distressed firms around bankruptcy defaults.

CLOs may be characterized as shadow banking institutions, as they are not subject to direct oversight, and operate as unregulated financial intermediaries. Given that regulatory bodies have limited supervisory authority to directly address the risks originating from CLOs and leveraged loans, future theoretical work on the design of optimal contracts with consideration of welfare effects can inform the tradeoffs associated with different policy proposals. The impact of policy reforms remains ambiguous with regard to covenants. On the one hand, greater stringency of covenants creates more credit in the economy ex-ante by ensuring that debt claims have minimal risk in most states of the world (DeMarzo (2005)). However, in some states, they can increase social costs through fire sales, price pressure, and amplification. Increasing laxity of covenants by altering the frequency at which they bind, the measurement of constraints, or covenant carve-outs, may reduce the effective cost of fire sales in some states of the world, however, it may also increase the risk of debt claims and limit control rights, which can reduce the amount of credit ex-ante and contribute to a credit crunch. Hence, it is unclear what the efficient design is, ex-ante, from a policy standpoint as well as which macroprudential tools may be most useful to minimize the social costs associated with reductions in balance sheet capacity, originating from the shadow banking sector.

Further, this work gives rise to additional questions regarding the structure and dynamics of CLO-like intermediaries. The role of covenants in the capital structure of CLOs is of paramount importance for understanding the origin of risks. This prompts the question of how secure and resilient securitization structures really are, given that CLO managers do not internalize the externalities of their actions; their capital and liquidity covenants do not incorporate welfare effects. Hence, there is another avenue of future research: study of the relation between the social costs of fire sales and financial structure. Moreover, CLOs provide an example of how frictions of intermediaries in a market setting can transmit to the real economy. Future work on risks in the shadow banking sector can deepen our understanding of the dynamics between the traditional banking sector and emerging financial intermediaries. Understanding novel sources of risk and their interactions with traditional financial institutions is crucial in developing deeper insights into how shocks can propagate across the entire financial system, as well as potential pathways of amplification.

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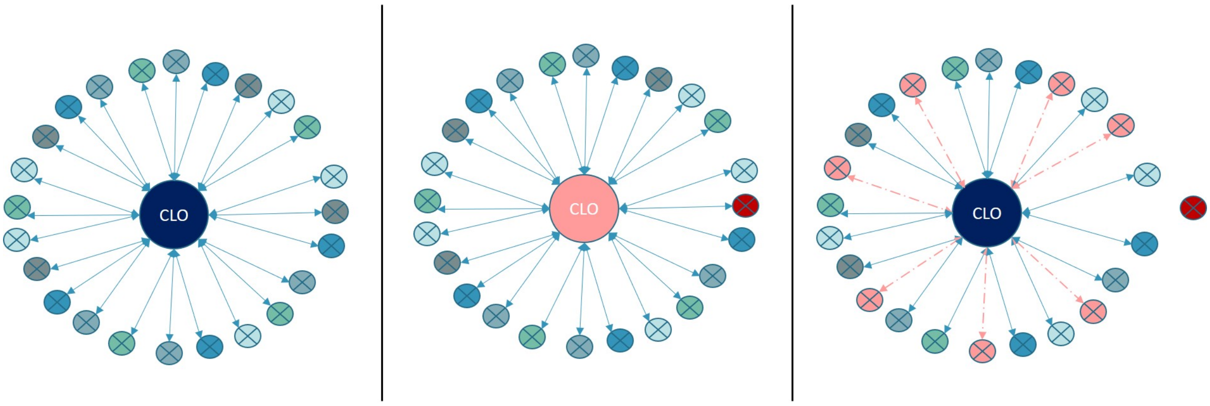
10 Figures and Tables

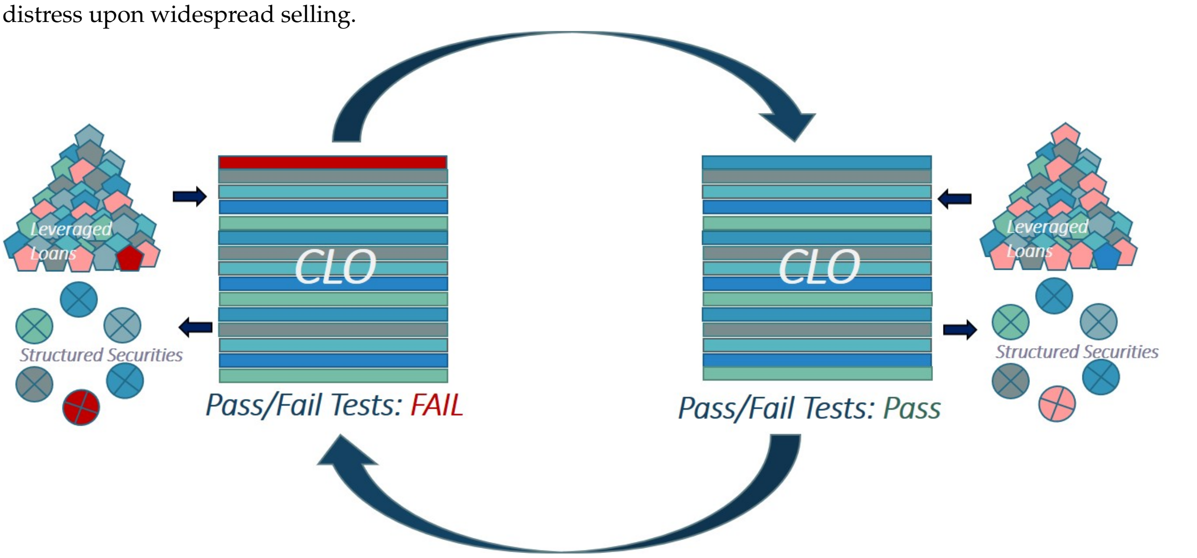
10.1 Figures

Figure 1: Research Setup: Links between Firms and CLOs



(a) Network of Firms and CLOs

Notes: The diagram consists of the three figures. The leftmost figure shows a CLO portfolio. The outer cicles represent firms. The center circle represents a CLO. The spokes establish a connection between the firm to the CLO. Moreover, firms are connected to each other through the intermediary, the CLO. The middle figure shows that if a firm experiences distress (red color), the CLO's performance may suffer and the CLO may also become constrained (pink color). The right figure shows that to alleviate constraints, the CLO will divest itself of the distressed firm, so there is no longer a spoke connected to it. Moreover, the CLO will sell liquid loans to generate more slack in the constraint (dashed spokes). The constrained issuers of these leveraged loans will experience distress upon widespread selling.



(b) Cycle of Distress

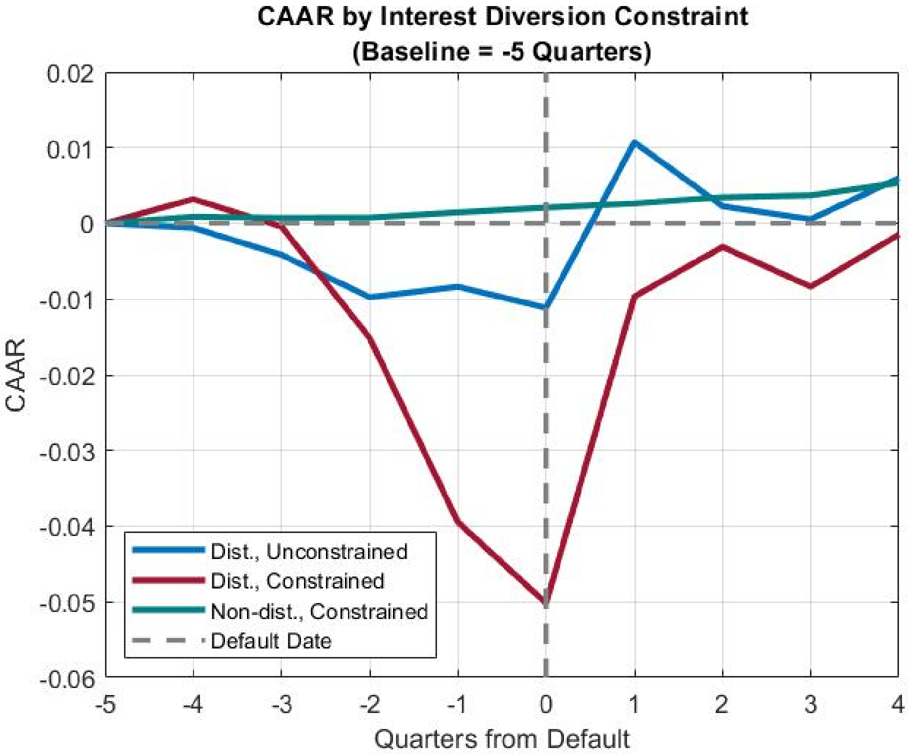
Notes: The figure demonstrates the link between CLO portfolio constraints and the quality of leveraged loans. The CLO is in violation of its covenant constraints, because of a loan that is near-default (left figure). To comply with the covenant, the CLO will generate slack in the constraint by divesting of the loan in distress and selling other, unrelated loans. This will allow the CLO to fulfill the covenants (right figure). However, in the process, as CLOs are the largest buyers of leveraged loans, fire sales of assets can increase the cost of financing to innocent bystanders, which can lead firms further into distress (left-figure). Hence, the cycle is perpetuated.

Figure 2: Thought Experiment

(a) Unconstrained (b) Constrained

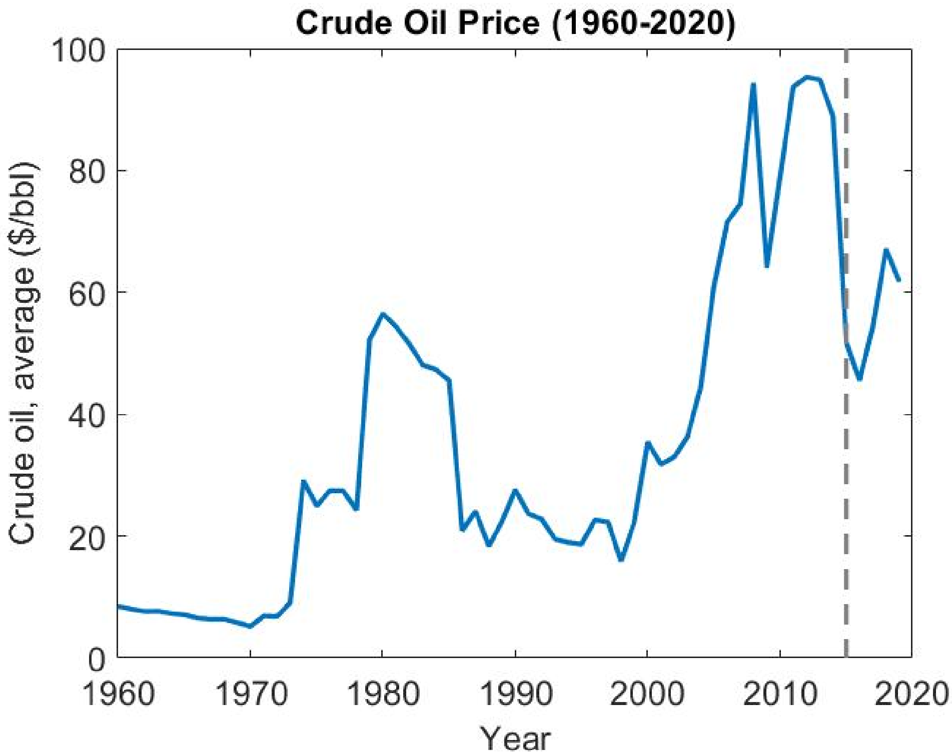
Notes: The figure illustrates the thought experiment belying the empirical strategy. There are two CLOs: CLO A and CLO B. CLO A does not hold any firms operating in the Oil & Gas industry ("Unconstrained"). CLO B has a sizeable exposure to firms in the O&G industry ("Constrained"). When the O&G price plunge occurs, CLO A is unaffected. CLO B is operating closer to its covenant thresholds, as many O&G portfolio firms may be distress. The yellow circle denotes a similar firm held by both CLOs. The objective is to study how the two yellow firms may differ based on ownership.

Figure 3: Motivation: Heterogeneity in CAAR around Defaults



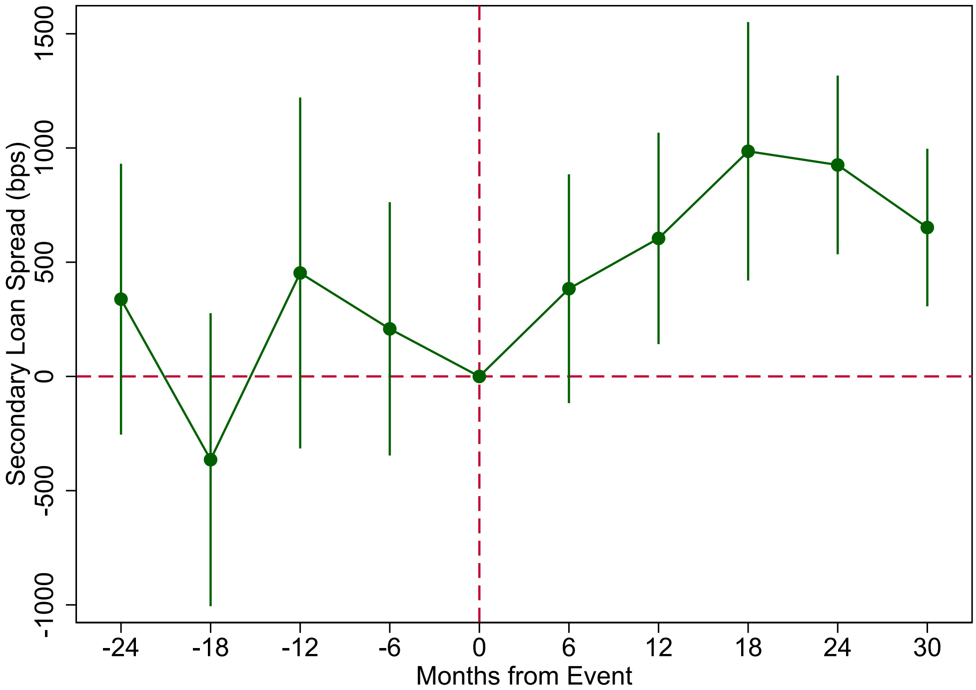
Notes: The figure compares the cumulative abnormal average returns (CAAR). The red line plots the CAAR for distressed loans held by constrained CLOs. The blue line plots the CAAR for distressed loans held by unconstrained CLOs. The green line plots the CAAR for non-distressed loans held by constrained CLOs. This last sample is generated by matching distressed firms to their non-distressed counterparts that operate in the same industry and size categories. The abnormal return is generated from the following regression: $ln(\frac{P_{i,t}}{P_{i,t-1}}) \approx \alpha + \beta Z_{i,t-1,t} + \gamma_0(Q_{i,t} - Q_{i,t-1}) + \gamma_1(Q_{i,t}ln(S_{i,t}) - Q_{i,t-1}ln(S_{i,t-1})) + \epsilon_{i,t-1,t}$, where P is the observed price, Z is a vector of fundamental value of i, Q is a purchase indicator, S is the trade size, ϵ is the error, i denotes the loan, and t denotes the day. These abnormal returns are averaged by quarters from default, and accumulated. The CAAR, five quarters before default, is normalized to be 0. The x-axis plots months from default. The y-axis plots the CAAR.

Figure 4: Crude Oil Price (1960-2020)



Notes: The figure shows the crude oil price from 1960-2020. The price is reported as the annual average $ per barrel. The x-axis reports the year. The y-axis reports the price. The dotted gray line denotes the price plunge. The monthly price around the price plunge is plotted in Figure A.4.

Figure 5: Assessment of Parallel Trends

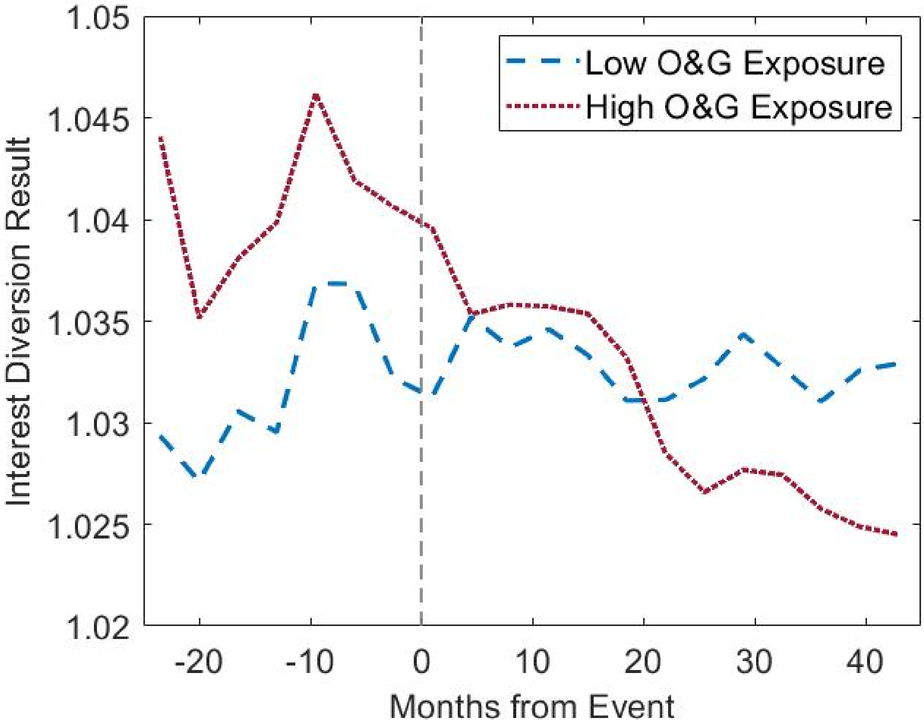


Notes: The figure presents a graph of parallel trends. The baseline regression specification takes the form as follows.

$$S_{c,f,t} = \sum_{\substack{k=-24 \\ k=k+6 \\ k\neq 0}}^{30} \beta_k \mathbb{1}_{k\leq t<k+6} \times (\text{O\&G Exposure})_{c,t} + \sum_{\substack{k=-24 \\ k=k+6 \\ k\neq 0}}^{30} \delta_k \mathbb{1}_{k\leq t<k+6} + \theta_1 \text{O\&G Exposure}_{c,t} + \alpha_{i,r} + \alpha_c + \epsilon_{c,f,t}$$

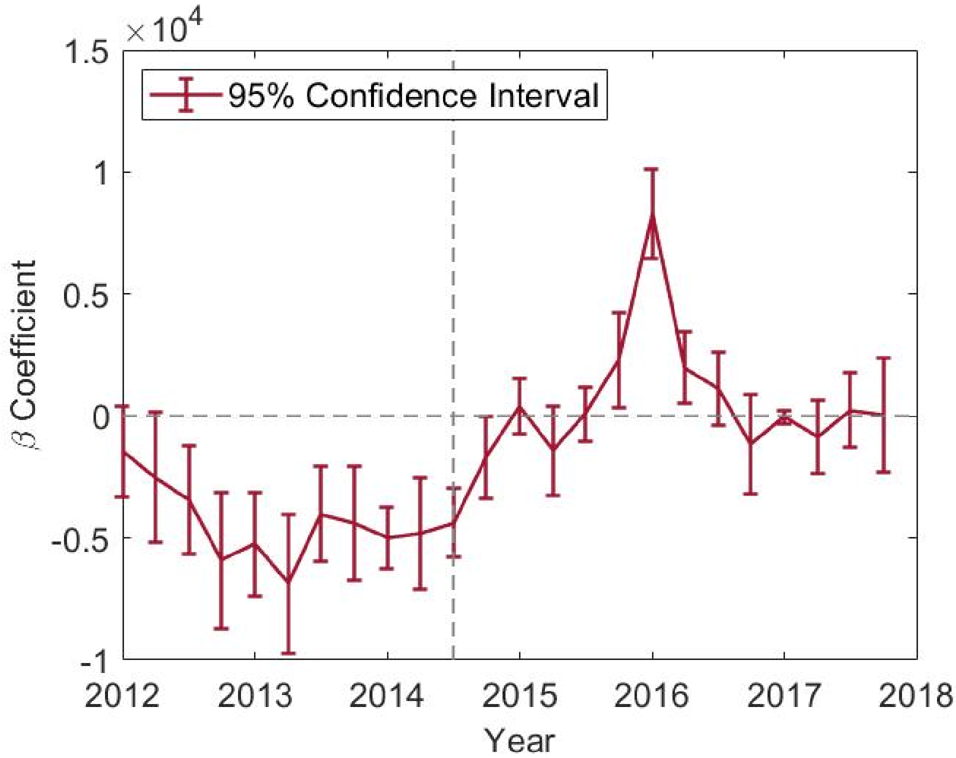
where $S_{c,f,t}$ is the secondary loans spread (bps), c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the quarter-year, i denotes the industry, r denotes the rating, q denotes the quarter. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while $\mathbb{1}_{k\leq t<k+6}$ is an indicator variable that takes a value of 1 if the time period corresponds to the six-month time period signified by k. I include leads and lags of the shock as well as their respective interactions with CLO O&G exposure. I exclude the last pre-treatment month to avoid perfect multicollinearity. The coefficients, β_i encapsulate the relation between the secondary loan spread of non-O&G issuers and CLO O&G exposure before and after the shock. The x-axis represents months around the O&G price plunge. The y-axis represents the secondary loan spread in bps of non-O&G issuers. Standard errors are clustered by CLO.

Figure 6: O&G Exposure and Interest Diversion Covenant



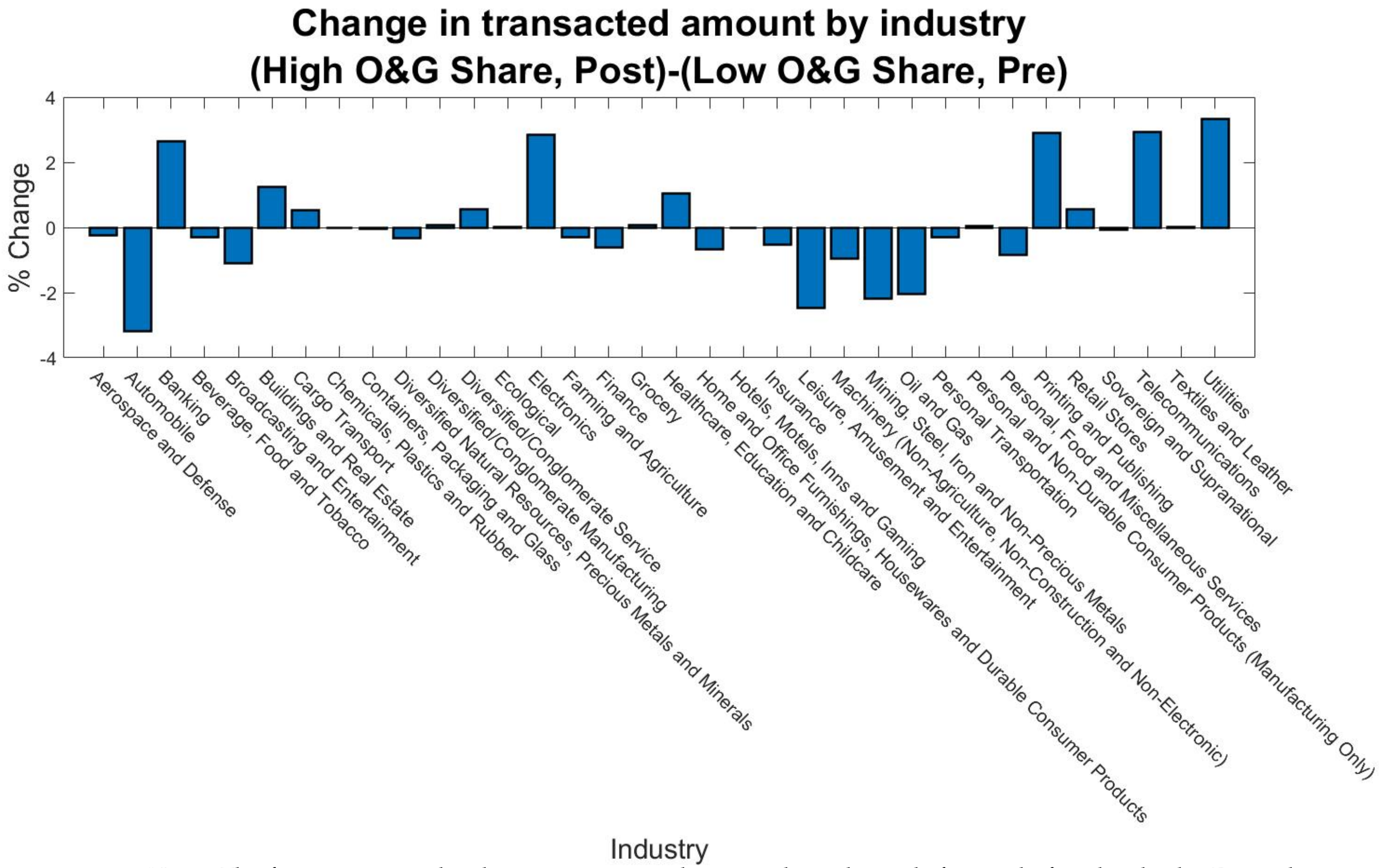
Notes: The figure presents the dynamic relation between O&G exposure and Interest Diversion covenant. CLOs are segmented based on O&G exposure. CLOs with above-median O&G exposure have *high O&G* exposure, while CLOs with below O&G exposure have *low O&G* exposure. The median distance from the Interest Diversion threshold is plotted for these two groups of CLOs. It is is plotted in red for CLOs with high O&G exposure, and blue for CLOs with low O&G exposure. I generate this plot with standard errors in Figure A.1. The x-axis represents the months around the O&G price plunge. The y-axis represents the distance from the Interest Diversion threshold.

Figure 7: Dynamic Effect of O&G Exposure on Coefficient of Secondary Loan Spread



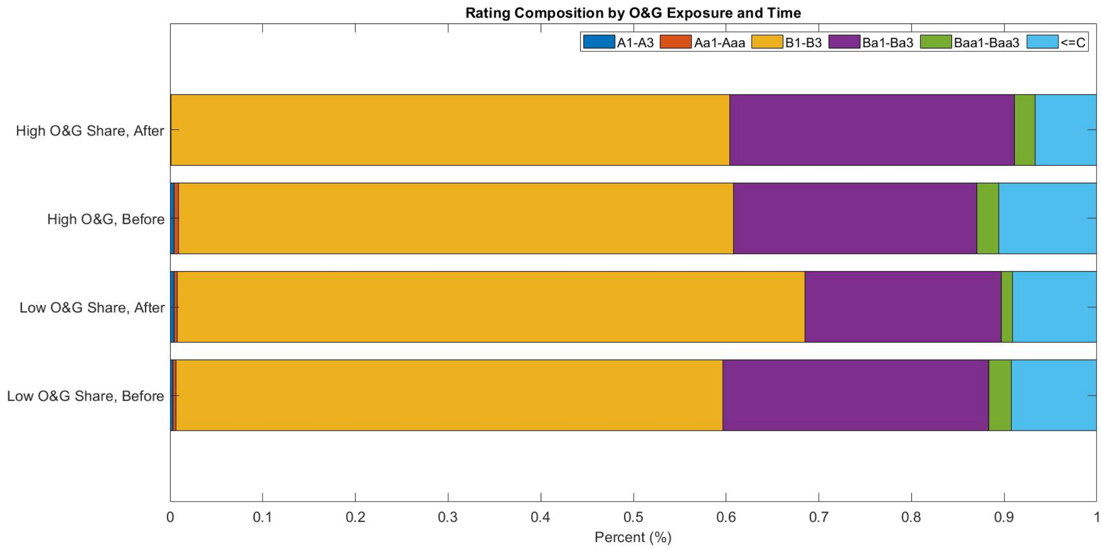
Notes: The figure plots the coefficients and the associated 95% confidence intervals of the interaction term from the following regression at the firm-CLO and quarter-year levels: $Y_{c,f,t} = \beta_0 + \sum_{k=2012}^{2017} \sum_{q=1}^{4} \beta_{4*(k-2012)+q} (\text{O\&G Exposure} \times \mathbb{1}_{t==kqt}) + \beta_{25}\text{O\&G Exposure}_{c,t} + \gamma_0' X_{c,t} + \alpha_{i,r} + \alpha_q + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is the secondary loan spread, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the quarter-year, i denotes the industry, r denotes the rating, and q denotes the quarter. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while $\mathbb{1}_{t==Quarter-Year}$ is an indicator variable that takes a value of 1 if the time period corresponds to quarter-year kq. The secondary loan spread is defined as $(100 - P) * 100$ where P is the transacted price. The x-axis indicates the quarter-year. The y-axis indicates the point estimate associated $\beta_{4*(i-2012)+q}$ estimate. Standard errors are two-way clustered by CLO and quarter-year.

Figure 8: CLO Management: Industry Concentration



Notes: The figure presents the change in transacted amount by industry before and after the shock. For each industry, I measure the amount transacted by CLOs with *high O&G* exposure after the shock, and, CLOs with *low O&G* exposure before the shock. CLOs with above-median distance to the Interest Diversion constraint have high O&G exposure, while CLOs with below-median distance to the Interest Diversion constraint have low O&G exposure. Differences between these two groups are presented in this bar graph – the % change (High O&G Share $\times$ Post - Low O&G Share $\times$ Pre). I list industries on the x-axis.

Figure 9: CLO Management: Ratings Composition



Notes: The figure presents the ratings composition of CLOs with *high* O&G exposure, and CLOs with *low* O&G exposure before and after the shock. CLOs with above-median distance to the Interest Diversion constraint have high O&G exposure, while CLOs with below-median distance to the Interest Diversion constraint have low O&G exposure. In the horizontal bar graph, the x-axis denotes the percent of each rating category, and the y-axis lists the categories of CLOs: High O&G Share, After; High O&G before; Low O&G Share, After; Low O&G Share, Before. Navy signifies A1-A3 rated loans, red is Aa1-Aaa, yellow is B1-B3, magenta is Ba1-Ba3, green is Baa1-Baa3, and cyan is CCC/Caa1 and below.

Table 1: Relation between O&G Exposure and Interest Diversion Covenant

Interest Diversion Result	(1)	(2)	(3)	(4)	(5)
Oil & Gas Share $\times$ Post	-14.2811*	-15.3161*	-21.9680*	-26.1065*	-23.2137*
	(8.5240)	(8.8995)	(13.0971)	(14.0993)	(13.1607)
Oil & Gas Share	12.2206	12.4952	18.3543	24.8367*	20.8959
Post	0.1593	0.2120	0.5779	0.9584*	1.0332**
	(0.2950)	(0.3151)	(0.3931)	(0.5139)	(0.4597)
Size Control		-0.2813*	-0.2652*	-0.0976	-0.0291
		(0.1562)	(0.1528)	(0.1628)	(0.1648)
Performance Control			0.0106	0.0122	0.0094
			(0.0066)	(0.0074)	(0.0072)
Age Control				0.0003	0.0003
				(0.0002)	(0.0002)
Year FE	No	No	No	No	Yes
N	6,911	6,911	2,394	2,392	2,392
R^2	0.0130	0.0268	0.0360	0.0743	0.1092

Standard errors are two-way clustered by manager and month-year in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and distance to the Interest Diversion covenant. The baseline regression specification takes the form $Y_{c,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \epsilon_{c,t}$ where $Y_{c,t}$ is the Interest Diversion result, c denotes the CLO, t denotes the time, and X denotes the vector of controls. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. There are no controls in Column 1. Size control is included in Column 2. Size and performance controls are included in Column 3. Size, performance, and age controls are included in Column 4. Size, performance, age controls, and year fixed effects are included in Column 5. Standard errors are two-way clustered by manager and month-year.

Table 2: Summary Statistics

	N	Q1	Median	Q3	Mean	Std. Dev.
Remaining Maturity (Months)	9,470,738	43.0000	57.0000	71.0000	55.6531	18.9541
Coupon Rate	9,470,362	3.9806	4.5000	5.5000	4.8180	1.6381
CLO Monthly Net Purchase	40,369	0.0000	0.0000	8,770,235	4,836,250	14,900,000
Transaction Price	797,682	99.0000	99.7500	100.1250	98.3300	5.0272
Bond Yield	709,867	0.0477	0.0834	1	0.3201	0.4154
All-in-drawn Spread (Term)	27,735	300	375	475	412.4735	178.2409
All-in-drawn Spread (Revolving)	17,181	175	250	375	276.7255	124.1632
ln(New Issuance Amount) (Term)	27,739	19.11383	19.85576	20.6179	19.78274	1.152291
ln(New Issuance Amount) (Revolving)	17,250	18.064	19.11383	20.07891	19.05494	1.496016
Debt Growth	307,289	-0.0262	-0.0034	0.0203	0.0006	0.0776
Payout	301,448	0.0000	0.0020	0.0194	0.0114	0.0337
R&D	121,143	0.0000	0.0055	0.0188	0.0202	0.0468
Acquisitions	312,335	0.0000	0.0000	0.0103	0.0226	0.0556
Cash Flow	326,023	0.0212	0.0288	0.0381	0.0306	0.0163
Employment Growth	307,929	-0.0313	0.0202	0.0926	0.0663	0.2153
Investment (CapEx)	322,343	0.0060	0.0152	0.0334	0.0261	0.0516
Investment (Δln(CapEx))	321,024	0.1291	0.3762	0.5978	0.0396	0.9044
Investment (Intensive)	335,078	-0.0091	0.0019	0.0189	0.0104	0.0451
Net Leverage	303,914	0.3031	0.4592	0.6264	0.4766	0.2831
Tobin's Q	254,353	1.2193	1.4980	1.8734	1.6328	0.5778
Profitability	330,710	-0.0010	0.0061	0.0137	0.0049	0.0195
Total Firm Liquidity (Baseline)	698,596	0.0000	0.2859	0.6524	0.3419	0.3441
Undrawn Firm Liquidity (Baseline)	698,596	0.0000	0.1963	0.5887	0.3012	0.3294
Total Line Ratio	691,831	0.0000	0.0334	0.0851	0.0585	0.0916
Undrawn Line Ratio	691,831	0.0000	0.0230	0.0697	0.0451	0.0682
Δ Risky Share	-0.2969	0.1035	0.7975	0.4236	2.027	

Notes: The table presents summary statistics for the outcome variables of interest used in this paper. The columns, left to right, denote the variable of interest, number of observations, 25^{th} value, median, 75^{th} quartile value, mean, and standard deviation in Columns 2-7.

Table 3: Implications for Assets Prices: Secondary Loan Spread

Discount from \$100 (bps)	(1)	(2)	(3)	(4)	(5)
Oil & Gas Share × Post	814.0516**	1067.3942**	1083.0137**	1110.2316**	1386.2939**
	(361.3008)	(463.8117)	(463.4510)	(480.8051)	(586.0540)
Oil & Gas Share	-940.6***	-1078.9**	-1117.9**	-1121.1**	-1502.9***
	(353.1320)	(445.9644)	(433.7492)	(456.0069)	(564.7256)
Post	181.6561***	201.9853***	112.2862***	106.0192***	
	(24.4957)	(27.5505)	(31.0844)	(31.6815)	
CLO Controls	No	Yes	Yes	Yes	Yes
Issuer Controls	No	No	Yes	Yes	Yes
Rating-Industry FE	Yes	Yes	Yes	Yes	Yes
Month-Year FE	No	No	No	No	Yes
Term Loan FE	No	No	Yes	Yes	Yes
Quarter FE	No	No	No	Yes	No
N	264,010	55,992	5,989	5,989	5,988
R^2	0.4204	0.4846	0.7022	0.7024	0.7276

Standard errors are two-way clustered by CLO and month-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and the secondary loan spread for non-O&G firms. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is the secondary loan spread, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, Z is a vector of issuer controls and X is a vector of CLO controls, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. The secondary loan spread is defined as $(100 - P) * 100$ where P is the transacted price. Columns 1-5 include rating-industry fixed effects. There are no controls in Column 1. CLO controls (size, annualized equity distribution, age) are included in Columns 2-5. Issuer controls (size, leverage, tangibility) are included in Columns 3-5. Term Loan FEs are included in Columns 3-5. Quarter FEs are included in Column 4. Month-year fixed effects are included in Column 5. Standard errors are two-way clustered by CLO and month-year.

Table 4: Implications for Assets Prices: New Bank Loan Spread

All-in-drawn Spread (bps)	(1)	(2)	(3)	(4)	(5)
Oil & Gas Share $\times$ Post	230.2450***	470.3327***	221.4401**	208.3574**	120.3353*
	(73.5514)	(125.2548)	(107.0835)	(96.4644)	(63.5722)
Oil & Gas Share	-148.4013**	-398.6626***	-218.9833**	-195.4887**	-109.7465*
	(65.2321)	(96.6537)	(104.1834)	(91.8992)	(62.1973)
Post	14.6159	14.3262	30.0096*	29.7519*	129.0296***
	(10.6677)	(12.4154)	(15.0916)	(15.4355)	(26.9190)
CLO Controls	No	Yes	Yes	Yes	Yes
Issuer Controls	No	No	Yes	Yes	Yes
Loan Control	No	No	Yes	Yes	Yes
Rating-Industry FE	Yes	Yes	Yes	Yes	Yes
Quarter FE	No	No	No	Yes	Yes
Year FE	No	No	No	No	Yes
Secured	No	Yes	Yes	Yes	Yes
N	915,846	178,843	28,880	28,880	28,880
R^2	0.3223	0.3764	0.7648	0.7704	0.7850

Standard errors are two-way clustered by CLO and month-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and new bank loan spread for non-O&G firms. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is the primary loan spread for term loans B and below, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, Z is a vector of issuer controls and X is a vector of CLO controls, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. The outcome variable is the all-in-drawn spread. The all-in-drawn spread is defined as the total annual spread above LIBOR for each dollar drawn from a loan. This includes both fees and interest payments. Columns 1-5 include rating-industry fixed effects. There are no controls in Column 1. CLO controls (size, annualized equity distribution, age) are included in Columns 2-5. Issuer controls (size, leverage, tangibility) are included in Columns 3-5. Loan specific variables like maturity and secured status are accounted for in Columns 3-5 and Columns 2-5, respectively. Quarter FEs are included in Columns 4-5. Year fixed effects are included in Column 5. Standard errors are two-way clustered by CLO and month-year.

Table 5: Implications for Assets Prices: Bond Credit Spread

Credit Spread (bps)	(1)	(2)	(3)	(4)	(5)
Oil & Gas Share $\times$ Post	236.0388***	232.4058***	143.3905*	150.3492**	83.0149***
	(56.0636)	(69.6300)	(79.2470)	(70.5222)	(25.1098)
Oil & Gas Share	-69.5514*	-128.5310**	-90.8455**	-92.9189***	-82.5557***
	(40.5874)	(58.6882)	(40.7209)	(31.1527)	(15.4512)
Post	-30.2837***	-15.6026*	-3.3422	-2.8813	39.6219**
	(8.0679)	(8.3251)	(11.5732)	(11.8570)	(15.5342)
CLO Controls	No	Yes	Yes	Yes	Yes
Issuer Controls	No	No	Yes	Yes	Yes
Bond Controls	No	Yes	Yes	Yes	Yes
Rating-Industry FE	Yes	Yes	Yes	Yes	Yes
Bond Type FE	No	No	No	No	Yes
Convertible FE	No	No	No	No	Yes
IG/HY FE	No	No	No	No	Yes
Security Level FE	No	No	No	No	Yes
Quarter FE	No	No	No	Yes	Yes
Year FE	No	No	No	No	Yes
N	593,416	138,538	21,501	21,501	21,441
R^2	0.5088	0.8107	0.6696	0.7008	0.7824

Standard errors are two-way clustered by CLO and month-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and transacted bond credit spreads for non-O&G firms. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is the transacted bond credit spread (computed by interpolation), c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, Z is a vector of issuer controls and X is a vector of CLO controls, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. Columns 1-5 include rating-industry fixed effects. There are no controls in Column 1. CLO controls (size, annualized equity distribution, age) are included in Columns 2-5. Issuer controls (size, leverage, tangibility) are included in Columns 3-5. Bond specific controls like maturity are included in Columns 2-5, while additional controls including bond type FE, convertible FE, IG/HY FE, and security level FE are included in Column 5. Quarter FEs are included in Columns 4-5. Year fixed effects are included in Column 5. Standard errors are two-way clustered by CLO and month-year.

Table 6: Imperfect Substitution to Existing Lines of Credit: Firm Liquidity

	(1) Total	(2) Undrawn	(3) Total	(4) Undrawn
Oil & Gas Share × Post	-1.5419***	-1.5599***	-1.5475***	-1.2701**
	(0.4108)	(0.4159)	(0.4863)	(0.4595)
Oil & Gas Share	1.0666***	1.1279***	0.9278*	0.8066*
	(0.3623)	(0.3809)	(0.4624)	(0.4337)
Post	0.0407	0.0051	0.0967***	0.0446
	(0.0336)	(0.0312)	(0.0322)	(0.0309)
CLO Controls	No	No	Yes	Yes
Issuer Controls	No	No	Yes	Yes
Rating-Industry FE	Yes	Yes	Yes	Yes
Quarter FE	No	No	Yes	Yes
N	327,340	302,966	205,198	190,015
R^2	0.2983	0.3436	0.3886	0.4317

Standard errors are two-way clustered by CLO and quarter-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and firm liquidity for non-O&G firms. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is (standardized) firm liquidity, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, Z is a vector of issuer controls and X is a vector of CLO controls, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. Columns 1-4 include rating-industry fixed effects. In Columns 1 and 3, the outcome variable is the ratio of a firm's total line of credit to the aggregate of total line of credit and cash and cash equivalents. In Columns 2 and 4, the outcome variable is the ratio of a firm's undrawn line to the aggregate of the undrawn line and cash and cash equivalents. In Columns 1 and 2, I do not include any controls. In Columns 3 and 4, I include CLO controls (size, annualized equity distribution, age) and issuer controls (size, leverage, tangibility), as well as quarter fixed effects, intended to control for seasonality. This regression reports the results on the intensive margin, i.e., results for firms with access to an existing line of credit. In Table A.8, I report the results from the extensive margin. Standard errors are two-way clustered by CLO and quarter-year.

Table 7: Firm Financial Adjustment

	(1) Debt growth	(2) Payout	(3) CapEx	(4) R&D	(5) Acquisitions	(6) Cash Flow
Oil & Gas Share × Post	-0.8351**	-2.3081***	-3.4409***	-1.5038***	-1.1973*	-0.7430*
	(0.3810)	(0.6131)	(1.1158)	(0.4785)	(0.5896)	(0.3888)
Oil & Gas Share	1.0162***	1.7728***	2.8516**	0.8353**	1.5410***	0.5371
	(0.3030)	(0.5606)	(1.0603)	(0.3532)	(0.5334)	(0.3205)
Post	-0.0212	0.2229**	0.8284***	0.2240***	0.3304***	0.1560
	(0.0442)	(0.0809)	(0.1904)	(0.0547)	(0.1038)	(0.1022)
CLO Controls	Yes	Yes	Yes	Yes	Yes	Yes
Issuer Controls	Yes	Yes	Yes	Yes	Yes	Yes
Rating-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	190,506	179,687	190,979	76,742	188,911	193,852
R^2	0.0812	0.2471	0.3601	0.2377	0.1724	0.3838

Standard errors are two-way clustered by CLO and quarter-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and firm financial measures for non-O&G firms. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ are the following standardized variables: Debt Growth in Column 1, Payout in Column 2, CapEx in Column 3, R&D in Column 4, Acquisitions in Column 5, and Cash Flow in Column 6. c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, Z is a vector of issuer controls and X is a vector of CLO controls, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. Columns 1-6 include rating-industry and year fixed effects, as well as CLO controls (size, annualized equity distribution, age) and issuer controls (size, leverage, tangibility). Standard errors are two-way clustered by CLO and quarter-year.

Table 8: Firm Real Adjustment

	(1) Emp. Growth	(2) Emp. Growth (Small)	(3) Emp. Growth (Big)	(4) Cap. Stock. Growth	(5) CapEx	(6) Investment Growth	(7) Net Lev.	(8) Tobin's Q
Oil & Gas Share × Post	-0.4849	-0.0888	-1.2238*	-1.4162***	-3.4409***	-3.9661	-0.0961**	-0.9214*
	(0.5677)	(0.6801)	(0.6743)	(0.3649)	(1.1158)	(2.6425)	(0.0432)	(0.4792)
Oil & Gas Share	0.6339	0.5624	0.5585	1.6322***	2.8516**	3.0061	0.0646	1.2018***
	(0.4867)	(0.6640)	(0.4752)	(0.3042)	(1.0603)	(2.5300)	(0.0406)	(0.3952)
Post	0.0944***	0.0030	0.1586***	0.1126	0.8284***	0.9547	-0.0012	-0.0151
	(0.0292)	(0.0234)	(0.0407)	(0.1040)	(0.1904)	(0.9045)	(0.0036)	(0.0477)
CLO Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Issuer Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rating-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	180,445	93,853	86,590	195,819	190,979	190,753	187,610	147,774
R^2	0.1706	0.1986	0.2933	0.1102	0.3601	0.0492	0.9274	0.5399

Standard errors are two-way clustered by CLO and quarter-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and firm real variables for non-O&G firms. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ are the following standardized variables: employment growth in Column 1, employment growth for small firms (below median size) in Column 2, employment growth for large firms (above median size) in Column 3, investment (capital stock growth) in Column 4, investment (CapEx) in Column 5, investment growth (Δ CapEx) in Column 6, net leverage in Column 7, and Tobin's Q in Column 8. c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, Z is a vector of issuer controls and X is a vector of CLO controls, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. Columns 1-6 include rating-industry and year fixed effects, as well as CLO controls (size, annualized equity distribution, age) and issuer controls (size, leverage, tangibility). Standard errors are two-way clustered by CLO and quarter-year.

Table 9: CLO Management: Net Purchase

Net Purchase	(1)	(2)	(3)	(4)	(5)
Oil & Gas Share × Post	-5.2031*	-6.4699*	-6.7383*	-6.7732*	-6.8214*
	(2.3101)	(3.1315)	(2.6373)	(2.9658)	(2.7157)
Oil & Gas Share	0.8070	0.9240	1.7711	1.7762	1.7448
	(0.6315)	(1.7882)	(1.2334)	(1.2290)	(1.1024)
Post	0.1973	-0.1183	0.0621	0.0816	0.0000
	(0.1777)	(0.1730)	(0.0869)	(0.1956)	(0.0000)
CLO Controls	No	Yes	Yes	Yes	Yes
Month-Year FE	No	No	No	No	Yes
Quarter	No	No	No	Yes	No
Year	No	No	Yes	Yes	No
N	24,417	5,189	5,189	5,189	5,189
R^2	0.0075	0.1773	0.1912	0.1971	0.2345

Standard errors are two-way clustered by manager and month-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and performance on CLO monthly net purchase of non-O&G debt. The baseline baseline regression specification is $Y_{c,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \epsilon_{c,t}$ where $Y_{c,t}$ is a CLO's monthly net purchase, c denotes the CLO, t denotes the time, and X denotes the vector of CLO controls. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. There are no controls in Column 1. I include CLO controls (size, annualized equity distribution, age) in Columns 2-5. I include time fixed effects; quarter fixed effects in Column 4, year fixed effects in Columns 3-4, and month-year fixed effects in Column 5. Standard errors are two-way clustered by manager and month-year.

Table 10: CLO Management: Portfolio Characteristics

	(1)	(2)	(3)	(4)
	Rem. Mat.	Rem. Mat.	Interest Rate	Interest Rate
Oil & Gas Share $\times$ Post	8.5502	22.4504**	-1.0863*	-1.4033***
	(10.8663)	(9.4293)	(0.6188)	(0.4369)
Oil & Gas Share	9.5378	3.4843	1.4825**	1.6655***
	(10.8364)	(9.7986)	(0.6143)	(0.5008)
Post	-1.0296**	-2.8994***	-0.0113	-0.0075
	(0.4675)	(0.5277)	(0.0236)	(0.0218)
CLO Controls	Yes	No	Yes	No
Issuer $\times$ Term Loan FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
CLO FE	No	Yes	No	Yes
Index FE	No	No	Yes	Yes
N	6,210,304	9,143,300	5,320,831	7,761,419
R^2	0.6106	0.6236	0.8183	0.8247

Standard errors are two-way clustered by manager and month-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and performance on CLO portfolio characteristics. The baseline regression specification takes the form $Y_{c,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \alpha_{f,l} + \alpha_c + \alpha_t + \epsilon_{c,t}$ where $Y_{c,t}$ are portfolio characteristics, c denotes the CLO, t denotes the time, and X denotes the vector of CLO controls. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. The outcome variable is remaining portfolio maturity in Columns 1 and 2. The outcome variable is interest rate in Columns 3 and 4. I use a within issuer-term loan estimator. I include CLO controls (size, age) in Columns 1 and 3, year fixed effects in Columns 1-4, CLO fixed effects in Column 2 and 4, and index fixed effects in Columns 3 and 4. Standard errors are two-way clustered by manager and month-year.

Table 11: Demand for Non-O&G Risky Firms' Debt

Δ Risky Share	(1)	(2)	(3)	(4)
O&G Share $\times$ Post	-14.2125*	-14.3701*	-14.4259*	-14.4126*
	(8.3431)	(8.3181)	(8.5739)	(8.5464)
O&G Share	15.5447**	15.6143**	16.2183**	15.9086*
	(7.7567)	(7.7595)	(7.9680)	(8.0263)
Post	0.9004***	0.9186***	0.7112**	
	(0.2764)	(0.2792)	(0.3456)	
CLO Controls	Yes	Yes	Yes	Yes
Month-Year FE	No	No	No	Yes
Quarter FE	No	Yes	Yes	No
Year FE	No	No	Yes	No
N	8,294	8,294	8,294	8,294
R^2	0.0706	0.0717	0.0811	0.1006

Standard errors are two-way clustered by manager and month-year in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and Δ CLO's risky share of assets. The baseline regression specification takes the form $Y_{c,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \epsilon_{c,t}$ where $Y_{c,t}$ denotes the (standardized) Δ risky share of a CLO, c denotes the CLO, t denotes the time, and X denotes the vector of CLO controls. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. The risky share of a CLO portfolio is the share of the portfolio that is a discounted obligation, defaulted asset, or has a rating CCC/Caa1 or below. In Columns 1-5, I include CLO controls (size, annualized equity distribution, age). I include time fixed effects; quarter fixed effects in Columns 2-3, year fixed effects in Column 3, and month-year fixed effects in Column 4. Standard errors are two-way clustered by manager and month-year.

Table 12: Implications for Assets Prices: Secondary Loan Spread for Non-O&G Risky Firms

Discount from \$100 (bps)	(1)	(2)	(3)	(4)	(5)
Oil & Gas Share × Post	4404.1**	7752.3***	7381.4***	6136.2***	4010.6***
	(1802.9807)	(1697.4543)	(1710.1165)	(1715.1226)	(1326.0558)
Oil & Gas Share	-4760.5***	-7341.2***	-7065.5***	-6167.0***	-2915.6**
	(1606.9343)	(1602.3684)	(1579.6625)	(1446.9484)	(1309.7172)
Post	440.6***	337.7**	372.7**	458.8**	
	(123.1163)	(140.3159)	(143.1075)	(176.4694)	
CLO Controls	No	Yes	Yes	Yes	Yes
Rating-Industry FE	Yes	Yes	Yes	Yes	Yes
Month-Year FE	No	No	No	No	Yes
Term Loan FE	No	No	Yes	Yes	Yes
Quarter FE	No	No	No	Yes	No
N	13,871	3,139	3,139	3,139	3,139
R^2	0.4958	0.5569	0.5600	0.5657	0.6796

Standard errors are two-way clustered by CLO and month-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and the secondary loan spread for non-O&G risky firms. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is the secondary loan spread, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, Z is a vector of issuer controls and X is a vector of CLO controls, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. The secondary loan spread is defined as $(100 - P) * 100$ where P is the transacted price. Columns 1-5 include rating-industry fixed effects. There are no controls in Column 1. CLO controls (size, annualized equity distribution, age) are included in Columns 2-5. Term Loan FEs are included in Columns 3-5. Quarter FEs are included in Column 4. Month-year fixed effects are included in Column 5. Standard errors are two-way clustered by CLO and month-year.

Table 13: Effects for Non-O&G Risky Firms

	(1) Size	(2) Debt Growth	(3) Emp. Growth ($\geq$P50)	(4) Investment	(5) Net Leverage
Rated $\leq$C $\times$ Oil & Gas Share $\times$ Post	-7.1067***	-7.9803**	-9.2628	-3.4990*	-10.8382**
	(2.3717)	(2.8640)	(6.8557)	(2.0156)	(4.3903)
Oil & Gas Share $\times$ Post	0.9237*	-0.5895	-1.3335	-1.4048***	0.2981
	(0.4580)	(0.3981)	(0.7958)	(0.4782)	(0.4118)
Rated $\leq$C $\times$ Oil & Gas Share	8.1666***	4.1134*	11.0638*	4.3749**	8.7201**
	(2.1453)	(2.2312)	(6.2163)	(1.7428)	(3.8153)
Rated $\leq$C $\times$ Post	-0.1397	0.3844	0.0154	-0.3880***	0.9556***
	(0.1464)	(0.2333)	(0.3060)	(0.1114)	(0.2911)
Oil & Gas Share	-1.8164***	0.6762**	0.8457	1.6407***	-0.4758
	(0.4186)	(0.3197)	(0.5690)	(0.4009)	(0.3615)
Post	0.0137	-0.0185	0.2262***	0.1169	-0.0211
	(0.0193)	(0.0491)	(0.0467)	(0.1046)	(0.0270)
Rated $\leq$C	-0.5667***	-0.0408	-0.3702*	-0.1977**	-0.1497
	(0.1046)	(0.1444)	(0.1825)	(0.0809)	(0.2650)
CLO Controls	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
N	208,217	193,853	96,117	210,726	191,037
R^2	0.2595	0.0183	0.0857	0.0372	0.2659

Standard errors are two-way clustered by CLO and quarter-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and real effects for non-O&G risky issuers. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \beta_4(\text{Risky Firm}_{c,f,t}) + \beta_5(\text{Risky Firm}_{c,f,t} \times \text{Oil Shock}_t) + \beta_6(\text{Risky Firm}_{c,f,t} \times \text{O\&G Exposure}_{c,t}) + +\beta_7(\text{Risky Firm}_{c,f,t} \times \text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_i + \epsilon_{c,f,t}$ where Risky firm denotes whether the issuer or firm f of a loan in CLO c has a rating below B3, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, i denotes the industry and r denotes the rating. Z is a vector of issuer controls and X is a vector of CLO controls. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. The outcome variables are size in Column 1, debt growth in Column 2, employment growth for large firms (above median size) in Column 3, investment (capital stock growth) in Column 4, and net leverage in Column 5. I use a within industry estimator across Columns 1-5, and include year fixed effects to control for common shocks. I include CLO controls (size, annualized equity distribution, age) across Columns 1-5. Standard errors are two-way clustered by CLO and month-year.

Table 14: External Validity: COVID-19 Shock

Discount (bps)	(1)	(2)	(3)	(4)	(5)
HMIGL Share × Post	4250.7066***	5123.5233***	5202.5286***	5256.4405***	5229.8358***
	(643.5020)	(271.7611)	(248.7648)	(350.1135)	(525.3903)
HMIGL Share	-286.7938	-325.1641	-317.3317	-411.8892	-50.5790
	(337.6176)	(242.2732)	(241.2589)	(345.4059)	(386.3425)
Post	1149.4720***	-167.0451	-139.0752	-216.2123*	
	(51.8000)	(121.5672)	(114.9629)	(117.6417)	
CLO Controls	No	Yes	Yes	Yes	Yes
Rating-Industry FE	No	Yes	Yes	Yes	Yes
Term Loan FE	No	No	Yes	Yes	Yes
Quarter FE	No	No	No	Yes	No
Month-Year	No	No	No	No	Yes
N	81,346	76,595	76,594	76,594	76,594
R^2	0.0880	0.5401	0.5477	0.5498	0.5580

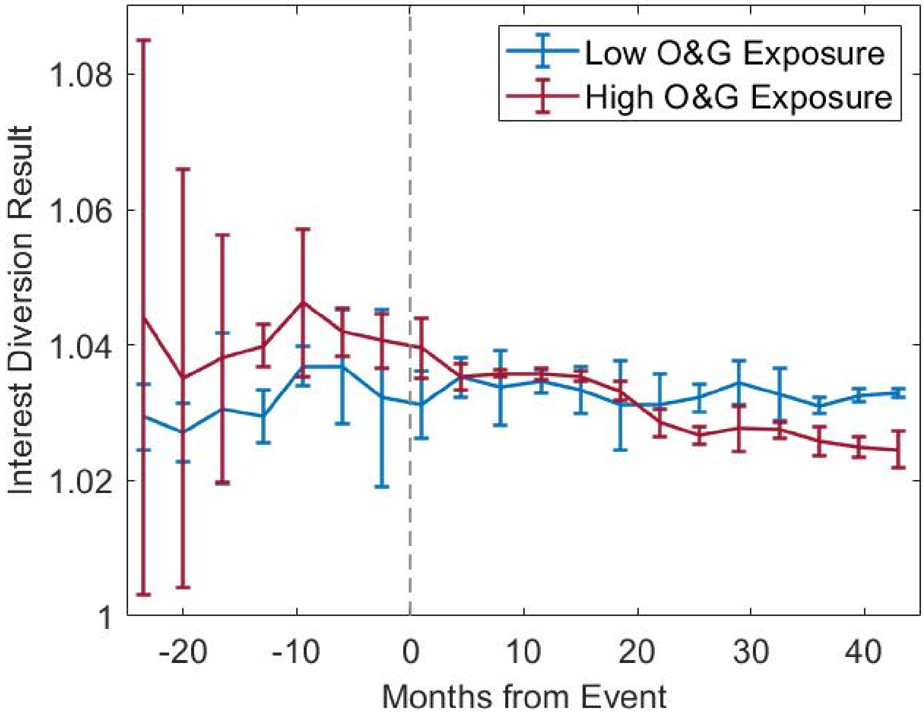
Standard errors are two-way clustered by CLO and quarter-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO HMIGL exposure and the secondary loan spread for non-HMIGL firms. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{HMIGL Exposure})_{c,t} + \beta_2(\text{COVID-19 Shock})_t + \beta_3(\text{HMIGL Exposure}_{c,t} \times \text{COVID-19 Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is the secondary loan spread, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, X denotes a vector of CLO controls, i denotes the industry and r denotes the rating. *HMIGL Exposure*$_{c,t}$ measures the HMIGL share of a CLO at a given point in time, while COVID-19 Shock$_t$ is an indicator variable that takes a value of 1 if the COVID-19 shock has occurred, and 0 otherwise. For simplicity, I refer to the *COVID-19 Shock* variable as *Post*. The secondary loan spread is defined as $(100 - P) * 100$ where P is the transacted price. Columns 2-5 include rating-industry fixed effects. There are no controls in Column 1. CLO controls (size, annualized equity distribution, age) are included in Columns 2-5. Term Loan FEs are included in Columns 3-5. Quarter FEs are included in Column 4. Month-year fixed effects are included in Column 5. Standard errors are two-way clustered by CLO and month-year.

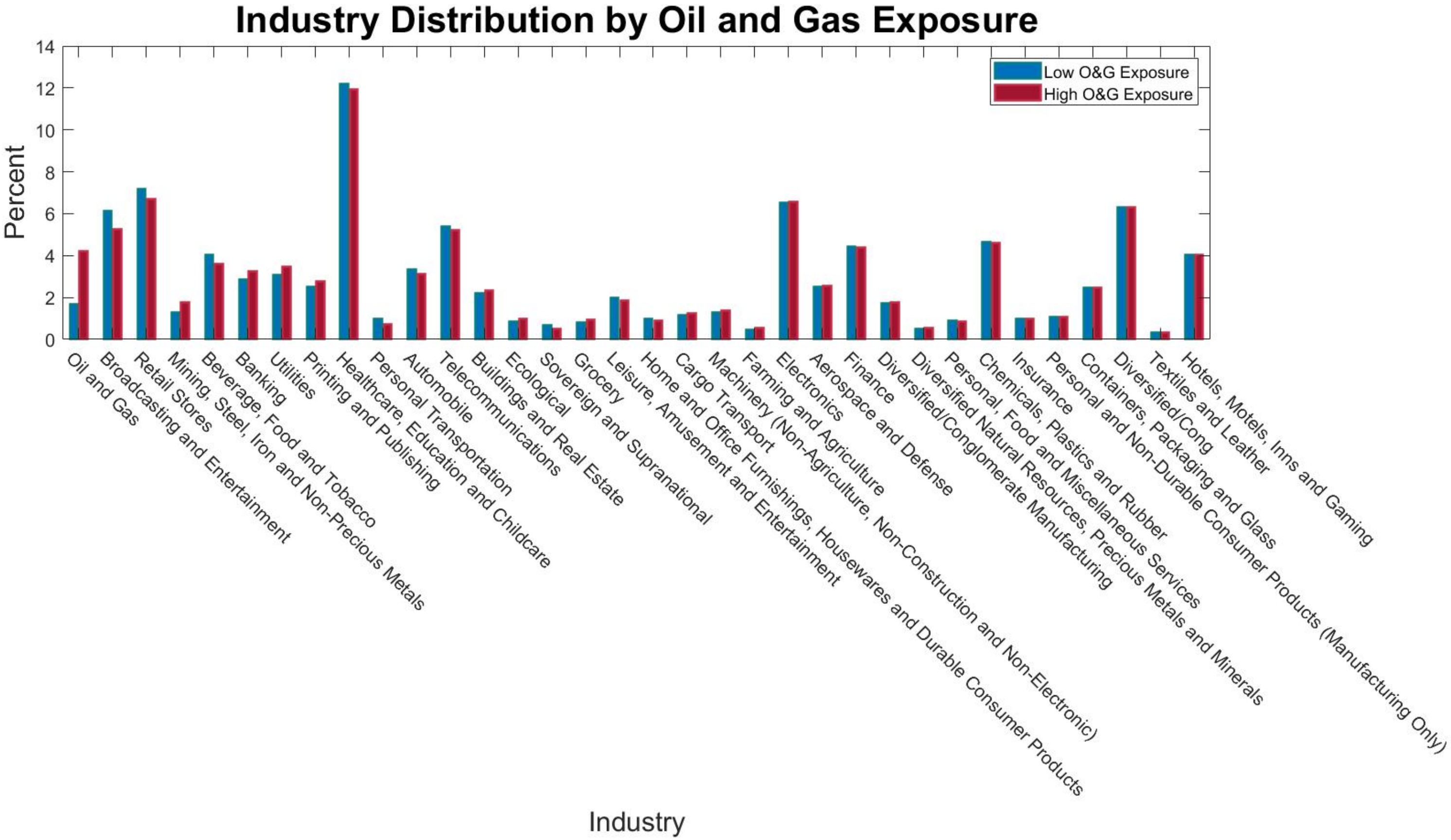
Appendix A Figures

Figure A.1: Standard Errors: O&G Exposure and Interest Diversion Covenant



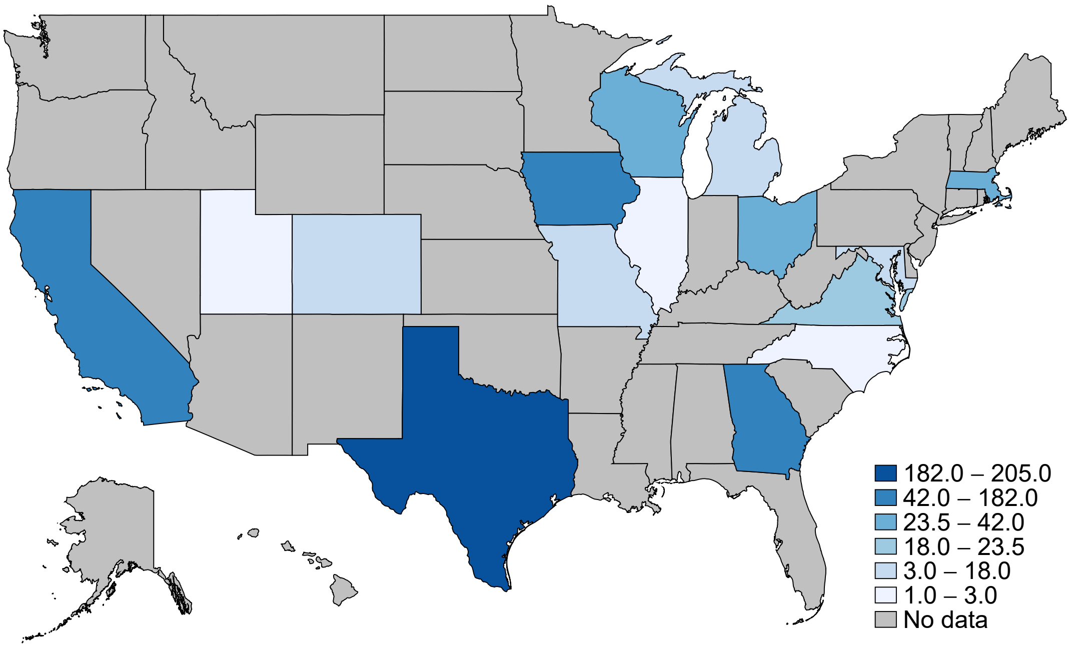
Notes: The figure presents the dynamic relation between O&G exposure and Interest Diversion covenant with 95% confidence intervals. CLOs are segmented based on O&G exposure. CLOs with above-median O&G exposure have *high O&G* exposure, while CLOs with below O&G exposure have *low O&G* exposure. The median distance from the Interest Diversion threshold is plotted for these two groups of CLOs. It is is plotted in red for CLOs with high O&G exposure, and blue for CLOs with low O&G exposure. I generate this plot with standard errors in Figure A.1. The x-axis represents the months around the O&G price plunge. The y-axis represents the distance from the Interest Diversion threshold.

Figure A.2: Industry Composition by CLO O&G Exposure

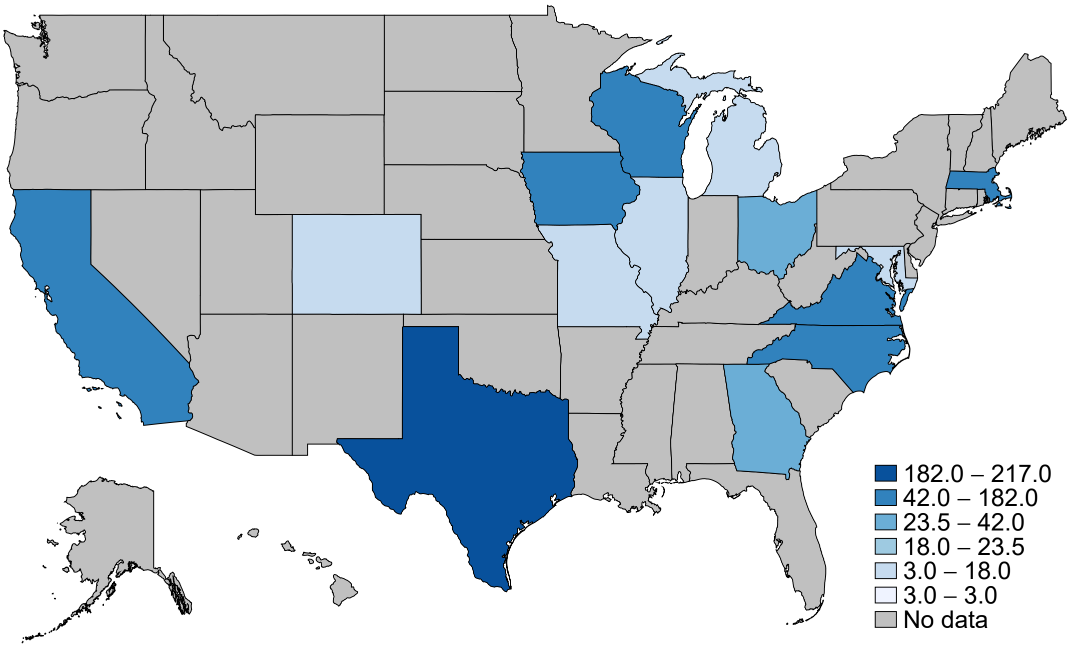


Notes: In this figure, I compare the industry distribution for CLOs with *high* O&G exposure to CLOs with *low* O&G exposure. CLOs with above-median O&G exposure have high O&G exposure, while CLOs with below median O&G exposure have low O&G exposure. The bar graph presents the industry share for CLOs with low O&G exposure in blue, and high O&G exposure in red. The industry Herfindahl-Hischman Index (HHI) is 0.0497 for CLOs with low O&G exposure and 0.0491 for CLOs with high O&G exposure. Industries are listed across the y-axis. The y-axis denotes the percent of a CLO portfolio in a given industry.

Figure A.3: Geographic Composition by CLO O&G Exposure



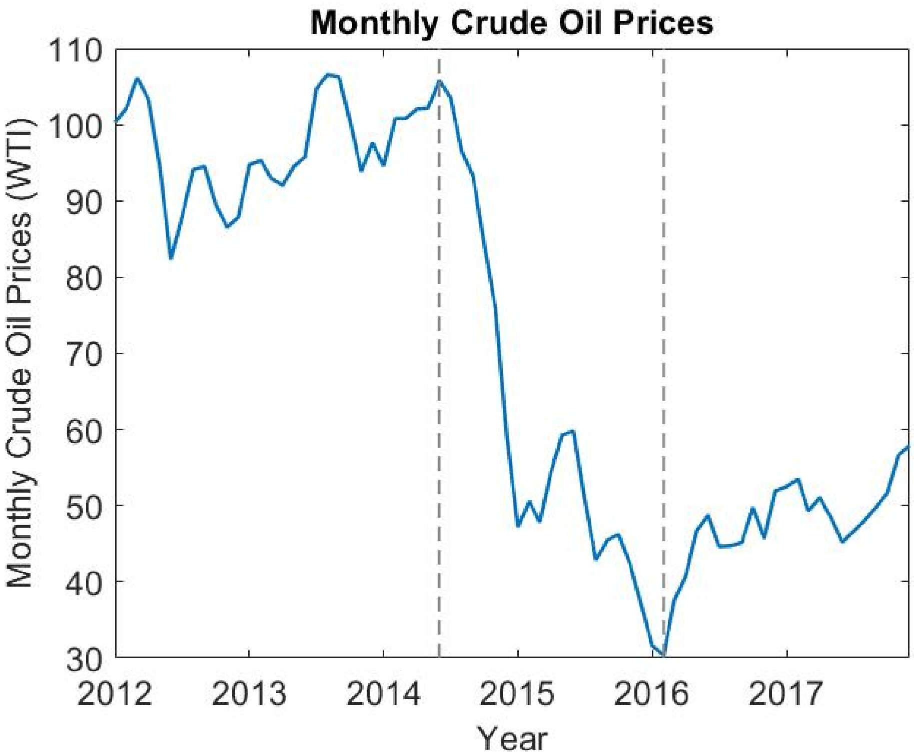
(a) Low O&G Exposure



(b) High O&G Exposure

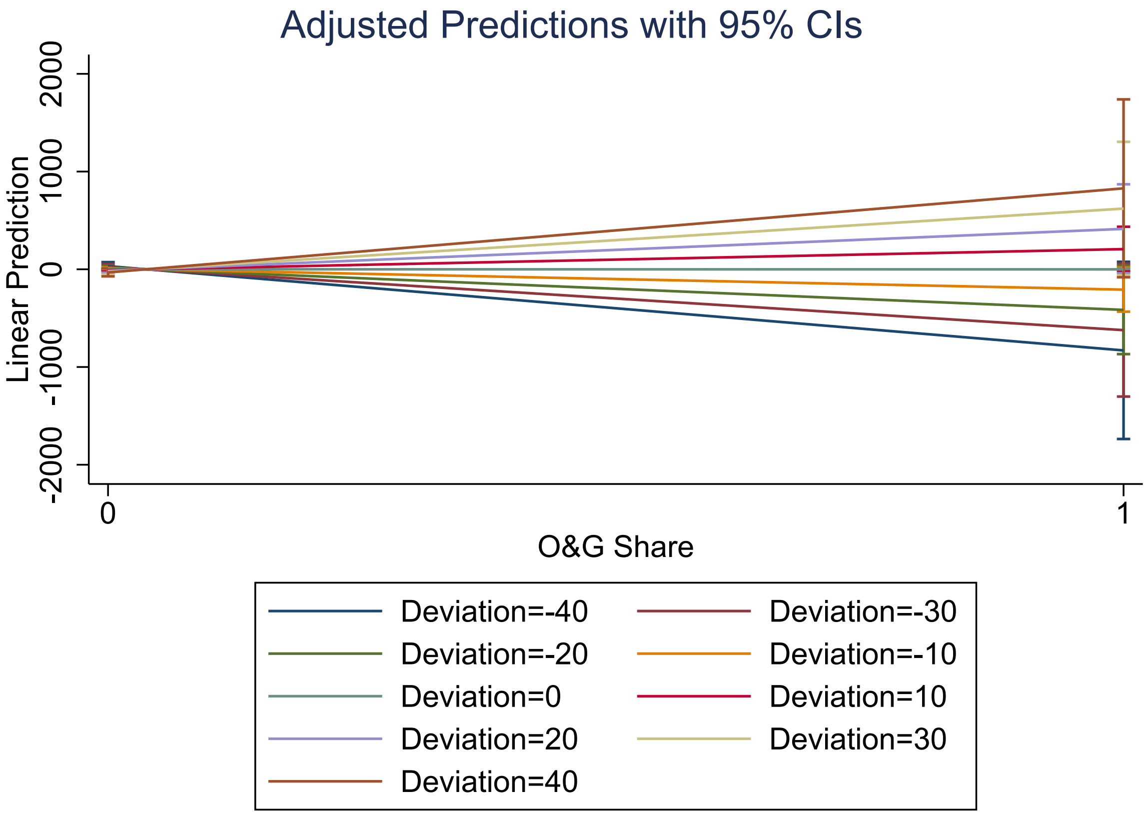
Notes: In this figure, I compare the geographic concentration of firm headquarters for CLOs with *high* O&G exposure to CLOs with *low* O&G exposure. CLOs with above-median O&G exposure have high O&G exposure while CLOs with below median O&G exposure have low O&G exposure. The plots present the number of firms headquartered in each state. Gray signifies that data is unavailable. Darker blue shading reflects a greater number of firms in that state. The top figure shows the geographic distribution of firm headquarters for CLOs with low O&G exposure. The bottom figure shows the geographic distribution of firm headquarters for CLOs with high O&G exposure. For CLOs with low O&G exposure, the Herfindahl-Hirschman Index is 0.1867, while it is 0.1447 for CLOs with high O&G exposure.

Figure A.4: Monthly Crude Oil Prices (2012-2018)



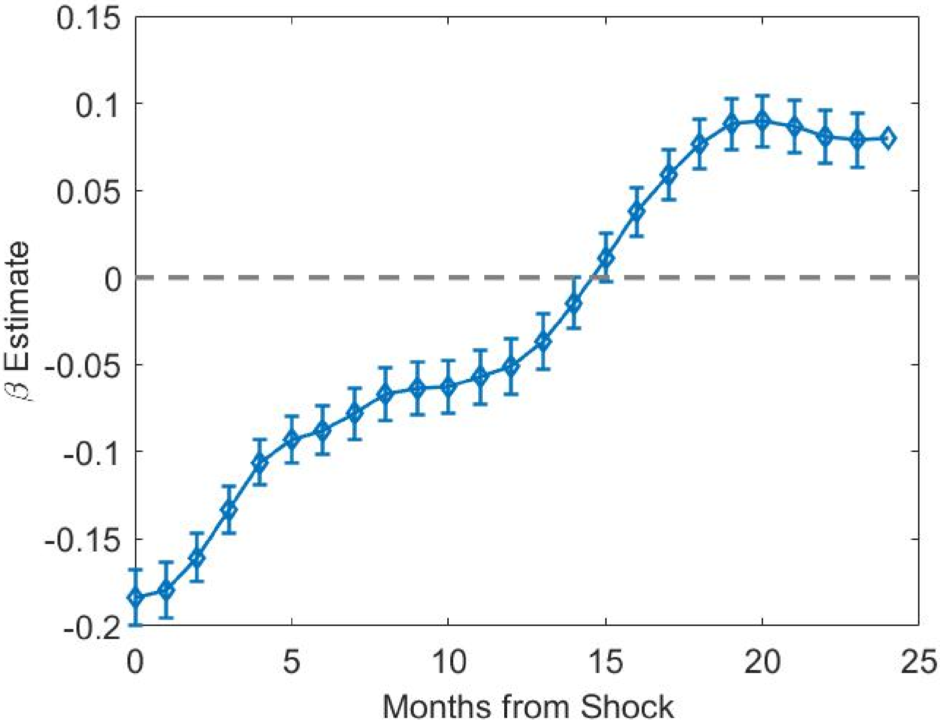
Notes: The figure shows the crude oil price from 2012-2018. The price is reported as the monthly average $ per barrel of crude oil (WTI). The x-axis reports the year. The y-axis reports the price. The dotted gray line denotes the price plunge period.

Figure A.5: O&G Exposure, Price, and Interest Diversion Covenant



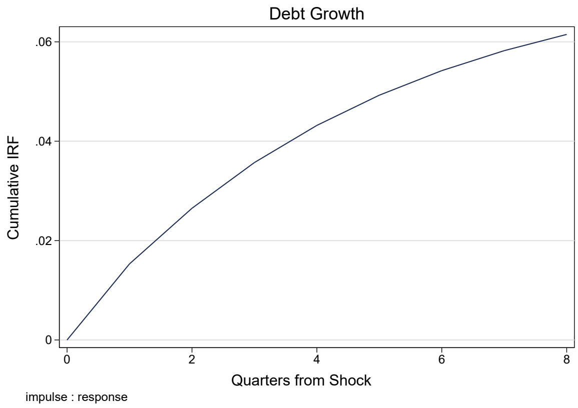
Notes: In this figure, I plot the marginal effects – the slope of the distance to the Interest Diversion threshold on the price deviation, while holding the value of the O&G share constant between 0 and 1, estimated from the following specification: Interest $\text{Diversion}_{c,t} = \beta_0 + \beta_1 \text{O\&G Exposure}_c + \beta_2 \text{Oil Price Deviation}_t + \beta_3(\text{O\&G Exposure}_c \times \text{Oil Price Deviation}_t) + \epsilon_{c,t}$ where c denotes the CLO, t denotes the time, *O&G Exposure*$_c$ fixes the O&G share to before the price plunge, while Oil Shock_t is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. The cross-sectional shares of O&G exposure are fixed. Temporal variation comes from the oil price $\text{deviation}_t = log(\frac{P_t}{70})$.

Figure A.6: Heterogeneous Dynamics in Response to Oil Price Shocks: Jordà Linear Projections

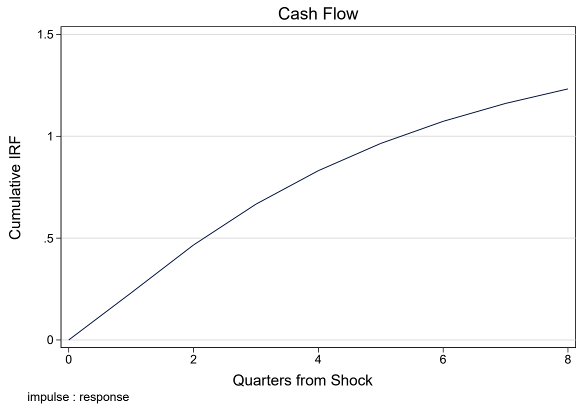


Notes: The figure plots the coefficients and the associated 95% confidence intervals of the interaction term from the following regression at the firm-CLO and month-year levels:$Y_{c,f,t} = \beta_0 + \beta_1(ln(OilPrice))_t + +\alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is the secondary loan spread, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the quarter-year, i denotes the industry, r denotes the rating. $\Delta ln(OilPrice)$ indicates the shock – the monthly price change in the price of oil. Results are generated for CLOs with *high O&G* exposure. CLOs with above-median Interest Diversion performance have high O&G exposure. The x-axis indicates the months from the shock. The y-axis indicates the point estimated with $\Delta ln(OilPrice)$.

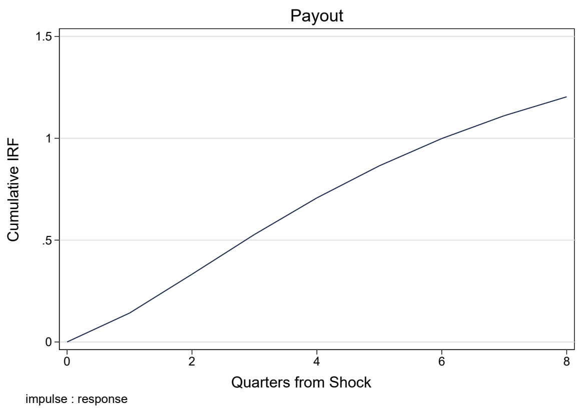
Figure A.7: Cumulative Impulse Response Functions of Firm Characteristics on Oil Price Shocks



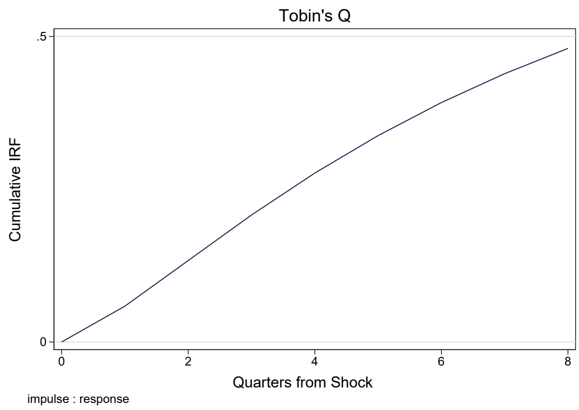
(a) Debt Growth



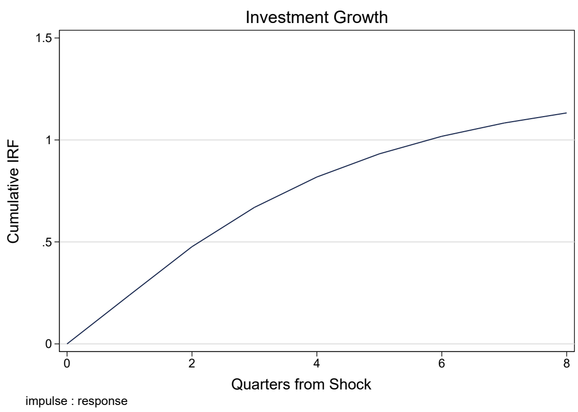
(b) Cash Flow



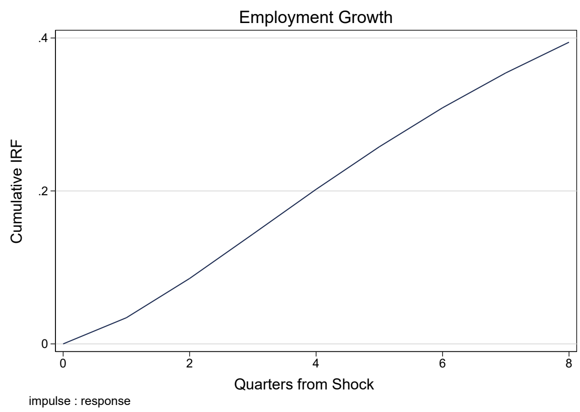
(c) Payout



(d) Tobin's Q



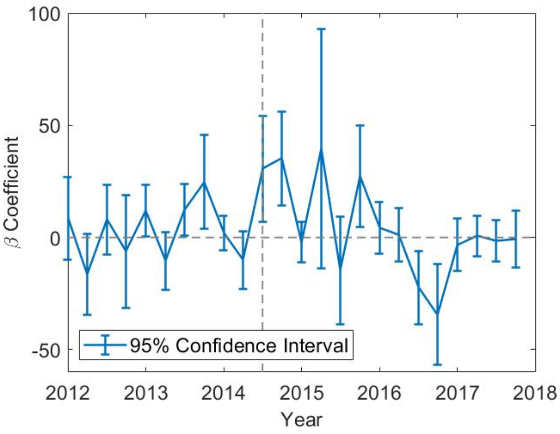
(e) Investment Growth



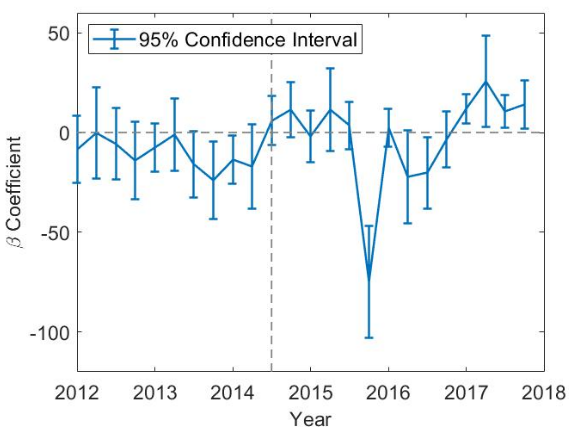
(f) Employment Growth

Notes: The figure presents the impulse response functions estimated from a panel VAR AR(1) model for CLOs with high O&G exposure – CLOs with above-median Interest Diversion performance. The response variables are debt growth (top left), cash flow (top right), payout (middle left), Tobin's Q (middle right), investment growth (bottom left), and employment growth(bottom right). The impulse is the oil price, defined as $ln(OilPrice)$ over consecutive quarters. I include CLO controls (size, annualized equity distribution, age) as well as issuer controls (size, leverage tangibility) as exogenous variables. All variables are standardized. The x-axis indicates the step (quarter) after the initial impulse. The y-axis indicates the cumulative IRF.

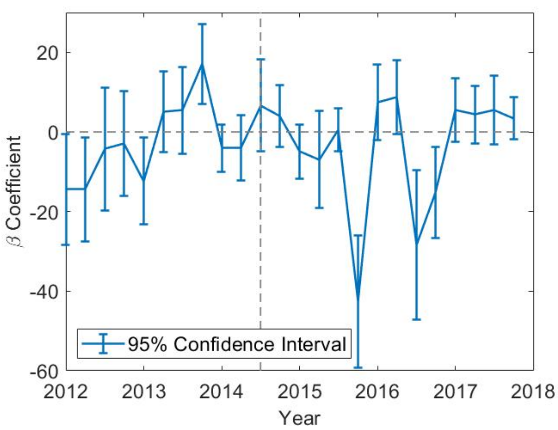
Figure A.8: Dynamic Effect of O&G Exposure on Coefficient of Firm Real Variables



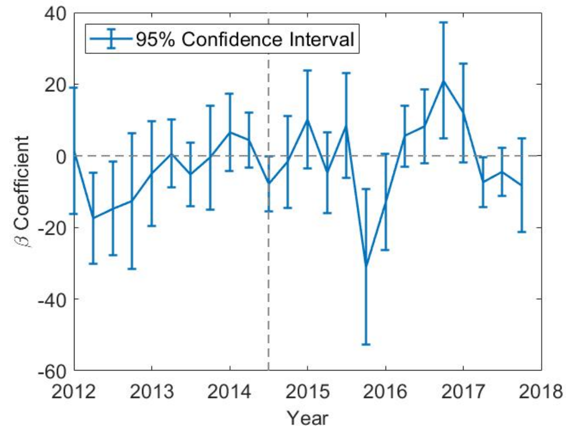
(a) Debt Growth



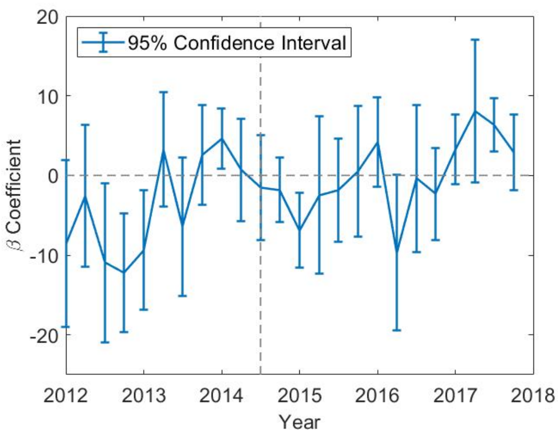
(b) Cash Flow



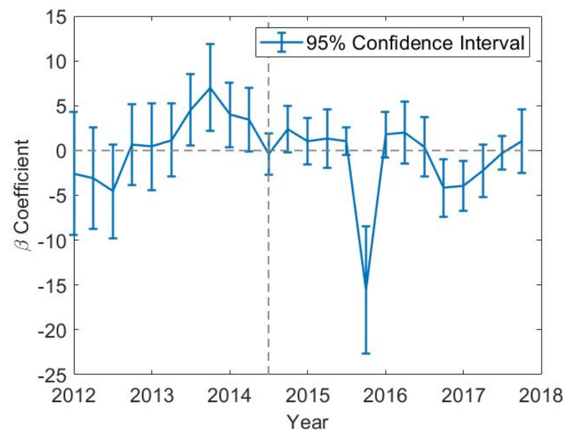
(c) Payout



(d) Tobin's Q



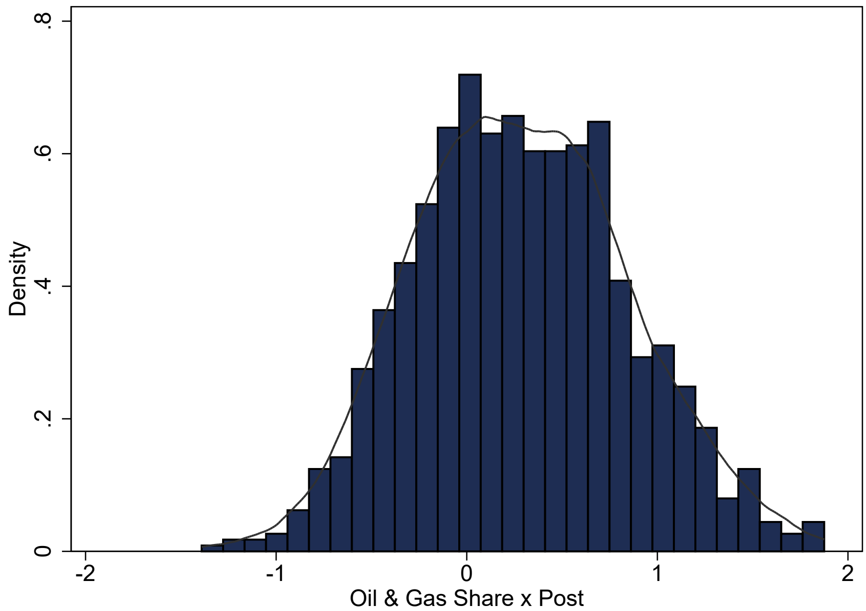
(e) Investment

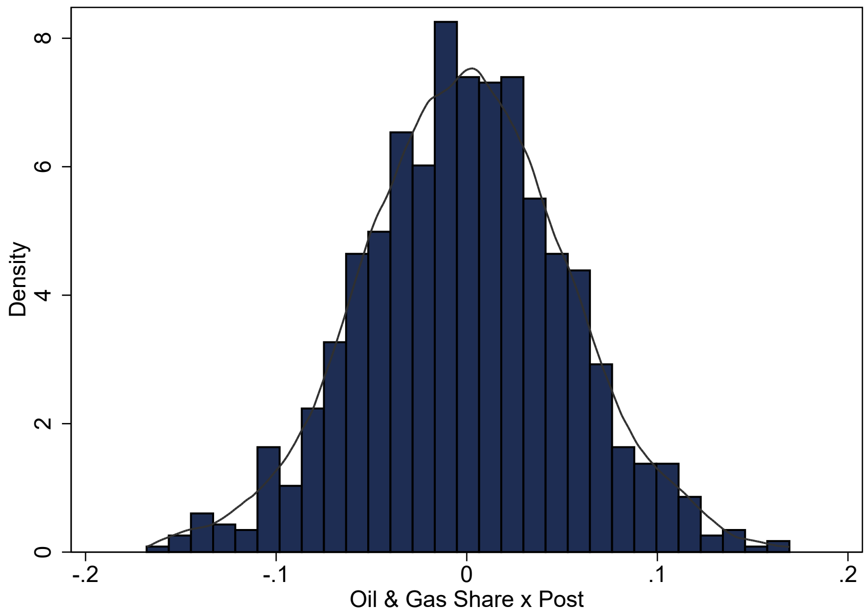


(f) Employment

Notes: The figure plots the coefficients and the associated 95% confidence intervals of the interaction term from the following regression at the firm-CLO and quarter-year levels: $Y_{c,f,t} = \beta_0 + \sum_{k=2012}^{2017}\sum_{q=1}^{4}\beta_{4*(k-2012)+q}(\text{O\&G Exposure}_{c,t} \times \mathbb{1}_{t==kqt}) + \beta_{25}\text{O\&G Exposure}_{c,t} + \gamma_0' X_{c,t} + \alpha_{i,r} + \alpha_q + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is the secondary loan spread, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the quarter-year, i denotes the industry, r denotes the rating, q denotes the quarter. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while $\mathbb{1}_{t==Quarter-Year}$ is an indicator variable that takes a value of 1 if the time period corresponds to quarter-year kq. The dependent variables are the standardized measures of debt growth (top left), cash flow (top right), payout (middle left), Tobin's Q (middle right), employment (bottom left), and investment (bottom right). The x-axis indicates the quarter-year. The y-axis indicates the associated $\beta_{4*(k-2012)+q}$ estimate. Standard errors are two-way clustered by CLO and quarter-year.

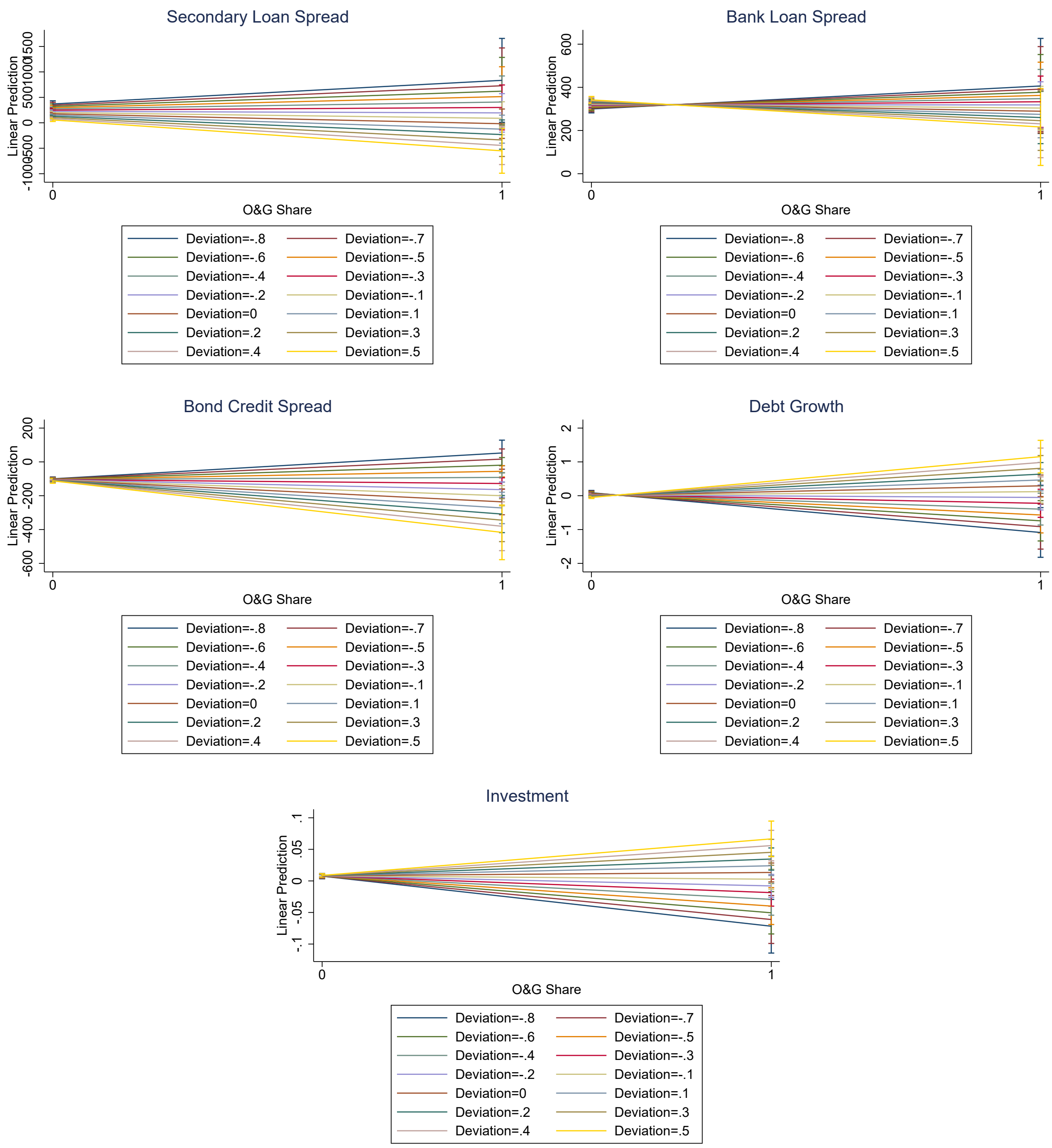
Figure A.9: Placebo Tests





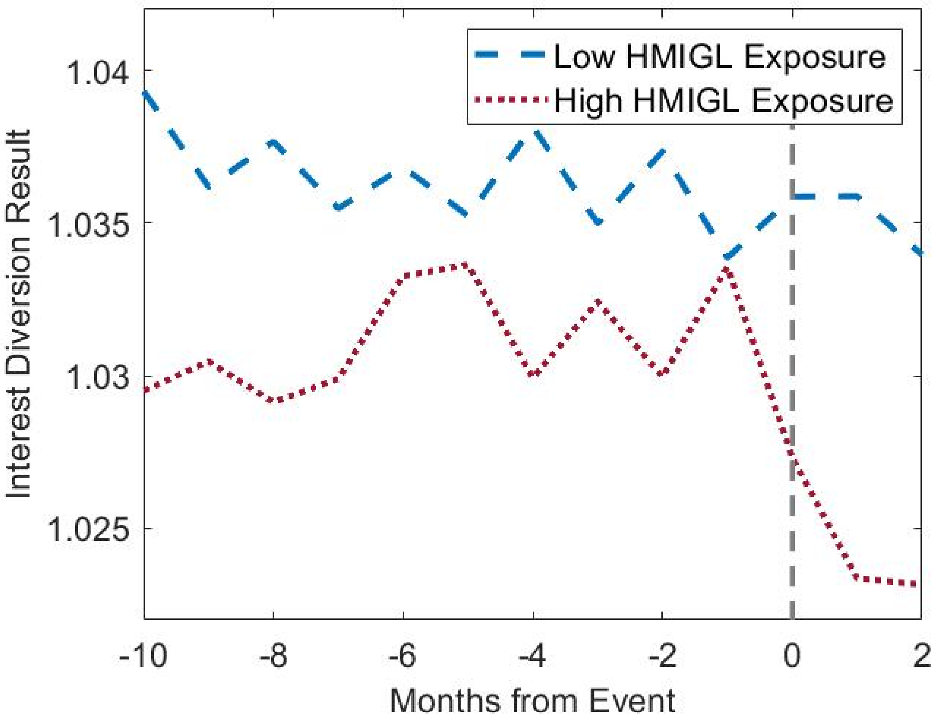
Notes: I plot the histograms from 1,000 Monte-Carlo simulations of the baseline results using two placebo tests. In the top figure, I randomize the date of the oil price plunge from a uniform distribution from 2012 to 2017. In the bottom figure, I randomize the O&G share from a uniform distribution. β_3 is plotted from the baseline specification: $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is the secondary loan price, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. The "true" estimated point estimates lie outside of the graph.

Figure A.10: Price Deviation and Fixed Initial Shares



Notes: In this figure, I plot the marginal effects – the slope of the distance to the Interest Diversion threshold on the price deviation, while holding the value of the O&G share constant between 0 and 1, estimated from the following specification: $Y_{c,f,t} = \beta_0 + \beta_1 \text{O\&G Exposure}_c + \beta_2 \text{Oil Price Deviation}_t + \beta_3(\text{O\&G Exposure}_c \times \text{Oil Price Deviation}_t) + \gamma_0' X_c + \gamma_1' Z_f + \alpha_{i,r} + \epsilon_{c,f,t}$, where c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, i denotes the industry and r denotes the rating. Z is a vector of issuer controls and X is a vector of CLO controls. The cross-sectional shares of O&G exposure are fixed. Temporal variation comes from the oil price deviation$_t$ $= log(\frac{P_t}{70})$. I produce these plots for the secondary loan spread (top left), bank loan spread (top right), bond credit spread (middle left), debt growth (middle right) and investment (bottom).

Figure A.11: HMIGL Exposure and Interest Diversion Covenant



Notes: The figure presents the dynamic relation between HMIGL (hotels, motels, inns, gaming and leisure) exposure and the Interest Diversion covenant. CLOs are segmented based on HMIGL exposure. CLOs with above-median HMIGL exposure have *high HMIGL* exposure, while CLOs with below HMIGL exposure have *low HMIGL* exposure. The median distance from the Interest Diversion threshold is plotted for these two groups of CLOs. It is is plotted in red for CLOs with high HMIGL exposure, and blue for CLOs with low HMIGL exposure. The x-axis represents the months around the O&G price plunge. The y-axis represents the distance from the Interest Diversion threshold.

Table A.1: CLO Comparison based on Observable Firm Characteristics

Low O&G Exposure	N	Q1	Median	Q3	Mean	Std. Dev.
Payout	143,069	0.0000	0.0022	0.0199	0.0127	0.0341
CapEx	152,884	0.0062	0.0153	0.0330	0.0257	0.0509
R&D	59,271	0.0000	0.0055	0.0187	0.0206	0.0480
Acquisitions	148,583	0.0000	0.0000	0.0103	0.0218	0.0541
Cash Flow	154,893	0.0220	0.0294	0.0386	0.0312	0.0162
Employment Growth	146,463	-0.0225	0.0244	0.0973	0.0722	0.2136
Investment	152,921	0.1638	0.3786	0.5938	0.0443	0.8987
Net Leverage	144,416	0.3018	0.4565	0.6300	0.4785	0.2834
Tobin's Q	120,533	1.2358	1.5130	1.8961	1.6510	0.5833
High O&G Exposure	N	Q1	Median	Q3	Mean	Std. Dev.
Payout	158,379	0.0000	0.0018	0.0190	0.0103	0.0333
CapEx	169,459	0.0058	0.0151	0.0338	0.0265	0.0521
R&D	61,872	0.0000	0.0055	0.0193	0.0198	0.0456
Acquisitions	163,752	0.0000	0.0000	0.0103	0.0234	0.0570
Cash Flow	171,130	0.0206	0.0283	0.0377	0.0300	0.0164
Employment Growth	161,466	-0.0375	0.0172	0.0896	0.0611	0.2166
Investment	168,103	0.1207	0.3746	0.6002	0.0354	0.9095
Net Leverage	159,498	0.3063	0.4606	0.6248	0.4749	0.2827
Tobin's Q	133,820	1.2025	1.4858	1.8676	1.6164	0.5724

Notes: In this table, I compare characteristics of firms that are held by CLOs with *high* O&G exposure to firms that are held by CLOs with *low* O&G exposure. CLOs with above-median O&G exposure have high O&G exposure while CLOs with below median O&G exposure have low O&G exposure. The characteristics of interest are: payout, capital expenditures, research and development, acquisitions, cash flow (operating income), employment growth, investment (capital stock growth), net leverage, and Tobin's Q. The number of observations, first quartile, median, third quartile, mean, and standard deviation associated with each variable are in Columns 2-7, respectively.

Table A.2: Absence of Portfolio Selection: Time-Series Evidence

Profitability	(1)	(2)	(3)
Oil Price Deviation	0.0427	0.2463	0.1918
	(0.0640)	(0.1521)	(0.1560)
Low O&G Share × Oil Price Deviation	-0.0603	0.0201	0.0148
	(0.0467)	(0.0157)	(0.0132)
CLO Controls	No	No	Yes
Issuer Controls	No	No	Yes
Rating-Industry FE	No	Yes	Yes
Year FE	No	Yes	Yes
N	940,545	933,315	588,741
R^2	0.0002	0.2256	0.2316

Standard errors are two-way clustered by manager and quarter-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: In this table I study if there are distinguishable differences in the correlation of profitability and oil price for firms in CLOs with high O&G exposure as compared to CLOs with low O&G exposure. CLOs with above-median O&G exposure have high O&G exposure while CLOs with below median O&G exposure have low O&G exposure. The baseline regression specification takes the form: $Y_{c,f,t} = \beta_0 + \beta_1 \text{Oil Price Deviation}_t + \beta_3 \text{Oil Price Deviation}_c \times \mathbb{1}_{\text{c has Low O\&G Exposure}} + \epsilon_{c,f,t}$, where c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time. $Y_{c,f,t}$ is firm profitability, defined by RoA. There are no controls in Columns 1-2. CLO controls (size, annualized equity distribution, age) and issuer controls (size, leverage, tangibility) are included in Columns 2, 3. In Column 2 and 3, I include rating-industry and year fixed effects in Columns 2, 3.

Table A.3: Absence of Portfolio Selection: Cross-Sectional Evidence

Coefficient Estimates			
$1_{\text{High O\&G CLO}}$	(1)	(2)	(3)
Covariance(Price, Profitability)	-1.9450	-2.4358	-2.5455
	(5.4393)	(6.0059)	(5.9088)
CLO Controls	No	Yes	Yes
Issuer Controls	No	No	Yes
Year FE	No	No	Yes
Marginal Estimates			
$1_{\text{High O\&G CLO}}$	(1)	(2)	(3)
Covariance(Price, Profitability)	-0.7745	-0.9273	-0.9374
	(2.1670)	(2.2902)	(2.1794)
CLO Controls	No	Yes	Yes
Issuer Controls	No	No	Yes
Year FE	No	No	Yes
N	1,027,515	682,584	628,590

Standard errors are clustered by manager in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: In this table, I study whether it can forecasted which CLO a non-O&G firm will be held in, based on the covariance between the firm's profitability, and oil price. CLOs with above-median O&G exposure have high O&G exposure while CLOs with below median O&G exposure have low O&G exposure. The baseline regression specification takes the form: $Pr(\mathbb{1}_{f \in c \text{ with high O\&G exposure}}) = \Phi(\alpha + \beta(\text{Covariance(Oil Price}_t, \text{Profitability}_{f,t})) + \gamma_0 X_{f,t} + \gamma_1 Z_{f,t} + \alpha_t + \epsilon_{f,t})$ where c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, Z is a vector of issuer controls and X is a vector of CLO controls. CLO controls (size, annualized equity distribution, age) are included in Columns 2, 3 and issuer controls (size, leverage, tangibility) are included in Column 3. I include year fixed effects in Column 3. The top panel exhibits the coefficient estimates. The bottom panel exhibits the marginal estimates.

Table A.4: Secondary Loan Spread: Issuer Fixed Effects

Secondary Loan Spread (bps)	(1)	(2)	(3)
O&G Share $\times$ Post	866.8**	1209.6***	1856.0**
	(330.6953)	(440.0477)	(812.1620)
O&G Share	-1011.2***	-1220.0***	-1974.7**
	(318.5081)	(417.2378)	(799.7503)
Post	123.6***	128.6***	
	(24.1302)	(32.2688)	
CLO Controls	No	Yes	Yes
Firm Controls	No	No	Yes
Issuer FE	Yes	Yes	Yes
Month-Year FE	No	No	Yes
Rating $\times$ Term Loan FE	No	No	Yes
Industry FE	No	No	Yes
N	267,691	56,315	5,975
R^2	0.5660	0.6234	0.7511

Standard errors are two-way clustered by manager and month-year in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and the secondary loan spread for non-O&G firms. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_f + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is the secondary loan spread, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. The secondary loan spread is defined as $(100 - P) * 100$ where P is the transacted price. Columns 1-3 include issuer fixed effects. There are no controls in Column 1. CLO controls (size, annualized equity distribution, age) are included in Columns 2, 3. Issuer controls (size, leverage, tangibility) are included in Columns 3. Month-year, rating$\times$ term loan and industry fixed effects are included in Column 3. Standard errors are two-way clustered by CLO and month-year.

Table A.5: New Bank Loan Quantity

ln(Amount)	(1)	(2)	(3)	(4)	(5)
Oil & Gas Share × Post	-0.7970*	-1.7636**	-0.9307	-1.0900	0.1024
	(0.4564)	(0.7239)	(0.6092)	(0.6565)	(0.3963)
Oil & Gas Share	0.5906	1.3922*	0.9329	1.0732	-0.1181
	(0.4316)	(0.7120)	(0.6273)	(0.6940)	(0.3750)
Post	0.0037	0.0573	-0.0785	-0.1218	-0.1595
	(0.0662)	(0.0799)	(0.1274)	(0.1495)	(0.2894)
CLO Controls	No	Yes	Yes	Yes	Yes
Issuer Controls	No	No	Yes	Yes	Yes
Loan Control	No	No	Yes	Yes	Yes
Rating-Industry FE	Yes	Yes	Yes	Yes	Yes
Quarter FE	No	No	No	Yes	Yes
Year FE	No	No	No	No	Yes
Secured	No	Yes	Yes	Yes	Yes
N	915,910	178,847	28,880	28,880	28,880
R^2	0.2739	0.3164	0.6197	0.6256	0.6696

Standard errors are two-way clustered by CLO and month-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and new bank loan volume. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is the natural log of the facility amount for term loans B and below, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, Z is a vector of issuer controls and X is a vector of CLO controls, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. The outcome variable is $ln(Amount)$ – the natural log of the loan amount of a facility. Columns 1-5 include rating-industry fixed effects. There are no controls in Column 1. CLO controls (size, annualized equity distribution, age) are included in Columns 2-5. Issuer controls (size, leverage, tangibility) are included in Columns 3-5. Loan specific variables like maturity and secured status are accounted for in Columns 3-5 and Columns 2-5, respectively. Quarter FEs are included in Columns 4-5. Year fixed effects are included in Column 5. Standard errors are two-way clustered by CLO and month-year.

Table A.6: New Revolving LoC Spread

All-in-drawn Spread (bps)	(1)	(2)	(3)	(4)	(5)
Oil & Gas Share × Post	91.3439*	225.8906**	159.8213**	158.6535**	66.2713
	(54.1799)	(95.4164)	(74.6315)	(68.7943)	(52.1248)
Oil & Gas Share	-82.2522	-225.6905**	-111.0714	-104.5303*	-40.9163
	(52.3589)	(90.9617)	(74.8371)	(61.9791)	(42.2743)
Post	4.6531	-14.1031	-13.5477	-21.3077	166.3735***
	(9.6836)	(12.6346)	(24.4728)	(23.1884)	(30.0729)
CLO Controls	No	Yes	Yes	Yes	Yes
Issuer Controls	No	No	Yes	Yes	Yes
Loan Control	No	No	Yes	Yes	Yes
Rating-Industry FE	Yes	Yes	Yes	Yes	Yes
Quarter FE	No	No	No	Yes	Yes
Year FE	No	No	No	No	Yes
Secured	No	Yes	Yes	Yes	Yes
N	341,832	63,832	10,593	10,593	10,593
R^2	0.5284	0.6025	0.8925	0.8953	0.9387

Standard errors are two-way clustered by CLO and month-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and new revolving credit facilities for non-O&G firms. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is the primary loan spread for revolving credit facilities, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, Z is a vector of issuer controls and X is a vector of CLO controls, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. The outcome variable is the all-in-drawn spread. The all-in-drawn spread is defined as the total annual spread above LIBOR for each dollar. This includes both fees and interest payments. Columns 1-5 include rating-industry fixed effects. There are no controls in Column 1. CLO controls (size, annualized equity distribution, age) are included in Columns 2-5. Issuer controls (size, leverage, tangibility) are included in Columns 3-5. Loan specific variables like maturity and secured status are accounted for in Columns 3-5 and Columns 2-5, respectively. Quarter FEs are included in Columns 4-5. Year fixed effects are included in Column 5. Standard errors are two-way clustered by CLO and month-year.

Table A.7: New Revolving LoC Quantity

ln(Amount)	(1)	(2)	(3)	(4)	(5)
Oil & Gas Share × Post	-1.2392**	-2.9380***	-1.2711**	-1.3002**	-1.0407*
	(0.5692)	(0.7439)	(0.5873)	(0.6261)	(0.5434)
Oil & Gas Share	1.2966**	3.0405***	0.4287	0.6066	0.3878
	(0.5693)	(0.6817)	(0.4217)	(0.3998)	(0.3569)
Post	0.1392	0.3129**	0.3522***	0.3081**	-0.0939
	(0.0988)	(0.1189)	(0.1023)	(0.1450)	(0.2744)
CLO Controls	No	Yes	Yes	Yes	Yes
Issuer Controls	No	No	Yes	Yes	Yes
Loan Control	No	No	Yes	Yes	Yes
Rating-Industry FE	Yes	Yes	Yes	Yes	Yes
Quarter FE	No	No	No	Yes	Yes
Year FE	No	No	No	No	Yes
Secured	No	Yes	Yes	Yes	Yes
N	342,552	63,837	10,598	10,598	10,598
R^2	0.5426	0.6719	0.8252	0.8290	0.8484

Standard errors are two-way clustered by CLO and month-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and new bank loan volume for revolving lines of credit. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is the natural log of the facility amount for revolving lines of credit, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, Z is a vector of issuer controls and X is a vector of CLO controls, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. The outcome variable is $ln(Amount)$ – the natural log of the loan amount of a facility. Columns 1-5 include rating-industry fixed effects. There are no controls in Column 1. CLO controls (size, annualized equity distribution, age) are included in Columns 2-5. Issuer controls (size, leverage, tangibility) are included in Columns 3-5. Loan specific controls (secured FE, maturity) are included in Columns 3-5. Quarter FEs are included in Columns 4-5. Year fixed effects are included in Column 5. Standard errors are two-way clustered by CLO and month-year.

Table A.8: Alternative Specification: Lines of Credit (Extensive)

Total	(1)	(2)	(3)
Oil & Gas Share × Post	-0.8242***	-0.8559**	-0.8698**
	(0.2924)	(0.3831)	(0.4039)
Oil & Gas Share	0.4719	0.5824	0.4440
	(0.2977)	(0.3920)	(0.4353)
Post	0.0466*	0.0564*	0.0927***
	(0.0271)	(0.0280)	(0.0314)
CLO Controls	No	Yes	Yes
Issuer Controls	No	No	Yes
Rating-Industry FE	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes
N	550,909	362,226	344,630
R^2	0.1071	0.1114	0.1292

Standard errors are two-way clustered by CLO and quarter-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and firm liquidity (extensive margin). The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is firm liquidity (standardized), c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, Z is a vector of issuer controls and X is a vector of CLO controls, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. Columns 1-3 include rating-industry fixed effects and quarter fixed effects. The outcome variable is the ratio of a firm's total line of credit to the aggregate of total line of credit and, cash and cash equivalents. This includes firms which do not have access to a line of credit – the extensive margin. I do not include any controls in Column 1. In Column 2, I include CLO controls (size, annualized equity distribution, age). In Column 3, I include CLO and issuer controls (size, leverage, tangibility). In Table A.9, I report the results from an alternative specification. Standard errors are two-way clustered by CLO and quarter-year.

Table A.9: Alternative Specification: Lines of Credit

	(1)	(2)	(3)	(4)
	Extensive Margin			Intensive Margin
Oil & Gas Share × Post	-0.8032**	-0.8606**	-0.6956**	-1.0194*
	(0.3024)	(0.3237)	(0.2706)	(0.5913)
Oil & Gas Share	0.4705*	0.6258*	0.4250	0.7105
	(0.2557)	(0.3171)	(0.2981)	(0.4183)
Post	0.1157***	0.1137***	0.1186***	0.2047***
	(0.0204)	(0.0194)	(0.0193)	(0.0276)
CLO Controls	No	Yes	Yes	Yes
Issuer Controls	No	No	Yes	Yes
Rating-Industry FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
N	546,855	359,899	338,193	124,607
R^2	0.2020	0.2147	0.2645	0.6226

Standard errors are two-way clustered by CLO and quarter-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and firm liquidity (extensive margin). The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is firm liquidity (standardized), c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, Z is a vector of issuer controls and X is a vector of CLO controls, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. Columns 1-4 include rating-industry fixed effects and quarter fixed effects. The outcome variable is defined as the ratio of total line of credits to lagged assets. In Columns 1-3, the specification reports the results on the extensive margin; I include firms that do not have access to an existing line of credit. In Column 4, I report the result on the intensive margin; only firms the access to an existing line of credit are included in the regression. In Column 1, I do not include any controls. In Column 2, I include CLO Controls. In Columns 3-4, I include CLO controls (size, annualized equity distribution, age) and issuer controls (size, leverage, tangibility). Standard errors are two-way clustered by CLO and quarter-year.

Table A.10: Wild Standard Errors: Firm Liquidity

	(1) Total	(2) Undrawn	(3) Total	(4) Undrawn
t-stat	-3.7911	-3.8005	-3.2173	-2.7979
Prob>|t|	0.0101	0.009	0.0181	0.0211
CLO Controls	No	No	Yes	Yes
Issuer Controls	No	No	Yes	Yes
Rating-Industry FE	Yes	Yes	Yes	Yes
Quarter FE	No	No	Yes	Yes
N	327,340	302,966	205,198	190,015
R^2	0.2983	0.3436	0.3886	0.4317

Standard errors are two-way clustered by CLO and quarter-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents inferences of t-statistics and p-value from wild bootstrapping. This addresses the concern of small number of clusters in the baseline specifications. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is (standardized) firm liquidity, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, Z is a vector of issuer controls and X is a vector of CLO controls, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. Columns 1-4 include rating-industry fixed effects. In Columns 1 and 3, the outcome variable is the ratio of a firm's total line of credit to the aggregate of total line of credit and cash and cash equivalents. In Columns 2 and 4, the outcome variable is the ratio of a firm's undrawn line to the aggregate of the undrawn line and cash and cash equivalents. In Columns 1 and 2, I do not include any controls. In Columns 3 and 4, I include CLO controls (size, annualized equity distribution, age) and issuer controls (size, leverage, tangibility), as well as quarter fixed effects, intended to control for seasonality. This regression reports the results on the intensive margin, i.e., results for firms with access to an existing line of credit. Standard errors are two-way clustered by CLO and quarter-year.

Table A.11: Wild Standard Errors: Firm Financial Adjustment

	(1) Debt growth	(2) Payout	(3) CapEx	(4) R&D	(5) Acquisitions	(6) Cash Flow
t-stat	-2.1843	-3.7617	-3.0881	-3.1561	-2.0276	-1.9175
Prob>|t|	0.0521	0.003	0.009	0.005	0.0811	0.0941
CLO Controls	Yes	Yes	Yes	Yes	Yes	Yes
Issuer Controls	Yes	Yes	Yes	Yes	Yes	Yes
Rating-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	190,506	179,687	190,979	76,742	188,911	193,852
R^2	0.0812	0.2471	0.3601	0.2377	0.1724	0.3838

Standard errors are two-way clustered by CLO and quarter-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents inferences of t-statistics and p-value from wild bootstrapping. This addresses the concern of small number of clusters in the baseline specifications. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ are the following standardized variables: debt growth in Column 1, payout in Column 2, capital expenditure in Column 3, R&D in Column 4, acquisitions in Column 5, and cash flow in Column 6. c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, Z is a vector of issuer controls and X is a vector of CLO controls, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. Columns 1-6 include rating-industry and year fixed effects, as well as CLO controls (size, annualized equity distribution, age) and issuer controls (size, leverage, tangibility). Standard errors are two-way clustered by CLO and quarter-year.

Table A.12: Wild Standard Errors: Real Financial Adjustment

	(1) Emp. Growth	(2) Emp. Growth (Small)	(3) Emp. Growth (Big)	(4) Cap. Stock. Growth	(5) CapEx	(6) Investment Growth	(7) Net Lev.	(8) Tobin's Q
t-stat	-0.8586	-0.1312	-1.8209	-3.8721	-3.0881	-1.5431	-2.2397	-1.9319
Prob>|t|	0.4184	0.9079	0.1031	0.001	0.005	0.1665	0.0521	0.0911
CLO Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Issuer Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rating-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	180,445	93,853	86,590	195,819	190,979	190,753	187,610	147,774
R^2	0.1706	0.1986	0.2933	0.1102	0.3601	0.0492	0.9274	0.5399

Standard errors are two-way clustered by CLO and quarter-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents inferences of t-statistics and p-value from wild bootstrapping. This addresses the concern of small number of clusters in the baseline specifications. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_{i,r} + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ are the following standardized variables: employment growth in Column 1, employment growth for small firms (below median size) in Column 2, employment growth for large firms (above median size) in Column 3, investment (capital stock growth) in Column 4, investment (CapEx) in Column 5, investment growth (Δ CapEx) in Column 6, net leverage in Column 7, and Tobin's Q in Column 8. c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, Z is a vector of issuer controls and X is a vector of CLO controls, i denotes the industry and r denotes the rating. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. Columns 1-6 include rating-industry and year fixed effects, as well as CLO controls (size, annualized equity distribution, age) and issuer controls (size, leverage, tangibility). Standard errors are two-way clustered by CLO and quarter-year.

Table A.13: Alternative Empirical Methodology: Fixed Initial Shares

	(1) Sec. Loan Spread	(2) Prim. Loan Spread	(3) Bond Spread	(4) Debt Growth	(5) Investment
Oil & Gas Share × Post	529.8253*	158.6700*	262.7116***	-1.0510*	-0.0660***
	(307.0559)	(87.1178)	(49.3898)	(0.5223)	(0.0198)
Oil & Gas Share	-385.5837**	-103.4501	-237.3163***	0.8625***	0.0404***
	(187.7755)	(71.9357)	(55.0354)	(0.2956)	(0.0103)
Post	138.2881***	-30.1941***	-14.0415*	0.0507	-0.0016
	(23.0607)	(8.1208)	(8.3469)	(0.0401)	(0.0034)
CLO Controls	Yes	Yes	Yes	Yes	Yes
Issuer Controls	No	No	No	Yes	Yes
Loan Control	No	Yes	No	No	No
Bond Control	No	No	Yes	No	No
Rating-Industry FE	Yes	Yes	Yes	Yes	Yes
Term Loan FE	Yes	No	No	No	No
Secured FE	No	Yes	No	No	No
Bond Type FE	No	No	Yes	No	No
Year FE	No	No	No	Yes	Yes
N	252,368	712,165	182,922	157,388	160,941
R^2	0.3000	0.2766	0.5961	0.0437	0.1098

Standard errors are two-way clustered by CLO and month-year (Col 1-3), and, CLO and quarter-year (Col 4-5) in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: In this table, I study whether the results differ under an alternative empirical specification. In this specification, the initial O&G shares are fixed before the price plunge occurs. The baseline specification is the following: $Y_{c,f,t} = \beta_0 + \beta_1 \text{O\&G Exposure}_c + \beta_2 \text{Oil Shock}_t + \beta_3(\text{O\&G Exposure}_c \times \text{Oil Shock}_t) + \epsilon_{c,f,t} + \gamma_0' X_c + \gamma_1' Z_f + \alpha_{i,r} + \epsilon_{c,f,t}$ where c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, Z is a vector of issuer controls and X is a vector of CLO controls, i denotes the industry and r denotes the rating. *O&G Exposure*$_c$ fixes the O&G share of a CLO to before the shock, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. The estimator is a within rating-industry estimator. CLO controls (size, annualized equity distribution, age) are included in Columns 1-5, and issuer controls (size, leverage, tangibility) are included in Columns 4-5. Loan and bond controls are maturity and duration in Column 2 and Column 3, respectively. I account for loan type through term loan fixed effects in Column 1, loan secured status through secured fixed effects in Column 2, and bond type through bond type fixed effects in Column 3. The outcome variables are secondary loan spread, primary loan spread (all-in-drawn spread), transacted bond credit spread, debt growth, and investment in Columns 1-5, respectively. Standard errors are two-way clustered by CLO and month-year in Column 1-3, and two-way clustered by CLO and quarter-year in Columns 4-5.

Table A.14: Alternative Specification: Binned Results

	(1) Sec. Loan Spread	(2) Prim. Loan Spread	(3) Bond Spread	(4) Debt Growth	(5) Investment
O&G Bin #2 × Post	14.2291	5.0898	7.5940*	-0.0087	-0.0015*
	(14.6455)	(4.7111)	(3.9107)	(0.0121)	(0.0008)
O&G Bin #3 × Post	56.0265***	10.0702**	9.1327*	-0.0148	-0.0018**
	(19.2175)	(4.5350)	(4.6650)	(0.0148)	(0.0008)
O&G Bin #4 × Post	78.3515***	26.4973***	12.1008***	-0.0329	-0.0030***
	(21.7534)	(5.8299)	(3.8004)	(0.0205)	(0.0009)
O&G Bin #2 ($25^{th} pct. < Share \leq 50^{th} pct.$)	14.0551	-3.0980	-2.3719	0.0032	0.0007
	(10.5035)	(3.8886)	(3.2771)	(0.0111)	(0.0006)
O&G Bin #3 ($50^{th} pct. < Share \leq 75^{th} pct.$)	-14.9659	-3.4411	-3.3762	0.0191	0.0013*
	(12.8036)	(3.5538)	(4.0771)	(0.0130)	(0.0007)
O&G Bin #4 ($Share \geq 75^{th} pct.$)	-39.4195***	-18.0952***	-5.2199	0.0389**	0.0032***
	(13.1997)	(4.5792)	(3.1428)	(0.0143)	(0.0006)
Post	99.8258***	-3.6084	-21.2242**	-0.0335	0.0046
	(21.3907)	(9.6464)	(8.9913)	(0.0439)	(0.0047)
CLO Controls	Yes	Yes	Yes	Yes	Yes
Issuer Controls	No	No	No	Yes	Yes
Loan Control	No	Yes	No	No	No
Bond Control	No	No	Yes	No	No
Rating-Industry FE	Yes	Yes	Yes	Yes	Yes
Term Loan FE	Yes	No	No	No	No
Secured FE	No	Yes	No	No	No
Bond Type FE	No	No	Yes	No	No
Year FE	No	No	No	Yes	Yes
N	127,495	266,653	138,033	190,506	195,819
R^2	0.3784	0.3959	0.8241	0.0812	0.1102

Standard errors are two-way clustered by CLO and month-year (Col 1-3), and, CLO and quarter-year (Col 4-5) in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: In this table, I study whether the results differ under an alternative empirical specification. In this specification, I bin CLOs into quartiles based on O&G exposure. CLOs with O&G exposure below the 25^{th} percentile of O&G exposure are in *O&G Bin #1*. CLOs with O&G exposure between the 25^{th} and 50^{th} percentile of O&G exposure are in *O&G Bin #2*. CLOs with O&G exposure between the 50^{th} and 75^{th} percentile of O&G exposure are in *O&G Bin #3*. CLOs with O&G exposure above the 75^{th} percentile of O&G exposure are in *O&G Bin #4*. I omit O&G Bin #1 to avoid multicollinearity. This yields the following baseline specification is the following: $\text{Y}_{c,f,t} = \beta_0 + \sum_{i=2}^{4} \beta_{i-1}\text{O\&G Bin \# i}_c + \beta_4\text{Oil Shock}_t + \sum_{i=2}^{4} \beta_{i+4}(\text{O\&G Bin \# i}_c \times \text{Oil Shock}_t) + \epsilon_{c,f,t} + \gamma_0' X_c + \gamma_1' Z_f + \alpha_{i,r} + \epsilon_{c,f,t}$ where c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, i denotes the industry and r denotes the rating. Z is a vector of issuer controls and X is a vector of CLO controls. *O&G Exposure*$_c$ fixes the O&G share of a CLO to before the shock, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. The estimator is a within rating-industry estimator. CLO controls (size, annualized equity distribution, age) are included in Columns 1-5, and issuer controls (size, leverage, tangibility) are included in Columns 4-5. Loan and bond controls are maturity and duration, respectively. I account for loan type through term loan fixed effects in Column 1, loan secured status through secured fixed effects in Column 2, and bond type through bond type fixed effects in Column 3. The outcome variables are secondary loan spread, primary loan spread (all-in-drawn spread), transacted bond credit spread, debt growth, and investment in Columns 1-5, respectively. Standard errors are two-way clustered by CLO and month-year in Column 1-3, and two-way clustered by CLO and quarter-year in Columns 4-5.

Table A.15: Alternative measures of CLO distress (2013-2017)

All-in-drawn Spread (Term)	(1)	(2)	(3)	(4)
Unhealthy #1 × Post	26.5011***			
	(9.3944)			
Unhealthy #1	-23.4864**			
	(9.2670)			
Unhealthy #2 × Post		27.1131**		
		(12.4008)		
Unhealthy #2		-25.2643**		
		(10.9793)		
Interest Diversion × Post			-4.6826	
			(3.7861)	
Interest Diversion × CLO Post				-6.2329**
				(2.3547)
Interest Diversion			4.1286	-0.8203
			(3.8272)	(1.7620)
Post	33.9818***	41.9852***	42.8941***	
	(11.1284)	(9.8249)	(9.7860)	
CLO Post				3.9697
				(9.4609)
Rating-Industry FE	Yes	Yes	Yes	Yes
Secured FE	Yes	Yes	Yes	Yes
N	767,160	767,160	758,302	758,302
R^2	0.2729	0.2726	0.2732	0.2702

Standard errors are double-clustered by manager and month-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between alternate measures of CLO distress and new bank loan spread. The baseline regression specification used in Columns 1-3 is the following: $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Health})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Health}_{c,t} \times \text{Oil Shock}_t) + \alpha_{i,r} + \alpha_s + \epsilon_{c,f,t}$ where $Y_{c,f,t}$ is the primary loan spread (all-in-drawn spread) for revolving lines of credit, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, i denotes the industry and r denotes the rating, and s denotes whether the loan issued by firm f is secured or not. Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. The definition of *O&G Health* is *Unhealthy #1* in Column 1, *Unhealthy #2* in Column 2, and a continuous measure of distance from the Interest Diversion constraints in Columns 3 and 4. *Unhealthy #1* takes a value of 1 if a CLO's distance to the Interest Diversion threshold is below the median, and is assigned 0, otherwise. *Unhealthy #2* takes a value of 1 if a CLO *fails* the Interest Diversion threshold, i.e., it operates below the threshold, and is assigned 0, otherwise. In Column 4, *CLO Post* – in lieu of *Post* in the baseline specification – takes a value 1 if the CLO experiences any O&G defaults, and is assigned a value of 0 otherwise. Columns 1-4 include rating-industry, and, secured fixed effects. Standard errors are two-way clustered by CLO and month-year.

Table A.16: Asset Prices for Non-O&G Risky Firms' Debt

	(1) Sec. Loan Spread	(2) Prim. Loan Spread	(3) Bond Spread
Rated $\leq$C $\times$ Oil & Gas Share $\times$ Post	10953.83***	1037.0520	673.1527**
	(2242.4400)	(1015.7912)	(293.3418)
Oil & Gas Share $\times$ Post	-281.2861	430.1994***	332.5609***
	(537.1886)	(154.8359)	(111.6757)
Rated $\leq$C $\times$ Oil & Gas Share	-12045.33***	-898.4544	-10.3881
	(2035.5994)	(625.9787)	(257.8974)
Rated $\leq$C $\times$ Post	-697.5114***	24.2065	7.6827
	(197.1447)	(90.9209)	(16.9053)
Oil & Gas Share	272.4252	-339.0030***	-189.5802*
	(510.2277)	(113.4521)	(99.8070)
Post	163.0975***	-46.4573***	-13.9121
	(38.4787)	(9.1651)	(11.3802)
Rated $\leq$C	1720.2839***	184.6412***	-38.7291***
	(135.7234)	(47.3642)	(13.3737)
CLO Controls	Yes	Yes	Yes
Loan Control	No	Yes	No
Bond Control	No	No	Yes
Industry FE	Yes	Yes	Yes
Term Loan FE	Yes	No	No
Quarter FE	Yes	Yes	Yes
N	56,299	183,836	138,251
R^2	0.2953	0.1671	0.7200

Standard errors are two-way clustered by CLO and month-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between CLO O&G exposure and asset prices for non-O&G risky issuers. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \beta_4(\text{Risky Firm}_{c,f,t}) + \beta_5(\text{Risky Firm}_{c,f,t} \times \text{Oil Shock}_t) + \beta_6(\text{Risky Firm}_{c,f,t} \times \text{O\&G Exposure}_{c,t}) + \beta_7(\text{Risky Firm}_{c,f,t} \times \text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_q + \epsilon_{c,f,t}$ where Risky firm denotes whether the issuer or firm f of a loan in CLO c has a rating below B3, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, i denotes the industry and r denotes the rating. Z is a vector of issuer controls and X is a vector of CLO controls. $Y_{c,t}$ is the asset price in bps, c denotes the CLO, t denotes the time, q denotes the quarter of the observation. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. The outcome variable is the secondary loan spread in Column 1, primary loan spread (all-in-drawn spread) in Column 2, and transacted bond credit spread in Column 3. I use a within industry estimator across all columns. I account for loan type through term loan fixed effects in Column 1. Loan control and bond controls are maturity and duration in Column 2 and Column 3, respectively. Standard errors are two-way clustered by CLO and month-year.

Table A.17: Effects for Non-O&G Risky Firms with Issuer Controls

	(1) Size	(2) Debt Growth	(3) Emp. Growth ($\geq$P50)	(4) Investment	(5) Net Leverage
Rated $\leq$C $\times$ Oil & Gas Share $\times$ Post	-7.5670***	-7.9388***	-6.0188	-5.0985**	-2.9455**
	(2.4466)	(2.6354)	(6.2002)	(1.9562)	(1.2139)
Oil & Gas Share $\times$ Post	0.7579	-0.6941*	-1.3953	-1.4556***	-0.2438*
	(0.5078)	(0.3868)	(0.9053)	(0.4715)	(0.1398)
Rated $\leq$C $\times$ Oil & Gas Share	9.0564***	3.7469*	7.4486	5.7955***	2.2358*
	(2.1686)	(1.9953)	(5.2858)	(1.6491)	(1.1369)
Rated $\leq$C $\times$ Post	0.0131	0.2667	0.0703	-0.1906*	0.1983*
	(0.1556)	(0.2112)	(0.3366)	(0.1067)	(0.0964)
Oil & Gas Share	-1.8033***	0.8134**	0.6761	1.6161***	0.1881
	(0.4743)	(0.3218)	(0.5914)	(0.3954)	(0.1230)
Post	0.0036	-0.0186	0.2274***	0.1156	-0.0106
	(0.0212)	(0.0468)	(0.0464)	(0.1050)	(0.0094)
Rated $\leq$C	-0.6040***	-0.0722	-0.3615*	-0.2613***	-0.0933
	(0.1153)	(0.1141)	(0.1816)	(0.0844)	(0.0779)
CLO Controls	Yes	Yes	Yes	Yes	Yes
Issuer Controls	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
N	198,141	192,046	87,330	197,406	189,194
R^2	0.2708	0.0323	0.1282	0.0499	0.9100

Standard errors are two-way clustered by CLO and quarter-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Notes: The table presents the relation between CLO O&G exposure and real effects for non-O&G risky issuers. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \beta_4(\text{Risky Firm}_{c,f,t}) + \beta_5(\text{Risky Firm}_{c,f,t} \times \text{Oil Shock}_t) + \beta_6(\text{Risky Firm}_{c,f,t} \times \text{O\&G Exposure}_{c,t}) + +\beta_7(\text{Risky Firm}_{c,f,t} \times \text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_i + \epsilon_{c,f,t}$ where Risky firm denotes whether the issuer or firm f of a loan in CLO c has a rating below B3, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, i denotes the industry and r denotes the rating. Z is a vector of issuer controls and X is a vector of CLO controls. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. The outcome variables are size in Column 1, debt growth in Column 2, employment growth for large firms (above median size) in Column 3, investment (capital stock growth) in Column 4, and net leverage in Column 5. I use a within industry estimator across Columns 1-5, and include year fixed effects to control for common shocks. I include CLO controls (size, annualized equity distribution, age) and issuer controls (size, leverage, tangibility) across Columns 1-5. Standard errors are two-way clustered by CLO and month-year.

Table A.18: Wild Standard Errors: Effects for Non-O&G Risky Firms

	(1) Size	(2) Debt Growth	(3) Emp. Growth (≥P50)	(4) Investment	(5) Net Leverage
t-stat	-3.0167	-2.7802	-1.3505	-1.7378	-2.4790
Prob>|t|	0.0110	0.0200	0.3230	0.1451	0.0490
CLO Controls	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
N	208,217	193,853	96,117	210,726	191,037
R^2	0.2595	0.0183	0.0857	0.0372	0.2659

Standard errors are two-way clustered by CLO and quarter-year in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents inferences of t-statistics and p-value from wild bootstrapping. This addresses the concern of small number of clusters in the baseline specifications. The baseline regression specification takes the form $Y_{c,f,t} = \beta_0 + \beta_1(\text{O\&G Exposure})_{c,t} + \beta_2(\text{Oil Shock})_t + \beta_3(\text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \beta_4(\text{Risky Firm}_{c,f,t}) + \beta_5(\text{Risky Firm}_{c,f,t} \times \text{Oil Shock}_t) + \beta_6(\text{Risky Firm}_{c,f,t} \times \text{O\&G Exposure}_{c,t}) + +\beta_7(\text{Risky Firm}_{c,f,t} \times \text{O\&G Exposure}_{c,t} \times \text{Oil Shock}_t) + \gamma_0' X_{c,t} + \gamma_1' Z_{f,t} + \alpha_i + \epsilon_{c,f,t}$ where Risky firm denotes whether the issuer or firm f of a loan in CLO c has a rating below B3, c denotes the CLO, f denotes the portfolio firm ($f \in c$), t denotes the time, i denotes the industry and r denotes the rating. Z is a vector of issuer controls and X is a vector of CLO controls. *O&G Exposure*$_{c,t}$ measures the O&G share of a CLO at a given point in time, while Oil Shock$_t$ is an indicator variable that takes a value of 1 if the O&G price plunge has occurred, and 0 otherwise. For simplicity, I refer to the *Oil Shock* variable as *Post*. The outcome variables are size in Column 1, debt growth in Column 2, employment growth for large firms (above median size) in Column 3, investment (capital stock growth) in Column 4, and net leverage in Column 5. I use a within industry estimator across Columns 1-4, and include year fixed effects to control for common shocks. I include CLO controls (size, annualized equity distribution, age) across Columns 1-4. Standard errors are two-way clustered by CLO and month-year.

Appendix B Data Construction of Firm-Level Variables

In this section, I describe the definition of variables. 2.5% of observations in each tail are winsorized for each variable. Results are not sensitive to the degree of winsorization. All variables report at the quarterly frequency but employment, (emp).

B.1 Variables

1. *Debt Growth* is defined as the quarterly difference in the log ratio of debt to assets ($\Delta ln(\frac{\texttt{dlttq+dlcq}}{\texttt{atq}})$).
2. *Payout* is the ratio of the sum of cash dividends (dvy) and net purchase of common and preferred stock (prstkcy-sstk) to four-quarter lagged total assets (atq).
3. *Investment (CapEx)* is the ratio of capital expenditures (capxy) to four-quarter lagged total assets (atq).
4. *R&D* is the ratio of research and development expenditures (xrdq) to total assets (atq).
5. *Acquisitions* is the ratio of acquisitions expenditures (acq) to total assets (atq).
6. *Cash Flow* is the ratio of the operating income before depreciation (oibdpq) to total assets (atq).
7. *Employment Growth* is defined as using the growth rate formula for employment – a variable that is reported at the annual frequency. Specifically, it is defined as the ratio of the annual difference in employment to the four-quarter lagged employment (emp)
8. *Investment (Capital Stock Growth)* is defined as the quarterly difference in the log of capital stock. This is the intensive margin of investment and comes from Ottonello and Winberry (2020). For each firm, the initial value of capital stock is equal to the level of gross plant, property and equipment (ppegt). This is k_{it+1} for firm i. The evolution of k_{it+1} is computed using changes in net plant, property and equipment (ppent). Missing observations of net plant, property, and equipment are estimated, using linear interpolation of values right before and after the observation, only if there are not two or more consecutive missing observations.
9. *Investment Growth* is the quarterly difference in the log of capital expenditures (Δ ln(capxy)).
10. *Net Leverage* is the ratio of total debt (dlcq+dltttq) minus net current assets . (actq-lctq) to total assets (atq)
11. *Tobin's Q* is the ratio of market value of assets to book value of assets. First, I compute the market value of equity – the product of price close at quarter and common shares outstanding (prccq $\times$ cshoq). Then, I compute the market value of assets as the sum of the market value of equity, total assets (atq), and deferred taxes and investment tax credit (txditcq), minus the book value of common stock (ceqq). Lastly, I take the ratio of the market value of assets to the book value of assets (atq).

12. *Size* is log of total assets (log(atq)).

13. *Leverage* is the ratio of total debt (`dlcq+dltttq`) to total assets (`atq`).

14. *Tangibility* is the ratio of capital stock (k_{it}) to the cash-adjusted total assets (`atq-cheq`). The capital stock is defined as described in *Investment (Capital Stock Growth)*.

15. *Profitability* is the return on assets, defined as the ratio of net income (`niq`) to total assets (`atq`).

Appendix C Static Model without Uncertainty and Testable Predictions

As explained in Kundu (2020*a*,*b*), among the coverage constraints, CLO managers operate closest to their capital constraints. Among the capital constraints, the Interest Diversion covenant is the most stringent. As a CLO approaches the covenant triggers, it can improve its covenant performance by selling loans above the book values. Alternatively, a CLO can take advantage of the incongruity in accounting rules for different types of loans. This is the focus of this section.

In this section, I consider several scenarios of trading choices and their effects on a CLO's distance from the Interest Diversion threshold. These case studies are intended to show how covenant considerations can induce different trading patterns, providing a rationale behind the empirical observations and hypotheses guiding this work. I provide evidence of how *realizations* of constraint in a static setting can induce different trading behavior. A dynamic model based on *expectations* of constraint is forthcoming.

C.1 Case 1: Price γ

I compare how selling an equal value of non-distressed assets and distressed assets affects the Interest Diversion ratio.[50] Given the "cliff effect" that is described in Section 3, in which CCC/Caa1 loans in excess of a concentration limit are marked to market, I assume that both non-distressed and distressed assets trade at the same price, γ. This is a reasonable assumption; the fundamental value of a CCC loan in a CLO that holds very few CCC loans is not any different from the fundamental value of a CCC loan in a CLO that holds a large share of CCC loans, in excess of its stipulated limit. I relax this assumption and consider how the result changes in the subsequent case study.

First, if the manager sells the entire share of distressed assets which are mark-to-market, subject to cash-in-the-market pricing, and uses the proceeds towards paying down liabilities, then:

$$ID^{sell} = \frac{(1-x)A}{L - x\gamma A} \tag{C.1}$$

where γ is the fraction of par value at which the distressed assets are sold.

Alternatively, if the manager sells a fraction, β, of non-distressed assets, $(1-x)$, and uses

[50] Even selling an equal quantity, α, produces the same result. Selling α share of the portfolio that is distressed:

$$ID^{sell} = \frac{(1-x)A + x\gamma A - \alpha\gamma A}{L - \alpha\gamma A}$$

Selling α share of the portfolio that is not distressed:

$$ID^{par} = \frac{(1-x)A + x\gamma A - \alpha A}{L - \alpha\gamma A}$$

$ID^{par} < ID^{sell}$ because the denominators are equivalent while, $\alpha A > \alpha\gamma A$. Therefore, selling a portion of the distressed share x is preferable to selling a portion of the non-distressed share.

the proceeds towards reducing liabilities, the Interest Diversion ratio is the following:

$$ID^{par} = \frac{x\gamma A + (1-\beta)(1-x)A}{L-(1-x)\beta\gamma A} \tag{C.2}$$

β is determined as the fraction that leaves the manager indifferent between selling distressed and non-distressed assets – both raise the same revenue. That is, selling the entire distressed share generates revenue of $x\gamma A$, used to pay down liabilities. Selling β fraction of the non-distressed assets generates revenue of $(1-x)\beta\gamma A$. By equating the two values, the marginal β is:

$$\beta = \frac{x}{1-x}. \tag{C.3}$$

As the denominator is equivalent to the denominator of ID^{sell} by construction, I compare the numerators. The manager can improve the Interest Diversion ratio by selling an equal amount of assets that mark-to-market or distressed over mark-to-par or non-distressed assets, if the numerator of ID^{sell} is larger than ID^{par}.

By substituting for β, the numerator of ID^{par}, $Assets(ID^{par})$ is found to be less than the numerator of ID^{mark}, $Assets(ID^{mark})$.

$$Assets(ID^{par}) = x\gamma A + (1-\frac{x}{1-x})(1-x)A \tag{C.4}$$

$$= x\gamma A + A - 2xA \leq A - xA \equiv Assets(ID^{mark}). \tag{C.5}$$

This relation is strict if $\gamma < 1$ – all assets trade at some discount.

Furthermore, for $ID^{sell} > ID^{post}$, i.e., selling the distressed share is preferable to holding the share through default, the following condition must be true:

$$L\theta < \gamma A(x\theta - x + 1). \tag{C.6}$$

This is highly plausible, given the empirical estimates of the parameters.

C.2 Case 2: Prices γ_n and γ_d

It may not be plausible that all loans – distressed and non-distressed – sell at the same market price. Next, I consider how the results change under a weaker assumption. I assume that non-distressed assets sell at γ_n and distressed assets sell at γ_d, hereafter.

First, if the manager sells the entire share of distressed assets which are mark-to-market, subject to cash-in-the-market pricing, and uses the proceeds towards paying down liabilities, then:

$$ID^{sell} = \frac{(1-x)A}{L-x\gamma_d A} \tag{C.7}$$

where γ_d is the fraction of par value at which the distressed assets are sold.

Alternatively, if the manager sells a fraction, β, of non-distressed assets, $(1-x)$, and uses the proceeds towards reducing liabilities, the Interest Diversion ratio is the following:

$$ID^{par} = \frac{x\gamma_2 A + (1-\beta)(1-x)A}{L-(1-x)\beta\gamma_n A} \tag{C.8}$$

β is determined as the fraction that leaves the manager indifferent between selling distressed and non-distressed assets – both raise the same revenue. That is, selling the entire distressed share generates revenue of $x\gamma_2 A$, used to pay down liabilities. Selling β fraction of the non-distressed assets generates revenue of $(1-x)\beta\gamma_n A$. By equating the two values, the marginal β is:

$$\beta = \frac{x\gamma_2}{(1-x)\gamma_n}. \tag{C.9}$$

As the denominator is equivalent to the denominator of ID^{sell} by construction, I compare the numerators. The manager can improve the Interest Diversion ratio by selling an equal amount of assets that mark-to-market or distressed over mark-to-par or non-distressed assets, if the numerator of ID^{sell} is larger than ID^{par}.

By substituting for β, the numerator of ID^{par}, $Assets(ID^{par})$ is found to be less than the numerator of ID^{mark}, $Assets(ID^{mark})$.

$$Assets(ID^{par}) = x\gamma_2 A + (1 - \frac{x\gamma_2}{(1-x)\gamma_n})(1-x)A \tag{C.10}$$

$$= x\gamma_2 A + (1-x)A - \frac{x\gamma_2}{\gamma_n}A \leq (1-x)A \equiv Assets(ID^{mark}) \tag{C.11}$$

$$\Rightarrow \gamma_n \leq 1 \tag{C.12}$$

In addition, there is a pecking order to CLO distressed sales. CLOs will sell loans in order of descending market value to maximize improvements to the Interest Diversion constraint. That is, if $\gamma_1 > \gamma_1^{'}$:

$$\frac{(1-x)A}{L-x\gamma_1 A} > \frac{(1-x)A}{L-x\gamma_1^{'} A}. \tag{C.13}$$

Hence, selling a given amount of loans that are marked to a higher price can increase a CLO's distance from its Interest Diversion constraint by a larger margin than selling the same amount of loans at a lower price.

To summarize, the presence of covenants are intended to curtail risk-shifting tendencies and ensure that there is a specific level of coverage and subordination for each tranche, with punitive consequences for the manager in event of a breach. In some states of the world, if a CLO's distressed holdings cause a manager to operate closer to her constraints, the manager will consider the following:

Predictions:

1. A manager will prefer selling assets at a premium over selling assets at a discount.

2. A manager will prefer selling assets that are marked at market price over selling assets that are marked at par, even if the assets trade at different prices – as long as both trade at a discount.

3. Selling mark-to-market assets can improve the Interest Diversion constraint. The manager will sell higher value assets before selling lower value assets to maximize improvements to the Interest Diversion constraint.

In particular, I hypothesize that upon experiencing constraint, CLO managers will sell risky loans that are mark-to-market – unrelated to the original source of distress – to generate more slack in the constraint. Covenant considerations provide the original impetus for fire sales in the secondary loan market, increasing the effective cost of capital for affected firms, which are forced to make financial and real adjustments.

Online Appendix for:

"The Externalities of Fire Sales: Evidence from Collateralized Loan Obligations"

Appendix D Tables

Table D.1: Extensive Margin: Distressed Loans and Covenant Results (Table 2 of Kundu (2020*b*))

	Risky Sale and Covenant Result						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\mathbb{1}_{\text{Risky Sale, ct}}$	WAS	WA Life	Interest Div.	Junior IC	Junior OC	Senior IC	Senior OC
Covenant Result	0.0065	-0.0189***	-0.0300***	0.0328***	-0.0380***	-0.0122	-0.0318***
	(0.0097)	(0.0048)	(0.0095)	(0.0119)	(0.0053)	(0.0105)	(0.0057)
Manager-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Arranger FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Trustee FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	13,933	14,820	5,209	12,388	13,072	13,656	14,959
R^2	0.0957	0.0942	0.1393	0.1068	0.1069	0.1030	0.0990

Standard errors in parentheses, and double clustered at the Manager Month-Year Level

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the relation between a CLO's decision to sell risky assets and quality and coverage covenant results. The baseline regression specification follows a linear probability model: $\mathbb{1}_{risky,ct} = \alpha + \beta \times \Delta Result_{ct} + \gamma_{my} + \delta_a + \delta_w + \epsilon_{ct}$. $\mathbb{1}_{risky,ct}$ takes on the value 1 if there is a decline in the share of risky assets (sum of defaulted and CCC-rated loans) between consecutive months, ϵ is the error, c denotes CLO, t denotes the month-year pair, m denotes CLO manager, y denotes the year, a denotes the arranger, and w denotes the trustee. The columns denote different covenant results (standardized); Weighted Average Spread covenant, Weighted Average Life covenant, Interest Diversion covenant, Junior IC covenant, Junior OC covenant, Senior IC covenant, and Senior OC covenant (Column 1-7, respectively).

Table D.2: Summary Statistics of Covenants (Table 3 of Kundu (2020*a*))

	N	Q1	Median	Q3	Mean	Std. Dev
Interest Diversion	7,482	1.0245	1.0320	1.0378	1.0320	0.0198
Junior IC	16,742	1.7011	2.0957	3.6171	2.7282	1.4409
Junior OC	16,701	1.0343	1.0429	1.0551	1.0525	0.0400
Senior IC	18,516	2.0941	2.8731	5.8178	4.0742	2.5709
Senior OC	20,905	1.0767	1.0881	1.1519	1.2052	0.3595
WA Life	18,997	0.7108	0.8880	1.0358	1.1961	1.6459
WARF	19,545	0.8780	0.9358	0.9872	0.9471	0.1203
WAS	18,358	1.0757	1.2067	1.4033	1.2723	0.2572

Notes: The table reports the summary statistics of the constraints – a distance to the constraints, measured as the ratio of covenant performance to covenant trigger. The covenants are listed in the first column. The second column indicates the number of observations. The third column indicates the value at the 25$^{\text{th}}$ percentile. The fourth column indicates denotes the median value. The fifth column indicates denotes the value at the 75$^{\text{th}}$ percentile. The sixth column denotes the mean. The seventh column indicates the standard deviation.

Appendix E Dynamic Model with Weaker Assumptions

In this version of the model of Section 4, I relax the assumption that the price of defaulted assets is 0 at $t = 2$. This necessitates optimizing over both x_n and x_d – both of which are choice variables – and introduces the price of defaulted assets in both the numerator and denominator of the constraint. While these changes reflect a key finding from Kundu (2020*b*) – the price of defaulted assets recovers post-bankruptcy – it complicates the solution, making interpretation difficult.

E.1 t = 0

At t = 0, the CLO manager starts with A_0 loans in her portfolio. All loans are non-distressed. Nothing happens in this period.

E.2 t = 1

At t = 1, x_1 fraction of loans in the CLO experience distress. $(1 - x_1)$ share of loans are non-distressed. Upon experiencing distress, e.g., downgrades, the CLO manager's Interest Diversion constraint does not bind.

That is, the constraint at the start of $t = 1$ satisfies the following condition.

$$\frac{x_1 A_0 \gamma_{dt} + (1 - x_1) A_0}{L} \geq \rho \tag{E.1}$$

where γ_{dt} is the price for all distressed loans, and ρ is the exogenous constraint.

Non-distressed loans pay out fixed return Y_n while distressed loans pay out a fixed return of Y_d that is greater than Y_n. These returns may be thought of as equity distributions to the CLO manager and are exogenous. In this period, the manager chooses new amounts z_d and z_n of the distressed and non-distressed loans, respectively.

$$\begin{aligned} max_{z_d, z_n} (1 - \pi)[z_d A_0 Y_d + z_n A_0 Y_n] + \pi V(x_2, A) - \beta_1((x_1 - z_d)A_0) \\ - \beta_1((1 - x_1 - z_n)A_0) - \beta_2((x_1 - z_d)A_0)^2 - \beta_2((1 - x_1 - z_n)A_0)^2 \end{aligned}$$

Dynamics of State Variables:

$$\boxed{A = z_d A_0 + z_n A_0} \tag{E.2}$$

$$\boxed{x_2 = \frac{z_d}{z_d + z_n}} \tag{E.3}$$

E.3 t = 2

The state variables are (x_2, A) as defined above. x_2 denotes the distressed share of the portfolio with total assets, A. At t = 2, the distressed loans default and yield 0 to the manager. When defaults are realized, the CLO manager's Interest Diversion constraint binds. Proceeds from sales of non-distressed and distressed loans are used towards paying down liabilities to satisfy the binding constraint. Therefore, the maximization is over two choice variables, x_n – the amount of new non-distressed loans, and x_d – the amount of new distress-ed loans, subject to the Interest Diversion constraint.

$$\begin{aligned} V(x_2, A) = &\max_{x_n, x_d} x_n A Y_n - \beta_1((1 - x_2 - x_n)A) - \beta_1((x_2 - x_d)A) \\ &- \beta_2((1 - x_2 - x_n)A)^2 - \beta_2((x_2 - x_d)A)^2 \end{aligned}$$

s.t.

$$\frac{x_n A + x_d \gamma_{dt} A}{L - (1 - x_2 - x_n)A\gamma_{nt} - (x_2 - x_d)A\gamma_{dt}} \geq \rho \tag{E.4}$$

E.4 Solution

For simplicity, I drop the time subscript associated with prices at time t.

E.4.1 Solution for t = 1:

$$\begin{aligned} \mathcal{L} &= (1 - \pi)[z_d A_0 Y_d + z_n A_0 Y_n] + \pi V(x_2, A) - \beta_1((x_1 - z_d)A_0)^2 \qquad \text{(E.5)} \\ &\quad - \beta_1((1 - x_1 - z_n)A_0) - \beta_2((x_1 - z_d)A_0)^2 - \beta_2((1 - x_1 - z_n)A_0)^2 \\ \frac{\partial \mathcal{L}}{\partial z_n} &= (1 - \pi)A_0 Y_n + \pi \frac{\partial V(x_2, A)}{\partial z_n} + \beta_1 A_0 + 2\beta_2(1 - x_1 - z_n)A_0^2 = 0 \qquad \text{(E.6)} \\ \frac{\partial \mathcal{L}}{\partial z_d} &= (1 - \pi)A_0 Y_d + \beta_1 A_0 + \pi \frac{\partial V(x_2, A)}{\partial z_d} + 2\beta_2(x_1 - z_d)A_0^2 = 0 \qquad \text{(E.7)} \end{aligned}$$

$$\begin{aligned} \frac{\partial V}{\partial z_n} &= \frac{\partial V}{\partial x_2}\frac{\partial x_2}{\partial z_n} + \frac{\partial V}{\partial A}\frac{\partial A}{\partial z_n} \\ &= (2\beta_2(1 - x_2 - x_n)A^2 - 2\beta_2(x_2 - x_d)A^2)\frac{-z_d}{(z_d + z_n)^2} \\ &\quad + (x_n Y_n - \beta_1(1 - x_2 - x_n) - \beta_1(x_2 - x_d) - 2\beta_2(1 - x_2 - x_n)A - 2\beta_2(x_2 - x_d))A_0 \\ &= (2\beta_2(1 - 2x_2 - x_n + x_d)A^2)\frac{-z_d}{(z_d + z_n)^2} \\ &\quad + (x_n Y_n - \beta_1(1 - x_n - x_d) - 2\beta_2(1 - x_n - x_d)A)A_0 \qquad \text{(E.8)} \\ \frac{\partial V}{\partial z_d} &= \frac{\partial V}{\partial x_2}\frac{\partial x_2}{\partial z_d} + \frac{\partial V}{\partial A}\frac{\partial A}{\partial z_d} \\ &= (2\beta_2(1 - 2x_2 - x_n + x_d)A^2)\frac{z_n}{(z_d + z_n)^2} \\ &\quad + (x_n Y_n - \beta_1(1 - x_n - x_d) - 2\beta_2(1 - x_n - x_d)A)A_0 \qquad \text{(E.9)} \end{aligned}$$

(3) - (4) gives us

$$(1-\pi)A_0(Y_n - Y_d) + \pi(\frac{\partial V}{\partial z_n} - \frac{\partial V}{\partial z_d}) + 2\beta_2(1-2x_1 - z_n + z_d)A_0^2 = 0 \tag{E.10}$$

(5) - (6)

$$-2\beta_2(1-2x_2-x_n+x_d)A^2\frac{z_n+z_d}{(z_d+z_n)^2} = -2\beta_2(1-2x_2-x_n+x_d)A_0A$$

substituting above into (7)

$$\boxed{(1-\pi)(Y_n-Y_d) - 2\pi\beta_2(1-2x_2-x_n+x_d)A + 2\beta_2(1-2x_1-z_n+z_d)A_0 = 0} \tag{E.11}$$

E.4.2 Solution for t = 2:

$$\begin{aligned}
\mathcal{L} &= x_nAY_n - \beta_1((1-x_2-x_n)A) - \beta_1((x_2-x_d)A) \\
&\quad - \beta_2((1-x_2-x_n)A)^2 - \beta_2((x_2-x_d)A)^2 \\
&\quad + \lambda(x_nA + x_d\gamma_dA - \rho(L - (1-x_2-x_n)A\gamma_n - (x_2-x_d)A\gamma_d))
\end{aligned}$$

$$\frac{\partial \mathcal{L}}{\partial x_n} = AY_n + \beta_1A + 2\beta_2(1-x_2-x_n)A^2 + \lambda(A - \rho A\gamma_n) = 0$$

$$\boxed{Y_n + \beta_1 + 2\beta_2(1-x_2-x_n)A + \lambda(1-\rho\gamma_n) = 0} \tag{E.12}$$

$$\frac{\partial \mathcal{L}}{\partial x_d} = \beta_1A + 2\beta_2(x_2-x_d)A^2 + \lambda(\gamma_dA - \rho A\gamma_d) = 0$$

$$\boxed{\beta_1 + 2\beta_2(x_2-x_d)A + \lambda(\gamma_d - \rho\gamma_d) = 0} \tag{E.13}$$

$$\boxed{x_nA + x_d\gamma_dA - \rho(L - (1-x_2-x_n)A\gamma_n - (x_2-x_d)A\gamma_d) = 0} \tag{E.14}$$

We have six unknowns $(x_n, x_d, z_n, z_d, \lambda, A)$ and six equations (2), (3), (11), (12), (13), (14).

Using Mathematica, solutions are:

$$x_n = \frac{P_n}{Q_n} \tag{E.15}$$
$$x_d = \frac{P_d}{Q_d} \tag{E.16}$$
$$z_n = \frac{L_n}{M_n} \tag{E.17}$$
$$z_d = \frac{L_d}{M_d} \tag{E.18}$$
$$\lambda = \frac{P_\lambda}{Q_\lambda} \tag{E.19}$$
$$A = \frac{P_A}{Q_A} \tag{E.20}$$

where P_n, Q_n, P_d, Q_d, L_n, M_n, L_d, M_d, P_λ, Q_λ, P_A, and Q_A are defined as follows.

$P_n = (-\beta_1\gamma_{dt} + \beta_1\gamma_{dt}^2 + 2A_0\beta_2\gamma_{dt}^2 - \beta_1\gamma_{dt}\pi + \beta_1\gamma_{dt}^2\pi + \beta_1\gamma_{dt}\rho - 2\beta_1\gamma_{dt}^2\rho - 4A_0\beta_2\gamma_{dt}^2\rho - 2A_0\beta_2\gamma_{nt}\rho + \beta_1\gamma_{dt}\gamma_{nt}\rho + 2\beta_2L\rho + \beta_1\gamma_{dt}\pi\rho - 2\beta_1\gamma_{dt}^2\pi\rho + \beta_1\gamma_{nt}\pi\rho + 2\beta_2L\pi\rho - 2\beta_2\gamma_{dt}L\pi\rho + \beta_1\gamma_{dt}^2\rho^2 + 2A_0\beta_2\gamma_{dt}^2\rho^2 - \beta_1\gamma_{dt}\gamma_{nt}\rho^2 + 2A_0\beta_2\gamma_{nt}^2\rho^2 - 2\beta_2\gamma_{nt}L\rho^2 + \beta_1\gamma_{dt}^2\pi\rho^2 - \beta_1\gamma_{nt}^2\pi\rho^2 + 2\beta_2\gamma_{dt}L\pi\rho^2 - 2\beta_2\gamma_{nt}L\pi\rho^2 - 4A_0\beta_2\gamma_{dt}^2x_1 + 8A_0\beta_2\gamma_{dt}^2\rho x_1 + 4A_0\beta_2\gamma_{nt}\rho x_1 - 4A_0\beta_2\gamma_{dt}^2\rho^2x_1 - 4A_0\beta_2\gamma_{nt}^2\rho^2x_1 + 2\beta_1\gamma_{dt}x_2 - 2A_0\beta_2\gamma_{dt}x_2 - 2\beta_1\gamma_{dt}^2x_2 - 2A_0\beta_2\gamma_{dt}^2x_2 + 2\beta_1\gamma_{dt}\pi x_2 - 2\beta_1\gamma_{dt}^2\pi x_2 - 2\beta_1\gamma_{dt}\rho x_2 + 4\beta_1\gamma_{dt}^2\rho x_2 + 4A_0\beta_2\gamma_{dt}^2\rho x_2 + 2A_0\beta_2\gamma_{nt}\rho x_2 - 2\beta_1\gamma_{dt}\gamma_{nt}\rho x_2 + 2A_0\beta_2\gamma_{dt}\gamma_{nt}\rho x_2 - 4\beta_2L\rho x_2 - \beta_1\gamma_{dt}\pi\rho x_2 + 3\beta_1\gamma_{dt}^2\pi\rho x_2 - \beta_1\gamma_{nt}\pi\rho x_2 - \beta_1\gamma_{dt}\gamma_{nt}\pi\rho x_2 - 2\beta_2L\pi\rho x_2 + 2\beta_2\gamma_{dt}L\pi\rho x_2 - 2\beta_1\gamma_{dt}^2\rho^2x_2 - 2A_0\beta_2\gamma_{dt}^2\rho^2x_2 + 2\beta_1\gamma_{dt}\gamma_{nt}\rho^2x_2 - 2A_0\beta_2\gamma_{nt}^2\rho^2x_2 + 4\beta_2\gamma_{nt}L\rho^2x_2 - \beta_1\gamma_{dt}^2\pi\rho^2x_2 + \beta_1\gamma_{nt}^2\pi\rho^2x_2 - 2\beta_2\gamma_{dt}L\pi\rho^2x_2 + 2\beta_2\gamma_{nt}L\pi\rho^2x_2 + 4A_0\beta_2\gamma_{dt}x_1x_2 + 4A_0\beta_2\gamma_{dt}^2x_1x_2 - 8A_0\beta_2\gamma_{dt}^2\rho x_1x_2 - 4A_0\beta_2\gamma_{nt}\rho x_1x_2 - 4A_0\beta_2\gamma_{dt}\gamma_{nt}\rho x_1x_2 + 4A_0\beta_2\gamma_{dt}^2\rho^2x_1x_2 + 4A_0\beta_2\gamma_{nt}^2\rho^2x_1x_2 - \gamma_{dt}^2Y_d + \gamma_{dt}^2\pi Y_d + 2\gamma_{dt}^2\rho Y_d + \gamma_{nt}\rho Y_d - 2\gamma_{dt}^2\pi\rho Y_d - \gamma_{nt}\pi\rho Y_d - \gamma_{dt}^2\rho^2Y_d - \gamma_{nt}^2\rho^2Y_d + \gamma_{dt}^2\pi\rho^2Y_d + \gamma_{nt}^2\pi\rho^2Y_d + \gamma_{dt}x_2Y_d + \gamma_{dt}^2x_2Y_d - \gamma_{dt}\pi x_2Y_d - \gamma_{dt}^2\pi x_2Y_d - 2\gamma_{dt}^2\rho x_2Y_d - \gamma_{nt}\rho x_2Y_d - \gamma_{dt}\gamma_{nt}\rho x_2Y_d + 2\gamma_{dt}^2\pi\rho x_2Y_d + \gamma_{nt}\pi\rho x_2Y_d + \gamma_{dt}\gamma_{nt}\pi\rho x_2Y_d + \gamma_{dt}^2\rho^2x_2Y_d + \gamma_{nt}^2\rho^2x_2Y_d - \gamma_{dt}^2\pi\rho^2x_2Y_d - \gamma_{nt}^2\pi\rho^2x_2Y_d + 2\gamma_{dt}^2Y_n - 4\gamma_{dt}^2\rho Y_n - \gamma_{nt}\rho Y_n + \gamma_{nt}\pi\rho Y_n - \gamma_{dt}\gamma_{nt}\pi\rho Y_n + 2\gamma_{dt}^2\rho^2Y_n + \gamma_{nt}^2\rho^2Y_n + \gamma_{dt}\gamma_{nt}\pi\rho^2Y_n - \gamma_{nt}^2\pi\rho^2Y_n - \gamma_{dt}x_2Y_n - 3\gamma_{dt}^2x_2Y_n + \gamma_{dt}\pi x_2Y_n - \gamma_{dt}^2\pi x_2Y_n + 6\gamma_{dt}^2\rho x_2Y_n + \gamma_{nt}\rho x_2Y_n + \gamma_{dt}\gamma_{nt}\rho x_2Y_n + \gamma_{dt}^2\pi\rho x_2Y_n - \gamma_{nt}\pi\rho x_2Y_n - 3\gamma_{dt}^2\rho^2x_2Y_n - \gamma_{nt}^2\rho^2x_2Y_n - \gamma_{dt}\gamma_{nt}\pi\rho^2x_2Y_n + \gamma_{nt}^2\pi\rho^2x_2Y_n)$

$Q_n = 2A_0\beta_2 + 2A_0\beta_2\gamma_{dt}^2 - \beta_1\pi + \beta_1\gamma_{dt}^2\pi - 4A_0\beta_2\gamma_{dt}^2\rho - 4A_0\beta_2\gamma_{nt}\rho - 2\beta_1\gamma_{dt}^2\pi\rho + 2\beta_1\gamma_{nt}\pi\rho + 2\beta_2L\pi\rho - 2\beta_2\gamma_{dt}L\pi\rho + 2A_0\beta_2\gamma_{dt}^2\rho^2 + 2A_0\beta_2\gamma_{nt}^2\rho^2 + \beta_1\gamma_{dt}^2\pi^2 - \beta_1\gamma_{nt}^2\pi\rho^2 + 2\beta_2\gamma_{dt}L\pi\rho^2 - 2\beta_2\gamma_{nt}L\pi\rho^2 - 4A_0\beta_2x_1 - 4A_0\beta_2\gamma_{dt}^2x_1 + 8A_0\beta_2\gamma_{dt}^2\rho x_1 + 8A_0\beta_2\gamma_{nt}\rho x_1 - 4A_0\beta_2\gamma_{dt}^2\rho^2x_1 - 4A_0\beta_2\gamma_{nt}^2\rho^2x_1 - Y_d - \gamma_{dt}^2Y_d + \pi Y_d + \gamma_{dt}^2\pi Y_d + 2\gamma_{dt}^2\rho Y_d + 2\gamma_{nt}\rho Y_d - 2\gamma_{dt}^2\pi\rho Y_d - 2\gamma_{nt}\pi\rho Y_d - \gamma_{dt}^2\rho^2Y_d - \gamma_{nt}^2\rho^2Y_d + \gamma_{dt}^2\pi\rho^2Y_d + \gamma_{nt}^2\pi\rho^2Y_d + Y_n + \gamma_{dt}^2Y_n - \pi Y_n + \gamma_{dt}\pi Y_n - 2\gamma_{dt}^2\rho Y_n - 2\gamma_{nt}\rho Y_n - \gamma_{dt}\pi\rho Y_n + 2\gamma_{nt}\pi\rho Y_n - \gamma_{dt}\gamma_{nt}\pi\rho Y_n + \gamma_{dt}^2\rho^2Y_n + \gamma_{nt}^2\rho^2Y_n + \gamma_{dt}\gamma_{nt}\pi\rho^2Y_n - \gamma_{nt}^2\pi\rho^2Y_n$

$P_d = -\beta_1 + \beta_1\gamma_{dt} + 2A_0\beta_2\gamma_{dt} - \beta_1\pi + \beta_1\gamma_{dt}\pi - \beta_1\gamma_{dt}\rho - 2A_0\beta_2\gamma_{dt}\rho + 2\beta_1\gamma_{nt}\rho - \beta_1\gamma_{dt}\gamma_{nt}\rho - 2\beta_2\gamma_{dt}L\rho - \beta_1\gamma_{dt}\pi\rho + \beta_1\gamma_{nt}\pi\rho + \beta_1\gamma_{dt}\gamma_{nt}\rho^2 - \beta_1\gamma_{nt}^2\rho^2 + 2\beta_2\gamma_{dt}L\rho^2 - 4A_0\beta_2\gamma_{dt}x_1 + 4A_0\beta_2\gamma_{dt}\rho x_1 + 2\beta_1x_2 - 2A_0\beta_2x_2 - 2\beta_1\gamma_{dt}x_2 - 2A_0\beta_2\gamma_{dt}x_2 + 2\beta_1\pi x_2 - 2\beta_1\gamma_{dt}\pi x_2 + 2\beta_1\gamma_{dt}\rho x_2 + 2A_0\beta_2\gamma_{dt}\rho x_2 + 2A_0\beta_2\gamma_{dt}^2\rho x_2 - 4\beta_1\gamma_{nt}\rho x_2 + 4A_0\beta_2\gamma_{nt}\rho x_2 + 2\beta_1\gamma_{dt}\gamma_{nt}\rho x_2 + 4\beta_2\gamma_{dt}L\rho x_2 + \beta_1\gamma_{dt}\pi\rho x_2 + \beta_1\gamma_{dt}^2\pi\rho x_2 -$

$3\beta_1\gamma_{nt}\pi\rho x_2 + \beta_1\gamma_{dt}\gamma_{nt}\pi\rho x_2 - 2\beta_2 L\pi\rho x_2 + 2\beta_2\gamma_{dt}L\pi\rho x_2 - 2A_0\beta_2\gamma_{dt}^2\rho^2 x_2 - 2\beta_1\gamma_{dt}\gamma_{nt}\rho^2 x_2 + 2\beta_1\gamma_{nt}^2\rho^2 x_2 - 2A_0\beta_2\gamma_{nt}^2\rho^2 x_2 - 4\beta_2\gamma_{dt}L\rho^2 x_2 - \beta_1\gamma_{dt}^2\pi\rho^2 x_2 + \beta_1\gamma_{nt}^2\pi\rho^2 x_2 - 2\beta_2\gamma_{dt}L\pi\rho^2 x_2 + 2\beta_2\gamma_{nt}L\pi\rho^2 x_2 + 4A_0\beta_2 x_1 x_2 + 4A_0\beta_2\gamma_{dt}x_1 x_2 - 4A_0\beta_2\gamma_{dt}\rho x_1 x_2 - 4A_0\beta_2\gamma_{dt}^2\rho x_1 x_2 - 8A_0\beta_2\gamma_{nt}\rho x_1 x_2 + 4A_0\beta_2\gamma_{dt}^2\rho^2 x_1 x_2 + 4A_0\beta_2\gamma_{nt}^2\rho^2 x_1 x_2 - \gamma_{dt}Y_d + \gamma_{dt}\pi Y_d + \gamma_{dt}\rho Y_d - \gamma_{dt}\pi\rho Y_d + x_2 Y_d + \gamma_{dt}x_2 Y_d - \pi x_2 Y_d - \gamma_{dt}\pi x_2 Y_d - \gamma_{dt}\rho x_2 Y_d - \gamma_{dt}^2\rho x_2 Y_d - 2\gamma_{nt}\rho x_2 Y_d + \gamma_{dt}\pi\rho x_2 Y_d + \gamma_{dt}^2\pi\rho x_2 Y_d + 2\gamma_{nt}\pi\rho x_2 Y_d + \gamma_{dt}^2\rho^2 x_2 Y_d + \gamma_{nt}^2\rho^2 x_2 Y_d - \gamma_{dt}^2\pi\rho^2 x_2 Y_d - \gamma_{nt}^2\pi\rho^2 x_2 Y_d + 2\gamma_{dt}Y_n - 2\gamma_{dt}\rho Y_n - \gamma_{dt}\gamma_{nt}\rho Y_n + \gamma_{dt}\gamma_{nt}\rho^2 Y_n - x_2 Y_n - 3\gamma_{dt}x_2 Y_n + \pi x_2 Y_n - \gamma_{dt}\pi x_2 Y_n + 3\gamma_{dt}\rho x_2 Y_n + \gamma_{dt}^2\rho x_2 Y_n + 2\gamma_{nt}\rho x_2 Y_n + 2\gamma_{dt}\gamma_{nt}\rho x_2 Y_n + \gamma_{dt}\pi\rho x_2 Y_n - 2\gamma_{nt}\pi\rho x_2 Y_n + \gamma_{dt}\gamma_{nt}\pi\rho x_2 Y_n - \gamma_{dt}^2\rho^2 x_2 Y_n - 2\gamma_{dt}\gamma_{nt}\rho^2 x_2 Y_n - \gamma_{nt}^2\rho^2 x_2 Y_n - \gamma_{dt}\gamma_{nt}\pi\rho^2 x_2 Y_n + \gamma_{nt}^2\pi\rho^2 x_2 Y_n$

$Q_d = (-2A_0\beta_2 - 2A_0\beta_2\gamma_{dt}^2 + \beta_1\pi - \beta_1\gamma_{dt}^2\pi + 4A_0\beta_2\gamma_{dt}^2\rho + 4A_0\beta_2\gamma_{nt}\rho + 2\beta_1\gamma_{dt}^2\pi\rho - 2\beta_1\gamma_{nt}\pi\rho - 2\beta_2 L\pi\rho + 2\beta_2\gamma_{dt}L\pi\rho - 2A_0\beta_2\gamma_{dt}^2\rho^2 - 2A_0\beta_2\gamma_{nt}^2\rho^2 - \beta_1\gamma_{dt}^2\pi\rho^2 + \beta_1\gamma_{nt}^2\pi\rho^2 - 2\beta_2\gamma_{dt}L\pi\rho^2 + 2\beta_2\gamma_{nt}L\pi\rho^2 + 4A_0\beta_2 x_1 + 4A_0\beta_2\gamma_{dt}^2 x_1 - 8A_0\beta_2\gamma_{dt}^2\rho x_1 - 8A_0\beta_2\gamma_{nt}\rho x_1 + 4A_0\beta_2\gamma_{dt}^2\rho^2 x_1 + 4A_0\beta_2\gamma_{nt}^2\rho^2 x_1 + Y_d + \gamma_{dt}^2 Y_d - \pi Y_d - \gamma_{dt}^2\pi Y_d - 2\gamma_{dt}^2\rho Y_d - 2\gamma_{nt}\rho Y_d + 2\gamma_{dt}^2\pi\rho Y_d + 2\gamma_{nt}\pi\rho Y_d + \gamma_{dt}^2\rho^2 Y_d + \gamma_{nt}^2\rho^2 Y_d - \gamma_{dt}^2\pi\rho^2 Y_d - \gamma_{nt}^2\pi\rho^2 Y_d - Y_n - \gamma_{dt}^2 Y_n + \pi Y_n - \gamma_{dt}\pi Y_n + 2\gamma_{dt}^2\rho Y_n + 2\gamma_{nt}\rho Y_n + \gamma_{dt}\pi\rho Y_n - 2\gamma_{nt}\pi\rho Y_n + \gamma_{dt}\gamma_{nt}\pi\rho Y_n - \gamma_{dt}^2\rho^2 Y_n - \gamma_{nt}^2\rho^2 Y_n - \gamma_{dt}\gamma_{nt}\pi\rho^2 Y_n + \gamma_{nt}^2\pi\rho^2 Y_n)$

$L_n = (-1 + x2)(-2A_0\beta_2 - 2A_0\beta_2\gamma_{dt}^2 + \beta_1\pi - \beta_1\gamma_{dt}^2\pi + 4A_0\beta_2\gamma_{dt}^2\rho + 4A_0\beta_2\gamma_{nt}\rho + 2\beta_1\gamma_{dt}^2\pi\rho - 2\beta_1\gamma_{nt}\pi\rho - 2\beta_2 L\pi\rho + 2\beta_2\gamma_{dt}L\pi\rho - 2A_0\beta_2\gamma_{dt}^2\rho^2 - 2A_0\beta_2\gamma_{nt}^2\rho^2 - \beta_1\gamma_{dt}^2\pi\rho^2 + \beta_1\gamma_{nt}^2\pi\rho^2 - 2\beta_2\gamma_{dt}L\pi\rho^2 + 2\beta_2\gamma_{nt}L\pi\rho^2 + 4A_0\beta_2 x1 + 4A_0\beta_2\gamma_{dt}^2 x1 - 8A_0\beta_2\gamma_{dt}^2\rho x1 - 8A_0\beta_2\gamma_{nt}\rho x1 + 4A_0\beta_2\gamma_{dt}^2\rho^2 x1 + 4A_0\beta_2\gamma_{nt}^2\rho^2 x1 + Y_d + \gamma_{dt}^2 Y_d - \pi Y_d - \gamma_{dt}^2\pi Y_d - 2\gamma_{dt}^2\rho Y_d - 2\gamma_{nt}\rho Y_d + 2\gamma_{dt}^2\pi\rho Y_d + 2\gamma_{nt}\pi\rho Y_d + \gamma_{dt}^2\rho^2 Y_d + \gamma_{nt}^2\rho^2 Y_d - \gamma_{dt}^2\pi\rho^2 Y_d - \gamma_{nt}^2\pi\rho^2 Y_d - Y_n - \gamma_{dt}^2 Y_n + \pi Y_n - \gamma_{dt}\pi Y_n + 2\gamma_{dt}^2\rho Y_n + 2\gamma_{nt}\rho Y_n + \gamma_{dt}\pi\rho Y_n - 2\gamma_{nt}\pi\rho Y_n + \gamma_{dt}\gamma_{nt}\pi\rho Y_n - \gamma_{dt}^2\rho^2 Y_n - \gamma_{nt}^2\rho^2 Y_n - \gamma_{dt}\gamma_{nt}\pi\rho^2 Y_n + \gamma_{nt}^2\pi\rho^2 Y_n)$

$M_n = 2A_0\beta_2(1 + \gamma_{dt}^2 + \pi - \gamma_{dt}\pi - 2\gamma_{dt}^2\rho - 2\gamma_{nt}\rho + \gamma_{dt}\pi\rho - \gamma_{nt}\pi\rho + \gamma_{dt}^2\rho^2 + \gamma_{nt}^2\rho^2 - 2x2 - 2\gamma_{dt}^2 x2 - \pi x2 + 2\gamma_{dt}\pi x2 - \gamma_{dt}^2\pi x2 + 4\gamma_{dt}^2\rho x2 + 4\gamma_{nt}\rho x2 - \gamma_{dt}\pi\rho x2 + \gamma_{dt}^2\pi\rho x2 + \gamma_{nt}\pi\rho x2 - \gamma_{dt}\gamma_{nt}\pi\rho x2 - 2\gamma_{dt}^2\rho^2 x2 - 2\gamma_{nt}^2\rho^2 x2)$

$L_d = -x2(-2A_0\beta_2 - 2A_0\beta_2\gamma_{dt}^2 + \beta_1\pi - \beta_1\gamma_{dt}^2\pi + 4A_0\beta_2\gamma_{dt}^2\rho + 4A_0\beta_2\gamma_{nt}\rho + 2\beta_1\gamma_{dt}^2\pi\rho - 2\beta_1\gamma_{nt}\pi\rho - 2\beta_2 L\pi\rho + 2\beta_2\gamma_{dt}L\pi\rho - 2A_0\beta_2\gamma_{dt}^2\rho^2 - 2A_0\beta_2\gamma_{nt}^2\rho^2 - \beta_1\gamma_{dt}^2\pi\rho^2 + \beta_1\gamma_{nt}^2\pi\rho^2 - 2\beta_2\gamma_{dt}L\pi\rho^2 + 2\beta_2\gamma_{nt}L\pi\rho^2 + 4A_0\beta_2 x1 + 4A_0\beta_2\gamma_{dt}^2 x1 - 8A_0\beta_2\gamma_{dt}^2\rho x1 - 8A_0\beta_2\gamma_{nt}\rho x1 + 4A_0\beta_2\gamma_{dt}^2\rho^2 x1 + 4A_0\beta_2\gamma_{nt}^2\rho^2 x1 + Y_d + \gamma_{dt}^2 Y_d - \pi Y_d - \gamma_{dt}^2\pi Y_d - 2\gamma_{dt}^2\rho Y_d - 2\gamma_{nt}\rho Y_d + 2\gamma_{dt}^2\pi\rho Y_d + 2\gamma_{nt}\pi\rho Y_d + \gamma_{dt}^2\rho^2 Y_d + \gamma_{nt}^2\rho^2 Y_d - \gamma_{dt}^2\pi\rho^2 Y_d - \gamma_{nt}^2\pi\rho^2 Y_d - Y_n - \gamma_{dt}^2 Y_n + \pi Y_n - \gamma_{dt}\pi Y_n + 2\gamma_{dt}^2\rho Y_n + 2\gamma_{nt}\rho Y_n + \gamma_{dt}\pi\rho Y_n - 2\gamma_{nt}\pi\rho Y_n + \gamma_{dt}\gamma_{nt}\pi\rho Y_n - \gamma_{dt}^2\rho^2 Y_n - \gamma_{nt}^2\rho^2 Y_n - \gamma_{dt}\gamma_{nt}\pi\rho^2 Y_n + \gamma_{nt}^2\pi\rho^2 Y_n)$

$M_d = 2A_0\beta_2(1 + \gamma_{dt}^2 + \pi - \gamma_{dt}\pi - 2\gamma_{dt}^2\rho - 2\gamma_{nt}\rho + \gamma_{dt}\pi\rho - \gamma_{nt}\pi\rho + \gamma_{dt}^2\rho^2 + \gamma_{nt}^2\rho^2 - 2x2 - 2\gamma_{dt}^2 x2 - \pi x2 + 2\gamma_{dt}\pi x2 - \gamma_{dt}^2\pi x2 + 4\gamma_{dt}^2\rho x2 + 4\gamma_{nt}\rho x2 - \gamma_{dt}\pi\rho x2 + \gamma_{dt}^2\pi\rho x2 + \gamma_{nt}\pi\rho x2 - \gamma_{dt}\gamma_{nt}\pi\rho x2 - 2\gamma_{dt}^2\rho^2 x2 - 2\gamma_{nt}^2\rho^2 x2)$

$P_\lambda = -\beta_1 - 2A_0\beta_2 - \beta_1\gamma_{dt} + \beta_1\gamma_{dt}\rho + \beta_1\gamma_{nt}\rho + 2\beta_2 L\rho + 4A_0\beta_2 x1 + 2\beta_1 x2 + 2A_0\beta_2 x2 + 2\beta_1\gamma_{dt}x2 - 2A_0\beta_2\gamma_{dt}x2 - 2\beta_1\gamma_{dt}\rho x2 - 2\beta_1\gamma_{nt}\rho x2 - 4\beta_2 L\rho x2 - 4A_0\beta_2 x1 x2 + 4A_0\beta_2\gamma_{dt}x1 x2 + Y_d - \pi Y_d - x2 Y_d + \gamma_{dt}x2 Y_d + \pi x2 Y_d - \gamma_{dt}\pi x2 Y_d - 2Y_n + \gamma_{nt}\rho Y_n + 3x2 Y_n - \gamma_{dt}x2 Y_n - 2\gamma_{nt}\rho x2 Y_n$

$Q_\lambda = 1 + \gamma_{dt}^2 + \pi - \gamma_{dt}\pi - 2\gamma_{dt}^2\rho - 2\gamma_{nt}\rho + \gamma_{dt}\pi\rho - \gamma_{nt}\pi\rho + \gamma_{dt}^2\rho^2 + \gamma_{nt}^2\rho^2 - 2x2 - 2\gamma_{dt}^2 x2 - \pi x2 + 2\gamma_{dt}\pi x2 - \gamma_{dt}^2\pi x2 + 4\gamma_{dt}^2\rho x2 + 4\gamma_{nt}\rho x2 - \gamma_{dt}\pi\rho x2 + \gamma_{dt}^2\pi\rho x2 + \gamma_{nt}\pi\rho x2 - \gamma_{dt}\gamma_{nt}\pi\rho x2 - 2\gamma_{dt}^2\rho^2 x2 - 2\gamma_{nt}^2\rho^2 x2$

$P_A = 2A_0\beta_2 + 2A_0\beta_2\gamma_{dt}^2 - \beta_1\pi + \beta_1\gamma_{dt}^2\pi - 4A_0\beta_2\gamma_{dt}^2\rho - 4A_0\beta_2\gamma_{nt}\rho - 2\beta_1\gamma_{dt}^2\pi\rho + 2\beta_1\gamma_{nt}\pi\rho + 2\beta_2 L\pi\rho - 2\beta_2\gamma_{dt}L\pi\rho + 2A_0\beta_2\gamma_{dt}^2\rho^2 + 2A_0\beta_2\gamma_{nt}^2\rho^2 + \beta_1\gamma_{dt}^2\pi\rho^2 - \beta_1\gamma_{nt}^2\pi\rho^2 + 2\beta_2\gamma_{dt}L\pi\rho^2 - 2\beta_2\gamma_{nt}L\pi\rho^2 - 4A_0\beta_2 x1 - 4A_0\beta_2\gamma_{dt}^2 x1 + 8A_0\beta_2\gamma_{dt}^2\rho x1 + 8A_0\beta_2\gamma_{nt}\rho x1 - 4A_0\beta_2\gamma_{dt}^2\rho^2 x1 - 4A_0\beta_2\gamma_{nt}^2\rho^2 x1 - Y_d - \gamma_{dt}^2 Y_d + \pi Y_d + \gamma_{dt}^2\pi Y_d + 2\gamma_{dt}^2\rho Y_d + 2\gamma_{nt}\rho Y_d - 2\gamma_{dt}^2\pi\rho Y_d - 2\gamma_{nt}\pi\rho Y_d - \gamma_{dt}^2\rho^2 Y_d - \gamma_{nt}^2\rho^2 Y_d + \gamma_{dt}^2\pi\rho^2 Y_d + \gamma_{nt}^2\pi\rho^2 Y_d + Y_n + \gamma_{dt}^2 Y_n - \pi Y_n + \gamma_{dt}\pi Y_n - 2\gamma_{dt}^2\rho Y_n - 2\gamma_{nt}\rho Y_n - \gamma_{dt}\pi\rho Y_n + 2\gamma_{nt}\pi\rho Y_n - \gamma_{dt}\gamma_{nt}\pi\rho Y_n + \gamma_{dt}^2\rho^2 Y_n + \gamma_{nt}^2\rho^2 Y_n + \gamma_{dt}\gamma_{nt}\pi\rho^2 Y_n - \gamma_{nt}^2\pi\rho^2 Y_n$

$Q_A = 2\beta_2(1 + \gamma_{dt}^2 + \pi - \gamma_{dt}\pi - 2\gamma_{dt}^2\rho - 2\gamma_{nt}\rho + \gamma_{dt}\pi\rho - \gamma_{nt}\pi\rho + \gamma_{dt}^2\rho^2 + \gamma_{nt}^2\rho^2 - 2x2 - 2\gamma_{dt}^2 x2 - \pi x2 + 2\gamma_{dt}\pi x2 - \gamma_{dt}^2\pi x2 + 4\gamma_{dt}^2\rho x2 + 4\gamma_{nt}\rho x2 - \gamma_{dt}\pi\rho x2 + \gamma_{dt}^2\pi\rho x2 + \gamma_{nt}\pi\rho x2 - \gamma_{dt}\gamma_{nt}\pi\rho x2 - 2\gamma_{dt}^2\rho^2 x2 - 2\gamma_{nt}^2\rho^2 x2$