A NEW THEORY OF CREDIT LINES (WITH EVIDENCE)*

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VERY PRELIMINARY

Abstract

We develop a model that suggests a heretofore unexplored role of credit lines: To mitigate debt dilution. The results give a new perspective on the literature on leverage ratchet effects, suggesting they can be curbed by (latent) credit lines, and on latent contracts, suggesting collusive outcomes are unlikely to arise in dynamic environments. The model explains numerous facts, including why credit lines are pervasive but rarely drawn down and why they are bundled with loans, especially for riskier borrowers. We find that the risk of credit line revocation increases borrower leverage and riskiness, suggesting that limited *bank* commitment can contribute to corporate distress. We find empirical support for this prediction.

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1 Introduction

Credit lines make up the bulk of committed bank credit. Most syndicated loans are bundled with a credit line. But only a small amount of such committed credit is actually utilized, even in times of crisis.[1] Why are credit lines so ubiquitous if so rarely utilized?

We develop a model that suggests that credit lines play a heretofore overlooked role, even if they are never drawn down: They can mitigate debt dilution. We show that, in some circumstances, credit lines in loan bundles serve as a commitment device: New lenders do not offer new debt if they anticipate a credit line being drawn down, diluting the value of their debt; as a result, old debt is not diluted by new debt in the first place.

The background environment in our model resembles those in the literature on leverage dynamics (notably, Admati et al. (2017) and DeMarzo and He (2021)). In it, a borrower B issues debt dynamically to lenders. Issuing debt yields gains from trade due to differences in the borrower's and lenders' valuation of the debt from, e.g., differences in preferences/beliefs or tax benefits of debt. But, against these benefits, increasing the quantity Q of debt issued has two costs, (i) a direct cost $c(Q)$, capturing costs to B, including not only coupon payments but also, e.g., costs arising from debt-induced agency costs, and (ii) an indirect cost, capturing a decrease in lenders' value, due to, e.g., increased default probabilities or anything else leading the supply curve to be downward sloping. The key friction is that

[1] On credit lines making up the bulk of bank credit and on utilization rates, see Berg, Saunders, and Steffen (2020), Greenwald, Krainer, and Paul (2021), Chodorow-Reich et al. (2021), and Sufi (2009); on bundling, see Figure 1 below as well as indirect evidence in Berg, Saunders, and Steffen (2020), Berger, Zhang, and Zhao (2020), and Berlin, Nini, and Yu (2020). In crises, drawdowns are concentrated in large firms that do not use bank term loans for balance sheet borrowing; see Berg, Saunders, and Steffen (2020), Chodorow-Reich et al. (2021), Greenwald, Krainer, and Paul (2021) and Ivashina and Scharfstein (2010).

borrowing is non-exclusive: After borrowing from one lender at date t, B can borrow from another at date $t + \mathrm{d}t$—there is only a period $\mathrm{d}t$ of exclusivity—and issuing new debt has an externality on old debt. Our innovation relative to the dynamic corporate finance literature is to allow not only for loan contracts, but also for credit lines, interpreted as options to borrow a quantity $\tilde{q}$ at a rate $1/\tilde{p}$.[2]

We begin with two benchmarks. In the first, we switch off non-exclusivity, assuming B can commit to issue debt to only one lender. In this case, B issues debt once and never again. A monopolist in the debt market, B understands that issuing more debt will depress its price, and restricts his issuance to keep the price above the marginal cost. The outcome is as in the static trade-off theory (Kraus and Litzenberger (1973)), in which B achieves his target leverage and keeps it there forever. The optimum, from B's point of view, is attained and there is no role for credit lines.

In the second benchmark, we switch off credit lines. This benchmark resembles the dynamic corporate finance models on debt dilution. In this case, once B has debt in place to one lender, he is tempted to take on new debt from another, passing the costs of new issuance on to the debt in place.[3] Thus the more debt B has, the more he wants, and the more his debt goes up. That is Admati et al.'s (2017) leverage ratchet effect.[4] So, in this case, B cannot commit to keep quantity low and cannot fetch the monopoly price. If the time $\mathrm{d}t$ between dates decreases, so B

[2]Although we focus on the corporate finance application, the set-up can also apply more generally. As is well known by now, B can be the monopolistic seller of any durable good (debt here) and the lenders its buyers (Coase (1972)). In that context, credit lines correspond to put options: the option to sell a quantity $\tilde{q}$ at price $\tilde{p}$.

[3]Formally, this result relies on the assumption that c is weakly concave. That captures that issuing another dollar of debt matters less if B already has a lot of debt outstanding, as is typical in the literature.

[4]Earlier papers on how non-exclusivity can induce excessive leverage include, e.g., Bizer and DeMarzo (1992) and Petersen and Rajan (1995).

can commit to one lender for only a shorter period, non-exclusivity becomes more severe, leading B to issue more debt. In anticipation of issuance going up, the price lenders are willing to pay drops—they require a higher rate as compensation for, e.g., the increased default risk of a more levered borrower. In the limit as $\mathrm{d}t \to 0$, the price approaches the marginal cost—all benefits of monopoly are eaten up by non-exclusivity, a result that echoes DeMarzo and He (2021) and Coase (1972).[5]

We move on to study the baseline model, with non-exclusivity across periods and loan-credit line bundles at date 0. We first analyze how credit lines in place at date $t > 0$ change the outcome. Then, solving backward, we solve for optimal bundling at date 0.

Our first main result is that a credit line in place —the option to increase (the face value of) outstanding debt by a quantity $\tilde{q}$ at rate $1/\tilde{p}$— can in fact prevent B from taking on new debt, due to what we call a "ratchet anti-ratchet effect." To see the idea, first observe that, in a reprise of the ratchet effect, higher leverage makes taking more debt (namely drawing the credit line) more attractive. At a certain point, lenders know that if they lend an additional amount q, B will immediately draw on the credit line so his debt outstanding will shoot up to $Q_0 + q + \tilde{q}$. For $\tilde{q}$ large, that dilutes their debt so much that they are no longer willing to lend in the first place (at least not at a price B is willing to accept). The ratchet effect is self-deterring: The anticipation of ratcheting up debt in the future (by a discrete amount) prevents it from ratcheting up today.

Our second main result endogenizes the loan-credit line bundle that B takes at date 0. We find that, when lenders can offer bundles, of which B can take up only one at date 0, the only outcome that survives is the exclusive outcome, in which B

[5]See also papers formalizing and extending the so-called Coase Conjecture, such as Bulow (1982), Gul et al. (1986), and Stokey (1981).

captures the monopoly rent: B borrows from one lender at date 0 and never borrows from anyone else. The reason is that lenders, competing at date 0, offer the loan that is most attractive to B—the monopoly outcome—bundled with a commitment device—the credit line—that allows B to commit to that outcome.

The credit line in the bundle is never drawn, and hence resembles the latent contracts in, e.g., Parlour and Rajan (2001) and Attar et al. (2019a, 2019b). Unlike in that literature, which emphasizes how non-competitive outcomes can arise, we show that the exclusive/monopoly outcome is effectively restored if lenders compete in bundles. The reason is that the bundles include a device that allows B to commit not to borrow from anyone else later on, so just an instant $\mathrm{d}t$ of exclusivity is enough to implement exclusivity forever.

For our third main result, we relax the assumption that lenders have full commitment, assuming instead that their credit lines could be revoked with some probability $1-\alpha$, as is common empirically (Chodorow-Reich and Falato (2022)). We show that if α is high, so credit lines are unlikely to be revoked, the full commitment outcome is still attained—credit lines need not be enforced perfectly to implement the desired outcome perfectly. But if α is lower, the full commitment outcome cannot be attained. The reason is that (latent) credit lines deter lenders only to the extent that drawing on them increases the supply of debt/depresses its price. That does not happen if the line is revoked. But they are not useless. We show that the chance that they are not revoked always allows B to commit to limit his debt so the price is above marginal cost, by a margin increasing in α.

We test this prediction using syndicated loan data from DealScan. In light of the findings in Chodorow-Reich and Falato (2022), we use negative shocks to lender health as a proxy for increased revocation risk. We find support for our theory:

When a borrower's credit lines become more likely to be revoked, it is more likely to borrow. That goes in the opposite direction from results in the literature that do not focus on credit line lenders, which we also replicate: When a borrower's lenders—not just its credit line lenders—are more likely to suffer a liquidity shock, it is less likely to borrow (Chodorow-Reich (2014) and Darmouni (2020)). Together, these findings suggests our finding is specific to credit lines and, we think, make our overall findings hard to explain with other theories.

We make several contributions to the literature. Relative to papers on dilution/the leverage ratchet effect, we show that with credit lines, the ratchet effect can be turned on its head, effectively used against itself (off equilibrium) to prevent excessive borrowing (on equilibrium). I.e. we show that credit lines serve as a commitment device, restoring the exclusive-monopoly outcome. Relative to papers on non-exclusive competition/latent contracts, we show that an arbitrarily small amount of exclusivity (i.e. for only a time increment $\mathrm{d}t$) effectively restores competition among creditors. Relative to papers on credit lines (e.g., papers in which credit lines serve as liquidity insurance, such as Holmström and Tirole (1998)), we suggest a new role of credit lines that is unstudied but consistent with a number of facts. Relative to papers on restoring the static monopoly outcome in the problem of selling a durable good over time (Coase (1972)), we show that put options—i.e. options to sell the good, be it debt or something else—can serve as a commitment device not to sell in the future.

2 Model

There is a borrower B and a continuum of lenders. Everyone is infinitely lived, discounts the future at rate ρ, and is deep pocketed.

B's flow payoff is as follows:

$$v_t \mathrm{d}t = y\mathrm{d}t + p_t q_t \mathrm{d}t - c(Q_t)\mathrm{d}t, \tag{1}$$

where y is the cash flow over $[t, t+\mathrm{d}t)$, Q_t is the stock of outstanding debt, q_t is the new debt issued over $[t, t+\mathrm{d}t)$, p_t is the unit price of debt issued over $[t, t+\mathrm{d}t)$, and c is the cost of outstanding debt. We suppose that $c(0) = 0$, $c' > 0$, and $c'' \leq 0$ and $c' \geq \bar{c}'$ for a strictly positive constant $\bar{c}'$. The cost c captures not only the expected coupon payments that must be made given an outstanding stock of debt, but also any debt-induced agency costs.

B's lifetime utility from date t onward is

$$V_t = \int_0^\infty e^{-\rho s}\, v_{t+s}\, \mathrm{d}s.^6 \tag{3}$$

Lenders' flow payoff from holding a unit of debt given stock Q_t is $\gamma(Q_t)\mathrm{d}t$, interpreted as the expected coupon payment. We suppose that $\gamma' < 0$ and $\gamma(\infty) = 0$. The first assumption captures dilution: The more debt outstanding, the lower is the expected coupon payment. This amounts to a downward-sloping demand curve, which holds true in all the ratchet-effect-type models. The second assumption is that the expected coupon goes to zero as the stock of debt becomes large.[7]

[6]By the way, if $v_\tau \equiv y$—i.e. there is no issuance—then

$$V_t = y\left(\frac{1}{\rho} + \mathrm{d}t\right) \overset{\mathrm{d}t \to 0}{\to} \frac{y}{\rho}. \tag{3}$$

[7]There is a discussion about an analogous assumption in the literature on durable goods monopolists, referred to as the "gap" and "non-gap" cases (see, e.g., McAfee and Wiseman (2008)).

The value of the lenders' stream of coupons on a unit of debt is

$$\Gamma(Q_t) = \int_0^\infty e^{-\rho s}\gamma(Q_{t+s})\mathrm{d}s. \tag{4}$$

Assumption 1. *We suppose that*

1. *Gains from trade:* $\gamma(0) > c'(0)$*,*
2. *First order approach:* $\gamma(Q)Q - c(Q)$ *is concave.*

The first assumption ensures that there are gains from trade between B and the lenders; the second allows us to use the first-order approach.

Contracts. At date 0, lenders post bundles of loans and contracts. At date $t > 0$, lenders post loans. At each date, B takes a bundle/loan from one lender or no contract.

Solution concept. The solution concept is Markov perfect equilibrium with state variable equal to B's balance sheet, i.e. his debt and credit lines: At each date, the lenders and B act—lenders post contracts and B chooses one and, if he has a credit line in place, chooses whether to draw it (in full)[8] or not—to maximize their future lifetime payoffs given their beliefs, such that their beliefs are consistent, and B's balance sheet is a sufficient statistic for the history with respect to the actions.

For a given credit line in place, whether it is drawn or not is a binary variable. That allows us to simplify notation, by dropping the explicit dependence on the credit line; we denote the value function without the credit line in place (i.e. after it has been drawn) by V and with it (i.e. before it has been drawn in place by $\tilde{V}$ (suppressing the explicit dependence of $\tilde{V}$ on the terms of the credit line in place $(\tilde{p}, \mathrm{d}\tilde{Q})$).

[8]It turns out that partial draw downs are not optimal in equilibrium anyway, a fact that follows shortly from the convexity of the value function.

3 Benchmarks and Preliminaries

We start with two benchmarks without credit lines, but only loan contracts. The first is the exclusive allocation in which B can commit not to borrow from multiple lenders, as in the classical trade-off theory/static monopolist's problem. The second is the non-exclusive allocation in which B cannot commit, as in the leverage ratchet effect/dynamic monopolist's problem.

3.1 Benchmark: Full Commitment

We first consider the problem in which B can commit to an issuance policy, in particular can commit not to issue debt to other creditors, so non-exclusivity/debt dilution is not a concern.

At date 0, B chooses a policy (Q_t for each t) all future issuance (in a competitive market at each date):

$$\text{maximize} \int_0^\infty e^{-\rho t}(y + p_t \mathrm{d}Q_t - c(Q_t))\mathrm{d}t \tag{5}$$

$$\text{s.t.} \qquad p_t \leq \int_0^\infty e^{-\rho s}\gamma(Q_{t+s})\mathrm{d}s \tag{6}$$

over the policy Q.

To see the solution, suppose that B issued debt at only one date, date τ, and never again. In that case, integrands above are constants, and the problem reduces to marginal revenue equals marginal cost:

$$\big(p_\tau Q_\tau\big)' = \frac{c'(Q_\tau)}{\rho}. \tag{7}$$

This problem is the same for any date τ, so it is optimal to issue once and then keep debt constant, as formalized next:

Proposition 1 (Exclusive benchmark). *With commitment/exclusive competition, B issues debt only at t_0 with quantity Q^e at price p^e where Q^e solves*

$$\gamma(Q^e) = c'(Q^e) - \gamma'(Q^e)Q^e. \tag{8}$$

and

$$p^e = \frac{\gamma(Q^e)}{\rho}. \tag{9}$$

Proof. Here we apply a guess-and-verify approach: We assume that it is optimal to set $\mathrm{d}Q_t = 0$ for all $t > 0$, solve for the optimal Q_0, and then show the B cannot benefit by issuing again.[9]

Step 1: Optimal issuance at date 0. The optimal date-0 issuance as if B never issues debt again, $Q_0 = \mathrm{d}Q_0$, solves

$$p_0 + \frac{\mathrm{d}p_0}{\mathrm{d}Q_0}Q_0 - \int_0^\infty e^{-\rho t}c'(Q_0)\mathrm{d}t = 0. \tag{10}$$

Using lenders' participation constraint and computing the integrals (which is easy for $Q_t \equiv Q_0$), we can rearrange to find an expression for the optimal Q_0:

$$p_0 = \frac{\gamma(Q_0)}{\rho} = \frac{c'(Q_0) - \gamma'(Q_0)Q_0}{\rho}. \tag{11}$$

Step 2: No issuance at date $\tau > 0$. Now we verify that the marginal benefit from

[9]That shows that it is a local optimum. We have verified that is also global by contradiction, supposing that $\mathrm{d}Q_\tau > 0$ for some $\tau > 0$ at the optimum and then showing that B must be able to benefit by either accelerating or postponing it—moving $\mathrm{d}Q_\tau$ to $\tau - \mathrm{d}t$ or to $\tau + \mathrm{d}t$—contradicting optimality.

having $\mathrm{d}Q_\tau \neq 0$ for some $\tau > 0$ is zero. To do so, we differentiate the objective

$$p_0 Q_0 + \int_0^\tau e^{-\rho t}(y - c(Q_0))\mathrm{d}t + p_\tau \mathrm{d}Q_\tau + \int_\tau^\infty e^{-\rho t}(y - c(Q_\tau))\mathrm{d}t = \tag{12}$$

$$= p_0 \mathrm{d}Q_0 + \frac{(y - c(Q_0))}{\rho}(1 - e^{-\rho\tau}) + e^{-\rho\tau} p_\tau \mathrm{d}Q_\tau + e^{-\rho\tau}\frac{(y - c(Q_\tau))}{\rho} \tag{13}$$

where $Q_\tau = Q_0 + \mathrm{d}Q_\tau$. The FOC is

$$\frac{\mathrm{d}p_0}{\mathrm{d}Q_\tau} Q_0 + e^{-\rho\tau} p_\tau + e^{-\rho\tau}\frac{\mathrm{d}p_\tau}{\mathrm{d}Q_\tau}\mathrm{d}Q_\tau - \frac{e^{-\rho\tau}}{\rho} c'(Q_0 + \mathrm{d}Q_\tau) = 0. \tag{14}$$

Now observe that $\mathrm{d}p_0/\mathrm{d}Q_\tau = \mathrm{d}p_\tau/\mathrm{d}Q_\tau$, because

$$p_0 = \int_0^\tau e^{-\rho t}\gamma(Q_0)\mathrm{d}t + \int_\tau^\infty e^{-\rho t}\gamma(Q_\tau)\mathrm{d}t = \int_0^\tau e^{-\rho t}\gamma(Q_0)\mathrm{d}t + e^{-\rho\tau} p_\tau \tag{15}$$

So, substituting from above and cancelling the $e^{-\rho\tau}$, the FOC reads

$$\frac{\mathrm{d}p_\tau}{\mathrm{d}Q_\tau}\mathrm{d}Q_0 + p_\tau + \frac{\mathrm{d}p_\tau}{\mathrm{d}Q_\tau}\mathrm{d}Q_\tau - c'(Q_0 + \mathrm{d}Q_\tau) = 0. \tag{16}$$

Using $Q_\tau = Q_0 + \mathrm{d}Q_\tau$, we have

$$p_\tau + \frac{\mathrm{d}p_\tau}{\mathrm{d}Q_\tau} = \big(p_\tau Q_\tau\big)' = \frac{c'(Q_0 + \mathrm{d}Q_\tau)}{\rho}. \tag{17}$$

I.e. the equation for the static optimum (11). $\square$

Here the borrower acts as a monopolist, setting marginal revenue equal to (the PV of) marginal cost. Substituting the price p from the lenders' break-even condition, we have:

$$p^e = \frac{c'(Q^e)}{\rho} - \frac{\gamma'(Q^e)Q^e}{\rho}. \tag{18}$$

Since $\gamma' < 0$, it follows that the price is above the marginal cost. The term $\gamma'(Q^e)Q^e$ reflects that B takes into account that issuing a unit more debt depresses the price—hence the $\gamma'(Q^e)$—for all debt—is multiplied by Q^e.

3.2 Benchmark: No Commitment/Non-Exclusivity

We now consider the case in which B can issue debt continuously but cannot commit to his future issuance, a setting that resembles DeMarzo and He (2021). As B lacks commitment, allocations need to now be time-consistent. Thus, we can solve the recursive formulation of the problem, with value function

$$V_t = v_t \mathrm{d}t + e^{-\rho \mathrm{d}t} V_{t+\mathrm{d}t}, \tag{19}$$

as the (Markov) state variable is the outstanding debt Q_t, we have that

$$V(Q) = \max_q \Big\{ y\mathrm{d}t + p(Q + q\mathrm{d}t)q\mathrm{d}t - c(Q)\mathrm{d}t + e^{-\rho \mathrm{d}t} V(Q + q\mathrm{d}t) \Big\}. \tag{20}$$

where B takes the price function p as given. In the limit as $\mathrm{d}t \to 0$, the equation becomes[10]

$$\rho V(Q) = \max_q \Big\{ p(Q) + V'(Q) \Big\} q + y - c(Q). \tag{21}$$

[10]This follows from standard calculations, heuristically as follows. Substitute $V(Q + q\mathrm{d}t) = V(Q) + V'(Q)q\mathrm{d}t + O(\mathrm{d}t^2)$ into equation (20) and multiply through by $(1 + \rho \mathrm{d}t) = e^{\rho \mathrm{d}t} + O(\mathrm{d}t^2)$ to get

$$V(Q) + \rho \mathrm{d}t V(Q) = \Big\{ y + p(Q + q\mathrm{d}t)q - c(Q) \Big\} \mathrm{d}t(1 + \rho \mathrm{d}t) + V(Q) + V'(Q)q\mathrm{d}t + O(\mathrm{d}t^2)$$

or

$$\rho V(Q) = y + p(Q + q\mathrm{d}t)q - c(Q) + V'(Q)q + \big\{ p(Q + q\mathrm{d}t)q - c(Q) \big\} \rho \mathrm{d}t + O(\mathrm{d}t).$$

The objective is linear in the control q, so it must have coefficient zero:

$$p(Q) + V'(Q) = 0, \tag{22}$$

an equation that also appears in DeMarzo and He (2021).[11]

Proposition 2 (Non-exclusive benchmark)**.** *In the limit as* $\mathrm{d}t \to 0$*, the value function is*

$$V(Q) = \frac{1}{\rho}\big(y - c(Q)\big), \tag{23}$$

the price is

$$p(Q) = \frac{1}{\rho}c'(Q), \tag{24}$$

and the issuance policy is

$$q = \frac{\gamma(Q) - c'(Q)}{-c''(Q)/\rho}. \tag{25}$$

Proof. The expression for V in (23) follows from substituting the equation from the optimal control (equation (22)) into the continuous-time HJB (equation (21)). The equation for p in (24), comes from differentiating the equation for V (equation (23)) and replacing V' with $-p$ from equation (22).

The issuance policy follows form the law of motion for the price,[12]

$$p(Q) = \gamma(Q) + p'(Q)q. \tag{26}$$

Using $p = c'/\rho$, differentiating and rearranging, gives the expression for q in the proposition. □

[11] There is the flavor of mixed strategy equilibrium here, as the optimum is determined not by B's direct incentives but by the market's need to make him indifferent over his choice of control.

[12] That equation, which can be seen as the Black–Scholes differential equation for a derivative with price p written on an underlying Q following $\mathrm{d}Q_t = q_t\mathrm{d}t$, is the limit of the standard discounting formula $p(Q) = \gamma(Q)\mathrm{d}t + e^{-\rho\mathrm{d}t}p(Q + q\mathrm{d}t)$.

Equation (24) says that the price equals (the present value of) B's marginal cost. I.e. the price is competitive, per the Coase Conjecture on a durable goods monopolists (Coase (1972)). B would like to ration quantities to keep prices above marginal cost, but is always tempted to issue more.

Before moving on, we state a corollary that follows from equation (23) and the assumption that c is concave:

Corollary 1 (Convex value)**.** *The value function is convex, with* $V'' = -c''/\rho$*.*

Proof. The result follows from Proposition 2 and the assumption that $c'' < 0$. □

4 Results

We now study our baseline model, where B lacks commitment but we allow lenders to offer credit lines together with their loans at $t = 0$. We show that when lenders are able to bundle credit lines with their loan offers, the commitment allocations of Section 3.1 obtain. We do so in two steps. First, we show that credit lines can act as a self-deterring mechanism by preventing lenders to make loan offers when they are in place (Section 4.1). Second, we show that competition on bundles of loans and credit lines implement the commitment allocation. Finally, we study how limited committed in the form of potential credit line revocation affects these predictions (Section 4.4).

4.1 The Ratchet Effect for Credit Lines

In our setting, a credit line is a pair $(\tilde{p}, \mathrm{d}\tilde{Q})$ that gives B the option to issue debt $\mathrm{d}\tilde{Q}$ at price $\tilde{p}$ at any time. We begin with an analog of the leverage ratchet effect from credit lines, which says that drawing a credit line becomes more attractive as debt increases, a consequence of the concavity of c.

Proposition 3 (Ratchet Effect for Credit Lines)**.** *Define $\bar{Q}$ as the smallest solution of $\gamma(Q) = c'(Q)$ and let $\mathrm{d}t \to 0$. For any credit line $(\tilde{p}, \mathrm{d}\tilde{Q})$ with $\tilde{p} > c'(\bar{Q})$, B draws the credit line for $Q \leq \bar{Q}$ sufficiently large.*

Proof. To start, we write the condition for B to prefer to draw the credit line than not:

$$y\mathrm{d}t + \tilde{p}\mathrm{d}\tilde{Q} - c(Q)\mathrm{d}t + e^{-\rho\mathrm{d}t}V(Q + \mathrm{d}\tilde{Q}) \geq y\mathrm{d}t - c(Q)\mathrm{d}t + e^{-\rho\mathrm{d}t}\tilde{V}(Q), \tag{27}$$

having used the notation that V is the value without the credit line in place (i.e. after it has been drawn) and $\tilde{V}$ is the value with it in place. Rearranging and sending $\mathrm{d}t \to 0$ gives

$$\tilde{p}\mathrm{d}\tilde{Q} + V(Q + \mathrm{d}\tilde{Q}) > \tilde{V}(Q). \tag{28}$$

Now we eliminate V and $\tilde{V}$ in equation (28), making use of the benchmarks above. To eliminate V, we observe that B does not have a credit line in place after having drawn, so we can substitute for V from the benchmark with no credit lines (Proposition 2). To eliminate $\tilde{V}$, we bound it above by the commitment outcome: B can do no better than borrowing an optimal amount $\mathrm{d}Q^*$ with commitment not to borrow again until he draws the credit line at an optimal time t^*:

$$\begin{aligned} \tilde{V}(Q) \leq p\mathrm{d}Q^* + \int_0^{t^*} e^{-\rho t}\Big(y - c(Q + \mathrm{d}Q^*)\Big)\mathrm{d}t + \\ + e^{-\rho t^*}\left(\tilde{p}\mathrm{d}\tilde{Q} + V(Q + \mathrm{d}Q^* + \mathrm{d}\tilde{Q})\right), \end{aligned} \tag{29}$$

where p is the equilibrium price in anticipation of not borrowing until t^* and then drawing the credit line and reverting to the non-exclusive outcome of Proposition 2:

$$p = \int_0^{t^*} e^{-\rho t}\gamma(Q + \mathrm{d}Q^*)\mathrm{d}t + e^{-\rho t^*}\int_0^{\infty} e^{-\rho t}\gamma(Q_{t^*+t})\mathrm{d}t \tag{30}$$

$$= \frac{1}{\rho}\left((1 - e^{-\rho t^*})\gamma(Q + \mathrm{d}Q^*) + e^{-\rho t^*}c'(Q + \mathrm{d}Q^* + \mathrm{d}\tilde{Q})\right), \tag{31}$$

having used the expression for the price under non-exclusivity in Proposition 2. Now substitute the price in equation (31) into the bound in inequality (29) and rearrange:

$$\begin{aligned}\tilde{V}(Q) \leq{} & \frac{1 - e^{-\rho t^*}}{\rho}\left(\gamma(Q + \mathrm{d}Q^*)\mathrm{d}Q^* + y - c(Q + \mathrm{d}Q^*)\right) + \\ & + e^{-\rho t^*}\left(\tilde{p}\mathrm{d}\tilde{Q} + \frac{1}{\rho}c'(Q + \mathrm{d}Q^* + \mathrm{d}\tilde{Q})\mathrm{d}Q^* + V(Q + \mathrm{d}Q^* + \mathrm{d}\tilde{Q})\right),\end{aligned} \tag{32}$$

where, using that $V'(Q) = -c'(Q)/\rho$ from equation (23) to cancel terms, the FOC gives the maximizer as (the solution of)

$$\mathrm{d}Q^* = \frac{\gamma(Q + \mathrm{d}Q^*) - c'(Q + \mathrm{d}Q^*)}{-\gamma'(Q + \mathrm{d}Q^*) - c''(Q + \mathrm{d}Q^* + \mathrm{d}\tilde{Q})/(e^{\rho t^*} - 1)}. \tag{33}$$

Using the bound above and that, since $V' < 0$, $V(Q + \mathrm{d}\tilde{Q}) \geq V(Q + \mathrm{d}Q^* + \mathrm{d}\tilde{Q})$, we have a sufficient condition for B to draw at Q:

$$\begin{aligned}\tilde{p}\mathrm{d}\tilde{Q} + V(Q + \mathrm{d}\tilde{Q}) > \frac{1}{\rho}\Bigg\{ & \left((1 - e^{-\rho t^*})\gamma(Q + \mathrm{d}Q^*) + e^{-\rho t^*}c'(Q + \mathrm{d}Q^* + \mathrm{d}\tilde{Q})\right)\mathrm{d}Q^* + \\ & + (1 - e^{-\rho t^*})\left(y - c(Q + \mathrm{d}Q^*)\right)\Bigg\} \\ & + e^{-\rho t^*}\left(\tilde{p}\mathrm{d}\tilde{Q} + V(Q + \mathrm{d}\tilde{Q})\right).\end{aligned} \tag{34}$$

Rearranging, replacing $V(Q)$ with $(y - c(Q))/\rho$ from Proposition 2, and canceling terms gives

$$\tilde{p}\mathrm{d}\tilde{Q} - \frac{c(Q + \mathrm{d}\tilde{Q})}{\rho} > \frac{\gamma(Q + \mathrm{d}Q^*) + \frac{c'(Q+\mathrm{d}Q^*+\mathrm{d}\tilde{Q})}{e^{\rho t^*}-1}}{\rho}\mathrm{d}Q^* - \frac{c(Q + \mathrm{d}Q^*)}{\rho}. \tag{35}$$

As Q increases toward $\bar{Q}$, $Q \uparrow \bar{Q}$, the gains from trade $\gamma(Q) - c'(Q)$ go to zero and, thus, by equation (33), $\mathrm{d}Q^* \to 0$. So, from equation (35), it suffices to satisfy

$$\tilde{p} > \frac{1}{\rho}\frac{c(Q + \mathrm{d}\tilde{Q}) - c(Q)}{\mathrm{d}\tilde{Q}} \geq \frac{1}{\rho}c'(Q + \mathrm{d}\tilde{Q}), \tag{36}$$

where the last last inequality follows from the concavity of c. The condition is satisfied for Q large enough given the condition in the statement of the proposition and the concavity of c. □

4.2 The Ratchet-Anti-Ratchet Effect

Here we show that given outstanding debt Q_0, there is a credit line $(\tilde{p}, \mathrm{d}\tilde{Q})$ such that when in place, lenders are not willing to post a loan contract that B is willing to accept. The reason is that, in anticipation of B's drawing the credit line, lenders' willingness to pay drops so much that there is no price at which they are willing to lend and B is willing to borrow. Thus B's debt level stays constant at Q_0.

To see how this works, suppose that B has debt Q_0 and a credit line $(\tilde{p}, \mathrm{d}\tilde{Q})$ that he is indifferent to drawing or not at Q_0:

$$y\mathrm{d}t + \tilde{p}\mathrm{d}\tilde{Q} - c(Q_0)\mathrm{d}t + e^{-\rho \mathrm{d}t}V(Q_0 + \mathrm{d}\tilde{Q}) = y\mathrm{d}t - c(Q_0)\mathrm{d}t + e^{-\rho \mathrm{d}t}\tilde{V}(Q_0). \tag{37}$$

So, by the logic of Proposition 3, B will choose to draw the line if he takes on any new debt $q\mathrm{d}t$.

Now B prefers *not* to take on the new debt at price p if his payoff from taking the loan and drawing the credit line is less than his payoff from doing neither:

$$\begin{aligned} &y\mathrm{d}t + pq\mathrm{d}t + \tilde{p}\mathrm{d}\tilde{Q} - c(Q_0)\mathrm{d}t + e^{-\rho\mathrm{d}t}V(Q_0 + q\mathrm{d}t + \mathrm{d}\tilde{Q}) \leq \\ &\leq y\mathrm{d}t - c(Q_0)\mathrm{d}t + e^{-\rho\mathrm{d}t}\tilde{V}(Q_0) \end{aligned} \tag{38}$$

By the assumption that B was indifferent to drawing the line given debt in place Q_0, we can replace the RHS with his payoff from taking $(\tilde{p}, \mathrm{d}\tilde{Q})$ given only Q_0 in place to re-write condition (38), for B not to borrow, as

$$\begin{aligned} &y\mathrm{d}t + pq\mathrm{d}t + \tilde{p}\mathrm{d}\tilde{Q} - c(Q_0)\mathrm{d}t + e^{-\rho\mathrm{d}t}V(Q_0 + q\mathrm{d}t + \mathrm{d}\tilde{Q}) \leq \\ &\leq y\mathrm{d}t + \tilde{p}\mathrm{d}\tilde{Q} - c(Q_0)\mathrm{d}t + e^{-\rho\mathrm{d}t}V(Q_0 + \mathrm{d}\tilde{Q}). \end{aligned} \tag{39}$$

Re-writing gives an upper bound on the price p of new debt:

$$p \leq -e^{-\rho\mathrm{d}t}\frac{V(Q_0 + q\mathrm{d}t + \mathrm{d}\tilde{Q}) - V(Q_0 + \mathrm{d}\tilde{Q})}{q\mathrm{d}t}. \tag{40}$$

The inequality must hold for all $q\mathrm{d}t$. Thus, given V convex, for any p, it is necessary and sufficient that it holds as $q\mathrm{d}t \to 0$ (cf. the argument for the ratchet effect above). That limiting condition is:

$$p \leq -V'(Q_0 + \mathrm{d}\tilde{Q}), \tag{41}$$

which gives the next result:

Lemma 1 (No New Debt)**.** *Suppose B has debt Q_0 and credit line $(\tilde{p}, \mathrm{d}\tilde{Q})$ in place, such that B is indifferent to drawing the line at Q_0.*

For $\mathrm{d}t \to 0$*, B prefers new debt* (p, q) *for some* q *to no new debt if and only if*

$$p \geq \frac{c'(Q_0 + \mathrm{d}\tilde{Q})}{\rho}. \tag{42}$$

Proof. The result follows from inequality (40) and equation (23), which implies that $V' = -c'/\rho$ for $\mathrm{d}t \to 0$. □

The result says that B does not want to issue at a price below marginal cost. The twist is that the marginal cost is conditional on having drawn the line, which is the relevant price for lenders anticipating that B will indeed draw it down.

We now turn to whether lenders are willing to lend. A lender that anticipates B will draw the credit line is willing to offer a loan (p, q) if and only if

$$\Gamma(Q_0 + q\mathrm{d}t + \mathrm{d}\tilde{Q}) \geq p. \tag{43}$$

Just comparing inequalities (42) and (43) above gives the next result:

Proposition 4 (Ratchet-Anti-ratchet)**.** *Consider the setting of Lemma 1 and suppose further that* $\log\big(\gamma(Q_{t+s})/\gamma(Q_t)\big) \leq k_0 + k_1 s$ *for constants* k_0 *and* $k_1 < \rho$ *with* Q_t *as in Proposition 2.*[13] *B does not take on new debt at any price lenders will lend at as long as* $\mathrm{d}\tilde{Q}$ *is sufficiently large.*

Proof. The result follows from from inequalities (42) and (43), the assumption that c' is bounded above zero, and, using the hypothesis in the proposition, that $\Gamma(Q_t) = \int_0^\infty e^{-\rho s}\gamma(Q_{t+s})\mathrm{d}s \leq \int_0^\infty e^{-\rho s}\gamma(Q_t)e^{k_0+k_1 s}\mathrm{d}s = \gamma(Q_t)e^{k_0}/(\rho - k_1)$ with $\gamma(Q) \to 0$ as $Q \to \infty$. □

[13] Given $Q_{t+s} = Q_t + \int_0^s q_u \mathrm{d}u$ and $\gamma' < 0$, that says that the rate of buy backs $-q_u$ cannot be too large. That ensures that the value of debt goes to zero as the level to infinity. Otherwise, lenders could be willing to pay a positive price new debt in a highly indebted borrower in anticipation of deleveraging.

Given our assumptions, any Q_0 can be supported by a sufficiently large credit line:

Corollary 2 (Supporting Q_0)**.** *For any Q_0, there is a credit line $(\tilde{p}, \mathrm{d}\tilde{Q})$ for which B does not borrow more than Q_0.*

Proof. The result follows from Proposition 4 and the expression for $(\tilde{p}, \mathrm{d}\tilde{Q})$ in equation (37). □

4.3 Bundling

We now suppose that lenders can offer bundles including loans and credit lines at date 0 and B can take exactly one bundle. After that lenders compete in loans and the equilibrium is the Markov perfect one in Proposition 2.

In this case, the outcome is the exclusive contracting outcome of Proposition 1:

Proposition 5 (Credit Line Bundles)**.** *If lenders compete in bundles, B chooses a bundle with a loan and a credit line at date 0 and never borrows again.*

The loan coincides with full-commitment/exclusive outcome (p^e, Q^e) in Proposition 1.

The credit line $(\tilde{p}, \mathrm{d}\tilde{Q})$ is such that B is indifferent to drawing given Q^e (equation (37) holds with $Q_0 = Q^e$) and $\mathrm{d}\tilde{Q}$ is large enough to ensure inequality (43) *is violated for all q.*

Proof. Suppose (in anticipation of a contradiction) that B takes up any bundle inducing a different outcome at date 0 in equilibrium. By Corollary 2, another lender can offer a bundle that implements Q^e and, by Proposition 1, it breaks even at p^e. By the definition of the full-commitment outcome, B is strictly better off. Thus, since B accepts at one contract at each date, there is $\epsilon > 0$ such that the lender can offer $(p^e - \epsilon, Q^e)$ and both B and the lender (that was previously getting zero) are strictly better off. That is a profitable deviation and therefore a contradiction to the proposed equilibrium. □

The idea behind Proposition 5 is that credit lines can serve as a commitment device never to borrow in the future (Proposition 4) if lenders can bundle loans with credit lines, an instant of exclusivity—from date 0 to date dt—can achieve exclusivity forever. Thus competition in bundles at date 0 achieves the same outcome as with exclusive competition forever.

As mentioned in the Introduction, this result contrasts with the literature on latent contracts (notably Parlour and Rajan (2001) and Attar et al. (2019a, 2019b)). Although our credit lines, never being drawn, resemble the latent contracts in that literature, the outcomes here do not resemble the outcomes there. With (i) exclusivity within periods, albeit arbitrarily short ones, and (ii) competition in bundles, not just loans, the non-competitive outcomes of that literature do not arise.

There is also a practical difference between credit lines in our model and latent (loan) contracts in the literature, namely that whereas a credit line is a contract agreed to between a borrower and a (potential) lender that must be honored, the latent contract is just an offer from a lender that can be retracted. That matters, because, in our model, lenders would prefer not to honor credit lines. At the time that they would be drawn, B is so levered that the rate $1/\tilde{p}$ is too low for the lender to break even. So, whereas credit lines, which are, per the contractual agreement, always available, can support a variety of outcomes, the analogous latent contracts, which can, and will, be retracted when B chooses to take them up, cannot.

4.4 Credit Line Revocation

So far, we have assumed that lenders fully commit to credit lines; they are never revoked. Here we relax that assumption. We assume that, conditional on being drawn, a lender honors the credit line with probability α and defaults, lending nothing, with complementary probability. One motivation for this is that the credit lines in our model are, by construction, loss making when drawn (see the discussion in Section 4.3) so lenders, would like to revoke them if they can; another is that the offering lenders could be distressed themselves and unable to honor their commitments (cf. Chodorow-Reich and Falato (2022)).

Either way, as above, B draws the credit line $(\tilde{p}, \mathrm{d}\tilde{Q})$ if and only if debt is above a threshold Q_0, defined by the same equation as above (equation (37)). If B is indifferent between drawing and not, he is also indifferent between drawing with probability α and not.[14]

Likewise, the condition for B not to want to borrow (in which case he draws on $(\tilde{p}, \mathrm{d}\tilde{Q})$) analogous to inequality (38), except with drawing the line replaced with drawing it with probability α:

$$\begin{aligned} y\mathrm{d}t + p\mathrm{d}\tilde{Q} + \alpha\left\{\tilde{p}\mathrm{d}\tilde{Q} - c(Q_0)\mathrm{d}t + e^{-\rho\mathrm{d}t}V(Q_0 + q\mathrm{d}t + \mathrm{d}\tilde{Q})\right\} + \\ + (1-\alpha)\Big\{ - c(Q_0)\mathrm{d}t + e^{-\rho\mathrm{d}t}V(Q_0 + q\mathrm{d}t)\Big\} \leq \\ \leq y\mathrm{d}t - c(Q_0)\mathrm{d}t + e^{-\rho\mathrm{d}t}V(Q_0), \end{aligned} \tag{45}$$

[14] Formally, the analog of the indifference condition (37) in which credit lines are revoked with probability α is:

$$\begin{aligned} y\mathrm{d}t + \alpha\left\{\tilde{p}\mathrm{d}\tilde{Q} - c(Q_0)\mathrm{d}t + e^{-\rho\mathrm{d}t}V(Q_0 + \mathrm{d}\tilde{Q})\right\} + \\ + (1-\alpha)\left\{-c(Q_0)\mathrm{d}t + e^{-\rho\mathrm{d}t}V(Q_0)\right\} = y\mathrm{d}t - c(Q_0)\mathrm{d}t + e^{-\rho\mathrm{d}t}V(Q_0). \end{aligned} \tag{44}$$

The α's cancel recovering the same equation as in the baseline model.

or, using B's indifference condition (44) to rewrite the RHS and rearranging,

$$\begin{aligned} pe^{\rho \mathrm{d}t} \leq & -\alpha \frac{V(Q_0 + q\mathrm{d}t + \mathrm{d}\tilde{Q}) - V(Q_0 + \mathrm{d}\tilde{Q})}{q\mathrm{d}t} + \\ & - (1-\alpha)\frac{V(Q_0 + q\mathrm{d}t) - V(Q_0)}{q\mathrm{d}t}. \end{aligned} \tag{46}$$

Per the argument in Section 4.2 (cf. equation (40)), it is necessary and sufficient that the inequality hold for $q\mathrm{d}t \to 0$, or that

$$p \leq -\alpha V'(Q_0 + \mathrm{d}\tilde{Q}) - (1-\alpha)V'(Q_0). \tag{47}$$

From here, we have the next result:

Lemma 2 (No New Debt with Revocation)**.** *Suppose B has debt Q_0 and a revocable credit line $(\tilde{p}, \mathrm{d}\tilde{Q})$ in place, such that B is indifferent to drawing the line at Q_0.*

For $\mathrm{d}t \to 0$, B prefers new debt (p, q) for some q to no loan if and only if

$$p \leq \frac{1}{\rho}\Big(\alpha c'(Q_0 + \mathrm{d}\tilde{Q}) + (1-\alpha)c'(Q_0)\Big). \tag{48}$$

Proof. The result follows from equation (47) and (23), which implies that $V' = -c'/\rho$ for $\mathrm{d}t \to 0$. □

The result says that B does not want to borrow at a price below marginal cost. The twist is that the marginal cost is conditional on drawing the line successfully with probability α.

We now turn to whether lenders are willing to lend. By the definition of Γ, a lender anticipates that B will draw the credit line successfully with probability α

is willing to offer a loan (p, q) if and only if

$$\alpha\Gamma(Q_0 + q\mathrm{d}t + \mathrm{d}\tilde{Q}) + (1-\alpha)\Gamma(Q_0 + q\mathrm{d}t) \geq p. \tag{49}$$

Just comparing inequalities (48) and (49) gives the next result:

Proposition 6 (Revocation)**.** *Consider the setting of Proposition 4. B does not take on new debt at any price lenders will lend at if and only if*

$$\alpha\Gamma(Q_0 + \mathrm{d}\tilde{Q}) + (1-\alpha)\Gamma(Q_0) \leq \frac{1}{\rho}\Big(\alpha c'(Q_0 + \mathrm{d}\tilde{Q}) + (1-\alpha)c'(Q_0)\Big). \tag{50}$$

Proof. Immediate from inequalities (48) and (49). □

Re-writing (50) gives an expression for the extent to which the price $p = \Gamma(Q_0)$ can exceed the marginal cost $c'(Q_0)$:

$$p - \frac{c'(Q_0)}{\rho} \leq \frac{\alpha}{1-\alpha}\left(\frac{c'(Q_0 + \mathrm{d}\tilde{Q})}{\rho} - \Gamma(Q_0 + \mathrm{d}\tilde{Q})\right) \overset{\mathrm{d}\tilde{Q}\to\infty}{\to} \frac{\alpha}{1-\alpha}\frac{\bar{c}'}{\rho}, \tag{51}$$

having used the assumptions that $c'(\infty) = \bar{c}'$ and $\gamma(\infty) = 0$. That says that for α large, high prices can be sustained; as we showed, the full commitment outcome is attained for $\alpha = 1$ (Proposition 5). But for α smaller, lower prices can be sustained with only the non-exclusive outcome $p = c'(Q_0)$ of Proposition 2 available as $\alpha \to 0^+$.

5 Empirical Analysis

Here we test the prediction in Proposition 6, that borrowers increase debt when the risk that credit lines are revoked goes up. In light of the findings in Chodorow-Reich and Falato (2022), we use a negative shock to lender health to proxy for an increase in revocation risk. For each borrower i, we construct an overall lender health shock following Chodorow-Reich (2014) and Darmouni (2020) and, analogously, a credit line lender health shock, which captures only the shocks to lenders with credit lines outstanding to borrower i (see Appendix A).

Using syndicated loan data from DealScan, we regress an indicator for a borrower taking on new debt against these lender shocks (as well as controls variables[15]):

$$\text{new debt}_i = \alpha + \beta \text{shock}_i + \gamma \text{shock CL}_i + \delta X_i + \varepsilon_i. \tag{52}$$

The findings are in Table 1. In short, we find that $\beta < 0$: In line with the literature, a negative shock to a borrower's lenders leads it to borrow less, presumably because credit supply contracts. However, we find that $\gamma > 0$: In line with our theory, a negative shock to a borrower's credit line lenders leads it to borrow more, possibly because the credit line no longer serves as a commitment device not to borrow.

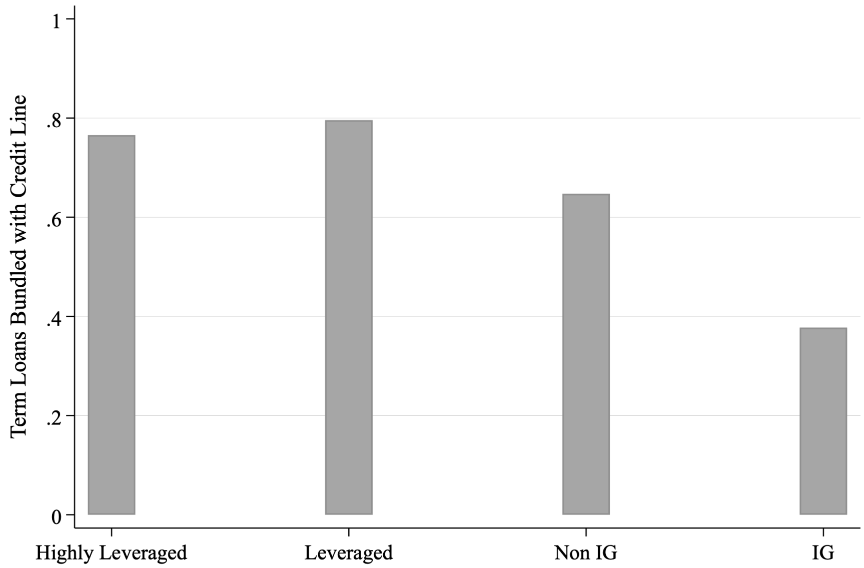
6 Conclusion

We study a model that suggests that credit lines play a heretofore overlooked role. They can mitigate debt dilution. The theory suggests the option to borrow—viz. a credit line—is valuable even if it is never exercised, explaining why credit lines are ubiquitous but rarely drawn. It also underscores how and why credit lines should be bundled with loans, a pervasive practice never previously studied in the theory literature.

[15]Controls include the number of syndicates that borrower i had taken debt from before the lender shocks, capturing borrowers' access to/need for credit as well as an indicator for having taken a credit line before the lender shocks, capturing general differences between borrowers that do/do not use credit lines.

Our paper contrasts with recent corporate finance papers on the leverage ratchet effect, suggesting that including credit lines in the contracting space makes the ratchet effect self-deterring, undoing its negative effects. It also contrasts with the literature on latent contracts, suggesting that the kinds of outcomes stressed in that literature might not obtain in dynamic environments.

Figure 1: Bundling Propensity and Firm Riskiness



This figure shows how the proportion of term loans that are bundled with a credit line vary by firm riskiness, as measured by Dealscan's classification of firms' market segments. The loans to the safest borrowers are Investment Grade ("IG"), then "Non-IG", "Leveraged", and "Highly Leveraged" respectively, where the distinction between the latter three categories depends on pricing thresholds. Data are from Dealscan, covering US C&I syndicated loans from 1997 through 2021 for which at least one lender is a US bank, and excluding financials.

	(1)	(2)	(3)	(4)
Shock	-0.16^{***}	-0.17^{***}	-0.17^{***}	-0.18^{***}
	(0.05)	(0.05)	(0.05)	(0.05)
Shock CL		0.03^{***}	0.02^{**}	0.03^{***}
		(0.01)	(0.01)	(0.01)
Number of Syndicates			0.03^{***}	0.04^{***}
			(0.01)	(0.01)
Pre CL Indic				-0.03^{**}
				(0.01)
Constant	0.20^{***}	0.19^{***}	0.19^{***}	0.18^{***}
	(0.04)	(0.04)	(0.04)	(0.04)
Observations	4883	4883	4883	4883
Adjusted R^2	0.002	0.003	0.009	0.010

Table 1: The table reports the effect of credit line revocation risk on firm borrowing per the regression in equation (52). The outcome variable is an indicator for borrowing in the syndicated loan market in the crisis period. The construction of the shocks as well as definition of crisis and normal periods are described in Appendix A. The controls include the number of syndicates firm i borrowed from during normal period and an indicator variable tracking if firm borrowed CL in normal period. Observations are at the firm level. Robust standard errors are reported in parentheses. Two and three stars indicate statistical significance at the 5% and 1% level, respectively.

A Data and Variable Construction

Here we describe details omitted from Section 5.

A.1 Data

We start with the universe of US C&I syndicated loans in DealScan from 1997 through 2021. We classify US C&I loans to be loans that are originated in the US and for which the deal purpose is listed as “general purpose” or “working capital”.

We exclude loans to financials.

A.2 Variable Construction

Lender share. In the Dealscan data, the lenders' share of the loan commitment within a given syndicate are sometimes unreported. In these cases, we impute lenders' shares following Chodorow-Reich (2014) and Darmouni (2020). Specifically, we calculate the average lender share of lead arrangers and participants separately for each syndicate structure during the time period surrounding the Global Financial Crisis, from 2004 through 2010, among syndicates that do not have missing lender shares.[16] We then fill in the missing lender shares with the average lender shares calculated for the corresponding syndicate structure.

Lender health shocks. For each borrower, we construct overall lender health shocks following Chodorow-Reich (2014) and Darmouni (2020) and, analogously, for lenders with credit lines outstanding to the borrower. Specifically, we define $\Delta L_{b,-i}$ as the decrease in a bank b's lending to firms $j \neq i$ in the crisis period vis-à-vis normal times:

$$\Delta L_{b,-i} := 1 - \frac{2\sum_{j\neq i} L_{b,j,\text{crisis}}}{\sum_{j\neq i} L_{b,j,\text{normal}}}, \tag{53}$$

where $L_{b,j}$ is the effective number of loan facilities from b to j during normal and crisis times, defined as 10/2005–6/2007 and 10/2008–6/2009, respectively. The effective number of loan facilities is the number of loan facilities originated, with each weighted by the corresponding lender share, as discussed above. We exclude refinancings and amendments (except extensions) during crisis times. We restrict the sample to firms that borrowed during the normal period and banks that are present

[16] By syndicate structure we mean the number of lead arrangers and the number of other participants in a syndicate.

in both the normal and crisis period. We winsorize $\Delta L_{b,-i}$ at 2%.

We then construct the shocks for each borrower i's lenders and credit line lenders as weighted sums of $\Delta L_{b,-i}$ over lenders in a borrower i's last pre-crisis syndicate:

$$\text{Shock}_i = \sum_{b \in S} \alpha_b \Delta L_{b,-i} \qquad\qquad \text{Shock CL}_i = \sum_{b \in S} \alpha_b^{\text{CL}} \Delta L_{b,-i}, \tag{54}$$

where S is the set of lenders in borrower i's last pre-crisis syndicate. For a lender $b \in S$, α_b is its average share across all loan facilities in the syndicate and α_b^{CL} is its share within the credit line facility. If borrower i's last pre-crisis syndicate has no CL or a CL that matures prior to 2008, we set Shock $\text{CL}_i = 0$.

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