

# THE PARADOX OF PLEDGEABILITY\*

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## Abstract

We develop a model in which collateral serves to protect creditors from the claims of other creditors. We find that borrowers rely most on collateral when cash flow pledgeability is high, because this is when it is easy to take on new debt, diluting existing creditors. Creditors thus require collateral for protection against being diluted. This causes a collateral rat race that results in all borrowing being collateralized. But collateralized borrowing has a cost: it encumbers assets, constraining future borrowing and investment, i.e. there is a collateral overhang. Our results suggest that the absolute priority rule, by which secured creditors are senior to unsecured creditors, may have an adverse effect—it may trigger the collateral rat race.

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# 1 Introduction

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Collateral matters.<sup>1</sup> By pledging collateral, borrowers alleviate enforcement frictions in financial contracts and thus loosen financial constraints. In other words, “collateral pledging makes up for a lack of pledgeable cash” (Tirole (2006), p. 169). This suggests that collateral should matter most when cash flow pledgeability is low. Yet, some of the world’s most developed debt markets rely heavily on collateral. Notably, upwards of five trillion dollars of securities are pledged as collateral in US interbank markets, where strong creditor rights, effective legal enforcement, intense regulatory supervision, and developed record-keeping technologies ensure that cash flow pledgeability is high. Why does collateral matter in these markets?

To address this question, we develop a model in which collateral does not mitigate enforcement problems between borrowers and creditors, as emphasized in the finance literature, but rather mitigates enforcement problems among creditors. These two roles of collateral correspond to the two components of property rights which accrue to secured creditors upon default: the “right of access”—here a creditor’s right to seize collateral—and the “right of exclusion”—here a creditor’s right to stop other creditors from seizing collateral (e.g., Hart (1995), Segal and Whinston (2012)). In this paper, we focus on this second role, which is also emphasized by practitioners and lawyers. For instance, Kronman and Jackson (1979) define “a secured transaction [as] the protection...against the claims of competing creditors” (p. 1143).

We find that, paradoxically, borrowers rely most on collateral when cash flow pledgeability is high. Indeed, this is when it is easy to take on new debt and so creditors require collateral as protection against being diluted. This causes a collateral rat race that results in all borrowing being collateralized. But collateralized borrowing has a cost: it encumbers assets, constraining future borrowing and investment, i.e. there is a collateral overhang. Our results suggest that the absolute priority rule, by which secured creditors are senior to unsecured creditors, may have an adverse effect—it may trigger the collateral rat race.

**Model preview.** In the model, a borrower, B, has two riskless projects, Project 0 and Project 1, to finance sequentially. B finances Project 0 by borrowing from one creditor,  $C_0$ , and, after Project 0 is underway, B can finance Project 1 by borrowing from another creditor,  $C_1$ . Project 0’s NPV is positive, but Project 1’s NPV, which is revealed after Project 0 is underway, may be positive or negative. Thus, it is efficient for B always to undertake Project 0 and to undertake Project 1 only in the event that its NPV is positive.

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<sup>1</sup>See, e.g., Benmelech and Bergman (2009, 2011), Rampini and Viswanathan (2013), and Rampini, Sufi, and Viswanathan (2014) for empirical evidence on the importance of collateral for borrowing.

B’s borrowing capacity is constrained by two frictions. First, cash flow *pledgeability* is limited. Specifically, the total repayment from B to his creditors cannot exceed a fixed fraction  $\theta$  of the projects’ cash flows (e.g. due to imperfect legal enforcement). Second, contracts are *non-exclusive* in that when B takes on debt to  $C_0$ , he cannot commit not to dilute this debt with new debt to  $C_1$ .<sup>2</sup> However, collateral mitigates this friction by establishing priority in bankruptcy.<sup>3</sup> To finance a project, B can borrow via either secured (i.e. “collateralized”) debt or via unsecured debt.<sup>4</sup> If B borrows via secured debt, the secured creditor has an exclusive claim over the project’s pledgeable cash flows. Thus, by borrowing collateralized, B “fences off” a project from the claims of competing creditors. This ring-fencing involves a cost  $(1 - \mu)$ , where we refer to  $\mu$  as the project’s collateralizability. If instead B borrows via unsecured debt, the creditor still has a claim on B’s pledgeable cash flow, but it is effectively junior to any new secured debt that B may take on. To be clear, we assume that collateralization mitigates the non-exclusivity friction but does not affect the limited pledgeability friction (see however Subsection 6.2).

Our view that collateral establishes priority among creditors echoes the law literature. Indeed, legally, “[t]he absolute priority rule describes the basic order of payment in bankruptcy. Secured creditors get paid first, unsecured creditors get paid next” (Lubben (2016), p. 581). Legal scholars have also observed that collateral may serve to dilute existing creditors, since “[l]ate-arriving secured creditors can leapfrog earlier unsecured creditors, redistributing value to the benefit of the issuer and the secured creditor but to the detriment of unsecured creditors” (Listokin (2008), p. 1039), as well as to “protect lenders against dilution by issuing secured debt” (Schwartz (1997), p. 1397).

**Results preview.** Our first main result is that if pledgeability  $\theta$  is sufficiently high, B may be able to borrow from  $C_0$  only via secured debt. To see why, suppose B finances Project 0 by borrowing from  $C_0$  via *unsecured* debt. Because unsecured contracts are non-exclusive, B can borrow from another creditor,  $C_1$ , to finance Project 1. If B collateralizes his projects to borrow from  $C_1$ , then  $C_1$  is prioritized over  $C_0$ —the new secured debt dilutes the existing unsecured debt. As a result,  $C_0$  may not lend to B via unsecured debt in the first place. However, this dilution occurs only if B is not too constrained to borrow from  $C_1$ —i.e. if B’s

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<sup>2</sup>Note that this assumption rules out covenants by which a borrower contractually commits to one creditor not to borrow from new creditors in the future. As we discuss in detail in Subsection 6.1, such covenants sometimes do mitigate the non-exclusive-contracting friction in reality. However, their effectiveness is limited in circumstances in which the borrower can use collateral to borrow secured from new creditors.

<sup>3</sup>Empirical support for our assumption that collateral mitigates the friction of non-exclusive contracting is in Degryse, Ioannidou, and von Schedvin (2016).

<sup>4</sup>In Subsection 6.5, we allow for more general borrowing instruments and show that our main results are robust. Further, Lemma 4 implies that the inefficiencies in our model are not driven by ad hoc contracting restrictions.

pledgeable cash flow exceeds his funding needs. In summary, if pledgeability is sufficiently high, then B dilutes  $C_0$ 's unsecured debt with new secured debt to  $C_1$  and, in anticipation,  $C_0$  may not lend unsecured, but only with collateral. I.e., for high  $\theta$ , there is a *collateral rat race*, by which collateralization is required to protect against future collateralization. Hence, contrary to common intuition in the finance literature, high cash flow pledgeability undermines unsecured credit.

Our second main result is that if B borrows from  $C_0$  via secured debt and collateralization is costly ( $\mu < 1$ ), B may be unable to do Project 1, even when it has positive NPV. This is because collateralizing Project 0 “uses up” pledgeable cash flow, making it difficult for B to borrow to finance Project 1. Hence, collateralization effectively encumbers B's assets, i.e. it limits B's ability to use them to invest in Project 1, even if it is valuable. We call this a “collateral overhang” problem. This resonates with practitioners' intuition that “asset encumbrance not only poses risks to unsecured creditors...but also has wider...implications since encumbered assets are generally not available to obtain...liquidity” (Deloitte Blogs (2014)).

Whenever  $\theta$  is high, B may borrow with a mix of secured debt and unsecured debt, leading to investment inefficiencies; there may be underinvestment as described above or, for other parameters, there may be over-investment. In particular, if the probability that Project 1 has positive NPV is sufficiently high, then B may borrow from  $C_0$  via unsecured debt. In this case, B can “reuse” pledgeable cash flow to borrow from  $C_1$  via secured debt. This leads to over-investment, since it subsidizes B's investment in Project 1, giving him the incentive to invest in it, even if it has negative NPV.

Whenever  $\theta$  is low, in contrast, B borrows only via unsecured debt and there is no investment inefficiency. In this case, B can finance Project 0 by borrowing from  $C_0$  via unsecured debt and can finance Project 1 by borrowing from  $C_1$  via junior unsecured debt exactly when it has positive NPV. Hence, increasing pledgeability may decrease efficiency.

**Policy.** Our model casts light on the ongoing policy debate about the supply of collateral in financial markets. Recently, central banks have been “manufacturing quality collateral” because “there's still not enough of the quality stuff to go around...as quality collateral becomes impossible to find.... The crunch has further been heightened by the general trend towards collateralised lending and funding” (Kaminska (2011)).<sup>5</sup> Our analysis suggests that expanding the supply of collateral may backfire by making creditors less willing to lend unsecured, thus tightening credit constraints. The reason is that when collateral supply is high, it is easy to borrow via secured debt. This makes it easy for a borrower to dilute

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<sup>5</sup>One way for a central bank to manufacture collateral from illiquid securities is to commit to lend against the securities at a specified rate and haircut, as the European Central Bank did with its Long-term Refinancing Operation and the Reserve Bank of Australia did with its Committed Liquidity Facility.

unsecured creditors by taking on new secured debt, which triggers the collateral rat race.

Moreover, the inefficiencies in our model are the result of the way courts enforce priority. Specifically, “[c]urrent law forces onto borrowers the power to defeat unsecured lenders by issuing secured debt, even when borrowers would prefer to give up that power in order to protect their unsecured lenders from the corresponding threat” (Bjerre (1999), p. 308). Indeed, our analysis suggests that upholding the absolute priority of secured debt can lead to inefficient investment, giving support to arguments advanced in the law literature against the absolute priority of secured debt (see Bjerre (1999) and Lubben (2016)).

**Financial collateral.** Interbank markets motivate our focus on the role of collateral in mitigating the non-exclusivity friction. When we extend the model to incorporate the role of collateral in mitigating the limited-pledgeability friction as well in Subsection 6.2, we find that this classical role of collateral dominates when pledgeability is low, but that the new role we focus on dominates when pledgeability is high. This is consistent with the pervasive use of collateral in interbank markets, such as the repo market. This is not easily explained by the classical theory—i.e. that pledging collateral makes up for a lack of pledgeable cash—for two reasons. (i) In interbank markets, pledging collateral may not be necessary to make up for a lack of pledgeable cash. In fact, in the securities lending market, cash itself *is* the collateral—borrowers pledge cash to borrow securities. Further, even in the repo market, the securities used as collateral are typically so liquid that they are referred to as “cash equivalents.” (ii) Relatedly, in the repo market, borrowers often buy securities “on margin”—i.e. a borrower uses a small amount of initial capital as a down payment to buy assets on credit, using the assets themselves as collateral. In this case, the borrowed assets coincide with the collateralized assets. This is the case in our model, but usually not in models in which collateral makes up for a lack of pledgeable cash. In these models, a borrower typically posts a “tangible” or “illiquid” asset as collateral to borrow cash.

**Related literature.** Our paper makes three main contributions relative to the literature. First, we provide an explanation for the pervasive use of collateral in high pledgeability environments, such as US interbank markets, which we argue is a challenge for received theories. Second, we provide a formal analysis of the role of collateral in mitigating conflicts of interest among creditors, which has not yet been explored in the corporate finance literature. Third, we show that the ability to provide exclusivity selectively can be a friction. This gives a new perspective on the problem of sequential borrowing with non-exclusive contracts.<sup>6</sup>

Our paper is also related to papers that argue that decreasing credit market frictions can have perverse effects. Myers and Rajan (1998) argue that increasing asset liquidity can

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<sup>6</sup>See Admati, DeMarzo, Hellwig, and Pfleiderer (2013), Bizer and DeMarzo (1992), Brunnermeier and Oehmke (2013), DeMarzo and He (2016), and Kahn and Mookherjee (1998).

decrease efficiency by reducing a borrower’s ability to commit to future investment decisions. We argue that increasing cash flow pledgeability can decrease efficiency because it reduces a borrower’s ability to commit to future borrowing decisions. Donaldson and Micheler (2016) suggest that increasing cash flow pledgeability can increase systemic risk, because it leads borrowers to favor non-resaleable over resaleable debt instruments (e.g., repos over bonds).

The collateral rat race in our model is reminiscent of the “maturity rat race” in Brunnermeier and Oehmke (2013), where short maturity, like collateral in our model, serves to establish priority. That paper, however, does not study the effects of cash flow pledgeability. Further, our other main results are independent of the rat race (see Subsection 6.6).

More broadly, our paper also relates to the literature on non-exclusive contracts in finance.<sup>7</sup> Our contribution here is to study how collateral can mitigate the effects of non-exclusivity, but amplify them in equilibrium: by allowing contracting parties to enter into exclusive relationships selectively, collateral can undermine the claims of other parties in sequential borrowing environments.<sup>8</sup> This suggests a caveat to papers emphasizing how non-exclusive contracts can undermine credit markets, such as Petersen and Rajan (1995) and Donaldson, Piacentino, and Thakor (2016). Also, we study the interaction of limited pledgeability and non-exclusive contracts, which these papers do not.

We also relate to the literature on collateral, covenants, and property rights in law and corporate finance, such as Ayotte and Bolton (2011), Bebchuk and Fried (1996), Kronman and Jackson (1979), Schwarcz (1997), Schwartz (1984), and Stulz and Johnson (1985). The idea of investing in a multi-lateral commitment by ring-fencing, i.e. “collateralizing,” a project builds on Kiyotaki and Moore (2000, 2001), who focus on the macroeconomic effects of such multi-lateral commitments.

Our paper is related to the literature on a possible shortage of collateral in funding markets, such as Caballero (2006) and Di Maggio and Tahbaz-Salehi (2015). We offer a new perspective by studying the role of collateral in mitigating non-exclusive contracting.

**Layout.** The paper proceeds as follows. Section 2 presents the model and discusses the contracting environment. Section 3 analyzes several benchmarks. Section 4 solves the model. Section 5 discusses welfare and policy. Section 6 analyzes extensions and robustness issues. Section 7 concludes. The Appendix contains all proofs.

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<sup>7</sup>See Acharya and Bisin (2014), Attar, Casamatta, Chassagnon, and Décamps (2015), Bisin and Gottardi (1999, 2003), Bisin and Rampini (2005), Leitner (2012), and Parlour and Rajan (2001). Parlour and Rajan (2001) suggest that “collateral can be interpreted as a commitment on the part of a consumer to accept only one contract” (p. 1322), in line with our view of collateral as mitigating the non-exclusivity friction.

<sup>8</sup>The literature on large shareholder trading vs. monitoring provides another setting in which sequential trade with a third party can decrease efficiency. See, e.g., DeMarzo and Urošević (2006), Faure-Grimaud and Gromb (2004), and Kihlstrom and Matthews (1990).

## 2 Model

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### 2.1 Players and Projects

There is one good called cash, which is the input of production, the output of production, and the consumption good. A borrower B lives for three dates,  $t \in \{0, 1, 2\}$ , and consumes at Date 2. B has no cash, but has access to two investment projects, Project 0 at Date 0 and Project 1 at Date 1. Both projects are riskless and payoff at Date 2, but the payoff of Project 1 is revealed only at Date 1. Specifically, Project 0 costs  $I_0$  at Date 0 and pays off cash flow  $X_0$  at Date 2 and Project 1 costs  $I_1$  at Date 1 and pays off cash flow  $X_1$  at Date 2, where  $X_1 \in \{X_1^L, X_1^H\}$  is a random variable realized at Date 1 with  $X_1^L < X_1^H$  and  $p := \mathbb{P}[X_1 = X_1^H]$ . Everyone is risk neutral and there is no discounting.

B can fund his projects by borrowing  $I_0$  at Date 0 and  $I_1$  at Date 1 from competitive credit markets: we assume that B makes a take-it-or-leave-it offer to borrow  $I_t$  from a risk-neutral creditor  $C_t$  at Date  $t \in \{0, 1\}$ .

### 2.2 Pledgeability and Collateralizability

B must promise to repay his creditors out of his projects' cash flows under two frictions. First, the pledgeability of cash flows is limited in that B may divert a fraction  $(1 - \theta)$  of cash flows, leaving only a fraction  $\theta$  for his creditors. We refer to  $\theta$  as the *pledgeability* of cash flows. Second, contracts are non-exclusive in that if B borrows from  $C_0$  at Date 0, he cannot commit not to borrow from  $C_1$  at Date 1, potentially diluting  $C_0$ 's initial claim.

The role of collateral in our model is to mitigate the effects of non-exclusive contracting: if a creditor's claim is collateralized (or "secured") by at least one project, that creditor has the exclusive right to the project's pledgeable cash flow if the borrower defaults, i.e. he has absolute priority over the project's pledgeable cash flow.<sup>9</sup> To collateralize a project, B must "fence it off" from the claims of competing creditors. "Ring-fencing" is the legal analog of physical fence-building: a borrower's ring-fenced assets are legally insulated from its other obligations.<sup>10</sup> However, there is a deadweight-cost  $(1 - \mu)X$  of collateralizing the project with cash flow  $X$ .<sup>11</sup> We refer to  $\mu$  as the *collateralizability* of projects.

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<sup>9</sup>Note that we assume for simplicity that the collateralization of each project is a binary decision—B either collateralizes or does not, he cannot collateralize only a fraction of a project. This does not affect the results.

<sup>10</sup>The idea that costly ring-fencing is necessary to protect claims from a third party follows Kiyotaki and Moore (2001).

<sup>11</sup>Equivalently, we could assume that B must post a haircut to borrow secured (see Subsection 6.3). Other interpretations of costly ring-fencing include the costs of storing in a custodian or warehouse, ex post monitoring costs (to ensure that collateral stays with the borrower), and ex ante auditing (to ensure that

## 2.3 Borrowing Instruments

B can choose to borrow via unsecured or secured (or “collateralized”) debt. At Date  $t$ , B borrows  $I_t$  from  $C_t$  against the promise to repay the fixed face value  $F_t$  at Date 2.<sup>12</sup> To borrow secured, B must collateralize his project. We assume that courts respect the absolute priority rule, by which secured creditors are senior to unsecured creditors. Thus, if B collateralizes a project with cash flow  $X$  to borrow secured from a creditor, then this creditor has priority over  $X$ , and so the project cannot be collateralized again and used to borrow secured from another creditor, since collateralization entails ring-fencing to protect the collateral as discussed above.

For simplicity, we assume that if B borrows unsecured from multiple creditors then the creditor that lent first is senior. Hence,  $C_0$ ’s unsecured debt is senior to  $C_1$ ’s unsecured debt. It could also be reasonable to assume that B’s unsecured debt is all treated equally, and we discuss this case of *pari passu* debt in Subsection 6.6. However, in keeping with the non-exclusivity assumption, we rule out the possibility that seniority is a contracting variable.

## 2.4 Payoffs

We now give the players’ terminal payoffs. First, define the variable  $\mu_t$  as follows:

$$\mu_t := \begin{cases} 0 & \text{if Project } t \text{ is not undertaken,} \\ \mu & \text{if Project } t \text{ is collateralized,} \\ 1 & \text{if Project } t \text{ is not collateralized.} \end{cases} \quad (1)$$

Thus, the total payoff  $W$  is given by

$$W = \mu_0 X_0 + \mu_1 X_1. \quad (2)$$

If B has debt  $F_0$  to  $C_0$  and  $F_1$  to  $C_1$ , his payoff is the sum of the non-pledgeable part of the payoff and whatever is left of the pledgeable part of the payoff after repaying the debt to  $C_0$  and  $C_1$ :  $(1 - \theta)W + \max\{\theta W - F_0 - F_1, 0\}$ . If B does not default—i.e.  $F_0 + F_1 \leq \theta W$ —then

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collateral is unencumbered). Further, “issuing security is itself costly because the parties would have to negotiate a security agreement, give public notice, and so forth” (Schwartz (1981), p. 9).

<sup>12</sup>Our restriction to debt contracts maturing at Date 2 is for simplicity. In Subsection 6.4 and Subsection 6.5, we expand the analysis to consider short-term contracts and contingent contracts, respectively, and the main results are unchanged. Moreover, Lemma 4 shows that short-term debt is indeed optimal under the assumption that B’s total debt portion is unobservable to its creditors, an assumption that does not otherwise change our analysis.



each creditor  $C_t$  gets  $F_t$ . If B does default—i.e.  $F_0 + F_1 > \theta W$ —then  $C_0$  and  $C_1$  divide  $\theta W$  according to priority.

## 2.5 Assumptions

We impose several restrictions on parameters. These restrict attention to cases of interest, i.e. in which non-exclusivity alone causes the outcome to be inefficient. In our model, decreasing pledgeability increases efficiency because it mitigates the non-exclusive-contracting friction. In general, however, decreasing pledgeability has the direct effect of decreasing efficiency by inhibiting borrowing. We restrict parameters in such a way that this countervailing force is effectively “switched off.” This is because we wish to focus on the interaction between pledgeability and non-exclusive contracting (which, to the best of our knowledge, has not been studied before), rather than on the direct effect of pledgeability on borrowing and efficiency (which has been well-studied; see, e.g., Holmstrom and Tirole (1997, 1998) or Kiyotaki (1998)).

ASSUMPTION 1. Net of the cost  $(1 - \mu)$  of collateralization, Project 0 has positive NPV and Project 1 has positive NPV if  $X_1 = X_1^H$ ; Project 1 has negative NPV if  $X_1 = X_1^L$ :

$$0 < I_0 < \mu X_0 \quad \text{and} \quad 0 < X_1^L < I_1 < \mu X_1^H. \quad (3)$$

ASSUMPTION 2. The pledgeable cash flow from Project 0 exceeds its cost of investment even if collateralized, but the pledgeable cash flow from Project 1 does not even if not collateralized:

$$I_0 \leq \theta \mu X_0 \quad \text{and} \quad \theta X_1^H < I_1. \quad (4)$$

ASSUMPTION 3. The combined pledgeable cash flow from Projects 0 and 1 exceeds the combined investment cost if and only if  $X_1 = X_1^H$ :

$$\theta(X_0 + X_1^L) < I_0 + I_1 < \theta(X_0 + X_1^H). \quad (5)$$

The two parameter restrictions below are less important. They rule out cases that complicate the analysis but do not enrich it.<sup>13</sup>

ASSUMPTION 4.

$$X_1^L > \frac{(1 - \mu(1 - \theta))X_0 - I_0}{\mu(1 - \theta)}. \quad (6)$$

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<sup>13</sup>Both restrictions matter only for the proof of Lemma 7.

This technical restriction ensures that the payoff of Project 1 is always large enough that B has the incentive to undertake it. Specifically, it ensures that if B can fund Project 1 by taking on new debt which dilutes existing debt, he will always do so.<sup>14</sup>

ASSUMPTION 5.

$$I_1 < \theta\mu(X_0 + X_1^H). \quad (7)$$

This is technical restriction simplifies the analysis by ensuring that the cost of Project 1 is not so large that B can never borrow from  $C_1$  to invest in it.

## 2.6 Discussion of Contracting Environment

The novel contracting assumptions in our environment are (i) courts treat secured debt as super-senior; (ii) borrowers cannot commit not to use collateral in the future; and (iii) collateralization is costly. As discussed above, (i) is typically satisfied, given the absolute priority rule. In contrast, (ii) and (iii) are more likely to be satisfied for some borrowers than for others.

(i) is typically satisfied. We take this feature of the bankruptcy law as given, but it may reflect courts' attempts to avoid economic efficiency. For instance, if courts deviated from the absolute priority rule, borrowers might find (inefficient) ways to get around contractual priority (e.g. via the leasing of assets). To avoid pushing firms into these inefficient evasion strategies, courts might "give up" and enforce the absolute priority rule. For a related argument based on influence costs, see Welch (1997).

(ii) is satisfied when so-called negative pledge covenants, which restrict future collateralization, are difficult to write or enforce. As we discuss in Subsection 6.1, this is the case for borrowers with many short-term creditors (such as banks), borrowers in financial distress, and borrowers with assets exempt from bankruptcy stays. Thus, our analysis suggests that collateral use should be increasing in borrowers' number of creditors, liability duration, distress probability or asset volatility, and proportion of repo and derivatives liabilities.

(iii) drives only our "collateral overhang" result, that borrowing secured may prevent B from borrowing to do positive NPV projects in the future. This assumption is satisfied when claims on collateral are difficult to verify or haircuts are high. In a corporate setting, this suggests that the collateral overhang is likely for receivables collateral, which requires auditing, monitoring, and registration, as compared to tangible collateral, which may not. In the financial setting, this suggests that the collateral overhang is more likely for illiquid

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<sup>14</sup>Note that it might also be reasonable to assume that B gets private benefits from empire building and, therefore, always has the incentive to undertake Project 1, regardless of its NPV (cf. footnote 30). In that case this assumption is unnecessary.

collateral, which demands a high haircut, than for liquid collateral, which does not.

Two types of borrowers that are likely to satisfy all these assumptions are borrowers that can use leased capital or repo financing. Leasing provides a way for new secured creditors to leapfrog existing creditors. A lease is effectively a super-senior secured loan: leased assets are not stayed in bankruptcy, so a lessor can repossess leased assets even before other secured creditors in the event of a borrower's default. A borrower can dilute his existing creditors by taking on new debt in the form of a lease. For leases, the collateralization cost may correspond to the inefficiencies arising from the separation of ownership and control, as in Eisfeldt and Rampini (2009).

Repos also provide a way for new secured creditors to leapfrog existing creditors, since a repo is formally a sale and repurchase of securities: a borrower sells securities to a creditor and other creditors have no recourse to the securities if the borrower defaults—indeed, like leased assets, these securities are exempt from the automatic stay in bankruptcy. In repo markets, the collateralization cost  $(1 - \mu)$  corresponds to the repo haircut (see Subsection 6.3).

### 3 Benchmarks

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In this section, we present three benchmarks: the first-best outcome, the outcome under exclusive contracting, and the constrained-efficient outcome.

#### 3.1 First Best

In the first-best outcome, all positive NPV projects are undertaken. It follows immediately from Assumption 1 that the first-best outcome is to undertake Project 0 at Date 0 and Project 1 at Date 1 if and only if  $X_1 = X_1^H$ . The next proposition gives the associated first-best expected surplus.

LEMMA 1. *In the first-best outcome, B undertakes Project 0 and undertakes Project 1 if and only if  $X_1 = X_1^H$ . The expected surplus is  $X_0 - I_0 + p(X_1^H - I_1)$ .*

#### 3.2 Exclusive Contracts

Assuming that exclusive contracts are feasible implies in particular that B can commit to borrow exclusively from a single creditor, i.e.  $C_1 = C_0$ .<sup>15</sup>

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<sup>15</sup>In fact, in our model, assuming exclusive contracts amounts to assuming B commits to borrow from a single creditor.

LEMMA 2. *With exclusive contracts, the first-best outcome obtains.*

The intuition is as follows. Assume B commits to borrowing only from  $C_0$ . In that case, B borrows at the fair price to fund each project he undertakes. This is because when B takes on debt at Date 1, he does so from  $C_0$ , and, thus, the interest rate that  $C_0$  charges on the new debt reflects its effect on the value of existing debt. As a result, B chooses to undertake only positive NPV projects, which leads to the first-best outcome.<sup>16</sup>

### 3.3 Planner's Problems

We now consider the outcomes a planner can implement given the limited pledgeability of cash flows and the seniority of secured debt.

LEMMA 3. *The planner can implement the efficient outcome by banning borrowing when  $X_1 = X_1^L$ .*

By banning new debt to  $C_1$  when  $X_1 = X_1^L$ , the planner implements efficiency. To do this, the planner must be able to observe and verify B's debt. Otherwise, B's ability to borrow privately puts an additional incentive constraint on the planner's problem, analogously to how the ability to engage in private trades puts additional incentive constraints on the planner's problem in the non-exclusive contracting literature (see, e.g., Bisin and Guaitoli (2004) or Attar and Chassagnon (2009)).<sup>17</sup>

LEMMA 4. *Suppose  $p = 0$  and the planner cannot prevent private borrowing.<sup>18</sup> If  $C_0$  must break-even, the planner cannot implement the efficient outcome.*

This is because, given limited pledgeability, the planner cannot satisfy B's incentive constraint and  $C_0$ 's break-even constraint simultaneously. This implies that it is non-exclusivity that prevents efficiency, rather than restrictions we impose on contractual forms (e.g. the restriction to debt).<sup>19</sup>

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<sup>16</sup>This intuition that with exclusive contracts B undertakes any and all positive NPV projects is a general feature of our environment, but the fact that the first-best outcome is achieved is not. In general, limited pledgeability alone could constrain B's borrowing, as we discuss further Subsection 6.2. However, this is ruled out in by Assumption 3, which ensures B always has enough pledgeable cash flow to finance positive NPV projects. Thus we focus on the inefficiencies of non-exclusivity (rather than of limited pledgeability).

<sup>17</sup>In particular, if private borrowing is possible, the relevant incentive constraint is that if,  $X_1 = X_1^L$ , B must prefer not to do Project 1 and to make any necessary transfers  $T$  to the planner than to borrow from  $C_1$  secured, do Project 1, and default:  $X_0 - T \geq \mu(1 - \theta)(X_0 + X_1^L)$ .

<sup>18</sup>We restrict attention to the special case in which  $p = 0$  for simplicity: since  $X_1$  is always  $X_1^L$  in this case, we avoid state-contingent incentive constraints for B not to borrow from  $C_1$  (see however Subsection 6.5).

<sup>19</sup>Indeed, if  $p = 0$ , the planner must collateralize Project 0 to prevent private borrowing, so the equilibrium surplus is  $\mu X_0 - I_0$ , which coincides with the equilibrium surplus given by equation (1) below (cf. Proposition 1).

## 4 Model Solution

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To characterize the equilibrium, we first solve two Date-0 subgames differing in whether B borrows via unsecured or secured debt at Date 0. Then we compare B's payoffs across subgames to find B's equilibrium choice of debt at Date 0.

### 4.1 Unsecured Debt to $C_0$

Suppose B borrows from  $C_0$  at Date 0 via unsecured debt with face value  $F_0$ . We focus on the case in which  $F_0 \geq I_0$  without loss of generality, since  $C_0$  must recoup (at least)  $I_0$  in expectation. We ask when B can borrow from  $C_1$  via unsecured or secured debt at Date 1.

**Unsecured debt to  $C_1$ .** In that case, the new debt to  $C_1$  is junior to the existing debt to  $C_0$ . Thus,  $C_1$  will lend to B via unsecured debt only if the projects' pledgeable cash flow  $\theta(X_0 + X_1)$  suffices to repay both  $I_1$  to  $C_1$  and  $F_0$  to  $C_0$ , or if

$$I_1 \leq \theta(X_0 + X_1) - F_0. \quad (8)$$

Given Assumption 3 and the fact that  $F_0 \geq I_0$ , this inequality is violated when  $X_1 = X_1^L$ .

LEMMA 5. *If B has unsecured debt to  $C_0$ , B cannot borrow unsecured from  $C_1$  if  $X_1 = X_1^L$ .*

**Secured debt to  $C_1$ .** In that case, this new debt to  $C_1$  is effectively senior to the existing debt to  $C_0$ . Thus, B can collateralize both Project 0 and Project 1 (or either one) and promise the pledgeable cash flow to  $C_1$ . As a result,  $C_1$  is willing to lend to B whenever

$$I_1 \leq \theta\mu(X_0 + X_1), \quad (9)$$

where the right-hand side is the pledgeable fraction  $\theta$  of the total cash flows  $X_0 + X_1$  net of the collateralization cost  $(1 - \mu)(X_0 + X_1)$ .

By borrowing from  $C_1$  via secured debt at Date 1, B can dilute his existing debt to  $C_0$ . This gives B the incentive to borrow and invest in Project 1 even when it has negative NPV.<sup>20</sup> Thus, B borrows at Date 1 whenever  $C_1$  is willing to lend to him, i.e. whenever his pledgeable cash flow is sufficiently high.

LEMMA 6. *If B borrows unsecured from  $C_0$  and  $X_1 = X_1^L$ , B borrows secured from  $C_1$  if and*

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<sup>20</sup>Assumption 4 ensures that the payoff  $X_1^L$  is large enough that B always wishes to dilute  $C_0$  to undertake Project 1. See the proof of Lemma 6 for the formal argument.

only if pledgeability is above a threshold

$$\theta^* := \frac{I_1}{\mu(X_0 + X_1^L)}. \quad (10)$$

In particular, this result implies that higher cash flow pledgeability loosens B's borrowing constraint at Date 1, to the point of allowing negative-NPV investments.

**Subgame equilibrium.** If pledgeability  $\theta$  is low, then B cannot borrow from  $C_1$  via secured debt if  $X_1 = X_1^L$  (Lemma 6). Without the risk of being diluted,  $C_0$  lends to B unsecured and B undertakes Project 1 only when it is efficient; he finances it by borrowing from  $C_1$  via unsecured debt (to avoid the collateralization cost). First best obtains.

If pledgeability  $\theta$  is high, then B can borrow from  $C_1$  via secured debt (Lemma 6) and dilute  $C_0$ 's debt whenever  $X_1 = X_1^L$ , which occurs with probability  $p$ . Whether  $C_0$  is willing to lend unsecured depends on  $p$ . If  $p$  is high,  $C_0$  is unlikely to be diluted and so is willing to lend unsecured at an interest rate compensating for dilution when  $X_1 = X_1^L$ . If  $p$  is low, however,  $C_0$  is so likely to be diluted that it never lends unsecured— $C_0$  cannot charge an interest rate high enough to compensate for dilution.

The next proposition summarizes B's equilibrium borrowing behavior, given that he borrows from  $C_0$  via unsecured debt.

LEMMA 7. Assume B can only borrow unsecured from  $C_0$  and define

$$\theta^{**} := \frac{I_1}{\mu X_0}, \quad (11)$$

$$p^* := \frac{I_0 + I_1 - \theta \mu (X_0 + X_1^L)}{\theta (X_0 + X_1^H) - \theta \mu (X_0 + X_1^L)} \in (0, 1), \quad (12)$$

$$p^{**} := \frac{I_0 + I_1 - \theta (\mu X_0 + X_1^L)}{\theta (X_0 + X_1^H) - \theta (\mu X_0 + X_1^L)} \in (0, p^*). \quad (13)$$

- If  $\theta \leq \theta^*$ , B borrows unsecured from  $C_0$ ; B borrows unsecured from  $C_1$  if  $X_1 = X_1^H$  and does not borrow if  $X_1 = X_1^L$ .
- If either  $\theta > \theta^*$  and  $p \geq p^*$  or  $\theta \geq \theta^{**}$  and  $p > p^{**}$ , B borrows unsecured from  $C_0$ ; B borrows unsecured from  $C_1$  if  $X_1 = X_1^H$  and secured if  $X_1 = X_1^L$ .
- Otherwise, B does not borrow from  $C_0$  or  $C_1$ .

We can now write B's expected payoff at Date 0. Since  $C_0$  and  $C_1$  break even in expectation, B captures the values of the projects he undertakes. Given B borrows unsecured from

$C_0$ , his payoff  $\Pi_B^u$  is given by:

$$\Pi_B^u = \begin{cases} X_0 - I_0 + p(X_1^H - I_1) & \text{if } \theta \leq \theta^*, \\ p(X_0 + X_1^H) + (1-p)(\mu(X_0 + X_1^L)) - I_0 - I_1 & \text{if } \theta^* < \theta < \theta^{**} \text{ and } p \geq p^*, \\ p(X_0 + X_1^H) + (1-p)(\mu X_0 + X_1^L) - I_0 - I_1 & \text{if } \theta \geq \theta^{**} \text{ and } p \geq p^{**}, \\ 0 & \text{otherwise.} \end{cases} \quad (14)$$

## 4.2 Secured Debt to $C_0$

Suppose B borrows from  $C_0$  via secured debt with face value  $F_0$ , again focusing on the case in which  $F_0 \geq I_0$ . We maintain the assumption that  $F_0 \leq \mu\theta X_0$ , and we verify that it holds in equilibrium later. We ask when B can borrow from  $C_1$  via unsecured or secured debt.

**Unsecured debt to  $C_1$ .** In that case, the new debt to  $C_1$  is junior to the existing debt to  $C_0$ . Thus,  $C_1$  will lend to B via unsecured debt only if the projects' pledgeable cash flow net of the collateralization cost suffices to repay  $I_1$  to  $C_1$  after having repaid  $F_0$  to  $C_0$ , or if

$$I_1 \leq \mu\theta X_0 - F_0 + \mu\theta X_1 = \mu\theta(X_0 + X_1) - F_0. \quad (15)$$

From Assumption 3 and the fact that  $F_0 \geq I_0$ , we have that if  $X_1 = X_1^L$ , the pledgeable cash flow that B has left after collateralizing Project 0 and repaying  $C_0$  is less than  $I_1$ . Hence we get the following.

LEMMA 8. *If B has secured debt to  $C_0$ , B cannot borrow unsecured from  $C_1$  if  $X_1 = X_1^L$ .*

**Secured debt to  $C_1$ .** B's ability to borrow from  $C_1$  via secured debt at Date 1 is limited, because B has already collateralized Project 0 to  $C_0$ , protecting  $C_0$ 's claim to its cash flows. Thus,  $C_1$  will lend to B via secured debt only if the pledgeable cash flow  $\mu\theta(X_0 + X_1)$  generated by the collateralized projects is sufficient to repay both  $I_1$  to  $C_1$  and  $F_0$  to  $C_0$ , or

$$I_1 \leq \mu\theta(X_0 + X_1) - F_0. \quad (16)$$

Note that this condition is more restrictive than equation (15), the condition for B to borrow from  $C_1$  via unsecured debt.

LEMMA 9. *If B has secured debt to  $C_0$ , B will not borrow secured from  $C_1$ .*

This is a result of the fact that if B borrows secured from  $C_0$ , then all new debt, secured or

unsecured, is effectively junior to  $C_0$ 's debt. As a result, B is better off borrowing unsecured from  $C_1$  than paying the cost  $(1 - \mu)X_1$  of collateralizing Project 1.

**Subgame equilibrium.** If B borrows secured from  $C_0$ , that debt is riskless because it has priority over Project 0's pledgeable cash flow. Thus, B can always set  $F_0 = I_0$  and, as a result, B can borrow unsecured from  $C_1$  if

$$I_1 \leq \theta(\mu X_0 + X_1) - I_0 \quad (17)$$

(i.e., if condition (15) holds for  $F_0 = I_0$ ). We can rewrite this condition as follows:

$$\mu \geq 1 - \frac{\theta(X_0 + X_1) - I_0 - I_1}{\theta X_0}. \quad (18)$$

Given that B never borrows from  $C_1$  via secured debt (Lemma 9) and never borrows from  $C_1$  if the payoff of Project 1 is low (Lemma 8), we can fully characterize B's Date-1 borrowing.

LEMMA 10. *If B has secured debt to  $C_0$  with face value  $I_0$ , B borrows from  $C_1$  if and only if  $X_1 = X_1^H$  and collateralizability is above a threshold  $\mu^*$ , given by*

$$\mu^* := 1 - \frac{\theta(X_0 + X_1^H) - I_0 - I_1}{\theta X_0}. \quad (19)$$

We can now characterize the subgame's equilibrium.

LEMMA 11. *Assume B can only borrow secured from  $C_0$ .*

- *If  $\mu \geq \mu^*$ , B borrows secured from  $C_0$ ; B borrows unsecured from  $C_1$  if  $X_1 = X_1^H$  and does not borrow from  $C_1$  if  $X_1 = X_1^L$ .*
- *If  $\mu < \mu^*$ , B borrows secured from  $C_0$  and B does not borrow from  $C_1$ .*

We can now write B's expected payoff at Date 0. Given  $C_0$  and  $C_1$ 's zero-profit condition, B captures the value of the projects he undertakes and his payoff is

$$\Pi_B^s = \begin{cases} \mu X_0 - I_0 + p(X_1^H - I_1) & \text{if } \mu \geq \mu^*, \\ \mu X_0 - I_0 & \text{otherwise.} \end{cases} \quad (20)$$

### 4.3 Equilibrium Borrowing

In equilibrium, B borrows from  $C_0$  unsecured if  $\Pi_B^u \geq \Pi_B^s$  and secured otherwise. B's equilibrium choice of debt instrument follows from comparing the expression for  $\Pi_B^u$  in equation (14) with that for  $\Pi_B^s$  in equation (20).



PROPOSITION 1.

- If  $\theta \leq \theta^*$ ,  $B$  borrows unsecured from  $C_0$ .
- If either

$$\theta^* < \theta < \theta^{**} \ \& \ p < p^* \quad \text{or} \quad \theta \geq \theta^{**} \ \& \ p < p^{**}, \quad (21)$$

$B$  borrows secured from  $C_0$ .

- Otherwise,  $B$ 's equilibrium choice of debt depends on the relative inefficiencies of unsecured and secured debt:  $B$  borrows unsecured from  $C_0$  if

$$p(1-\mu)X_0 + pX_1^H + (1-p)[1 - (1-\mu)\mathbb{1}_{\{\theta^* < \theta < \theta^{**}\}}]X_1^L - I_1 \geq \mathbb{1}_{\{\mu \geq \mu^*\}}p(X_1^H - I_1) \quad (22)$$

and secured otherwise.

This implies that  $B$  may have a mix of different types of debt in equilibrium, with secured debt to one creditor and unsecured debt to the other.

COROLLARY 1. *Suppose that  $\theta > \theta^*$ , secured and unsecured debt coexist in equilibrium.*

## 5 Welfare and Policy

In this section, we first show that the first-best outcome obtains in equilibrium if and only if pledgeability is sufficiently *low*—there is a “paradox of pledgeability.” We then show that borrowing via unsecured debt leads to over-investment and borrowing via secured debt leads to under-investment—there is a “collateral overhang” problem. Finally, we suggest that expanding the supply of collateral may have adverse effects, because it can induce a “collateral rat race.”

### 5.1 The Paradox of Pledgeability

Since creditors  $C_0$  and  $C_1$  are competitive,  $B$ 's equilibrium payoff  $\Pi_B = \max\{\Pi_B^u, \Pi_B^s\}$  coincides with the equilibrium surplus. We can now compare the equilibrium surplus with the first-best surplus.

PROPOSITION 2. (PARADOX OF PLEDGEABILITY.) *The first-best level of surplus is attained if and only if pledgeability is low enough, i.e., if  $\theta \leq \theta^*$ .*

The intuition is as follows. An increase in pledgeability  $\theta$  allows  $B$  to pledge more of his cash flows to  $C_1$ , making  $C_1$  more willing to lend. This makes it easier for  $B$  to take on new debt

to  $C_1$ . However, this new debt may dilute B's existing debt to  $C_0$ , making  $C_0$  unwilling to lend—increasing pledgeability makes it easier to borrow at Date 1 and, hence, paradoxically, makes it harder to borrow at Date 0.<sup>21</sup> This result follows from the non-exclusivity friction: when B borrows from  $C_0$ , he cannot commit not to borrow from  $C_1$ . When pledgeability is low, this friction does not induce an inefficiency because B is too constrained to borrow from  $C_1$  when  $X_1 = X_1^L$ —low pledgeability makes B's contract with  $C_0$  effectively exclusive, by allowing B to commit not to borrow from  $C_1$  to dilute  $C_0$ 's debt. Not so when pledgeability is high.

Note that in general, very low pledgeability would prevent borrowing at Date 0. This inefficient outcome is ruled out by Assumption 3 (see Subsection 6.2).

## 5.2 Collateral Rat Race

We now turn to the inefficiency of borrowing via unsecured debt, which arises for high pledgeability. If B borrows unsecured from  $C_0$  and pledgeability is high, B can dilute  $C_0$ 's debt by borrowing secured from  $C_1$  (Lemma 6). As a result, B's investment in Project 1 is subsidized, since B funds it via secured debt to a new creditor,  $C_1$ , at the expense of his old creditor,  $C_0$ . In other words, undertaking Project 1 is a way for B to syphon off cash flows from  $C_0$ . This subsidy distorts B's incentives, inducing B to undertake Project 1 when  $X_1 = X_1^L$ , even though it has negative NPV.

LEMMA 12. *Suppose  $\theta > \theta^*$ . If B borrows unsecured from  $C_0$ , B over-invests in Project 1 when  $X_1 = X_1^L$ .*

The resulting inefficiency may be so severe that  $C_0$  is unwilling to lend unsecured, even though Project 0's pledgeable cash flow exceeds its investment cost— $\theta X_0 > I_0$  (Assumption 2).

PROPOSITION 3. (COLLATERAL RAT RACE.) *If condition (21) is satisfied, B's secured borrowing from  $C_0$  results form a collateral rat race: if B could commit not to borrow secured from  $C_1$ ,  $C_0$  would lend unsecured to B.*

The intuition is as follows. When pledgeability is high, B would fund the low-return Project 1 by borrowing secured from  $C_1$  to dilute his unsecured debt to  $C_0$ . B repays  $C_1$  in full, but

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<sup>21</sup>It is worth emphasizing that this argument relies on the fact that Project 1 has a fixed scale. If B could do a perfectly scalable version of Project 1, he could always do it on a small scale and therefore dilute  $C_0$ . With this version of Project 1, B's ability to dilute  $C_0$  does not depend on  $\theta$ —in this version, collateral is still used in high pledgeability environments, but may not be used more than in low pledgeability environments. However, as long as there is some fixed cost of starting up a project or, alternatively, of issuing, collateralizing, or foreclosing on debt, this paradox of pledgeability still holds.

defaults on his debt to  $C_0$ . Hence,  $C_0$  requires collateral to protect against this. In other words, collateralization is required at Date 0 to protect against collateralization at Date 1: there is a collateral rat race.

This suggests that the ability to use collateral can create a friction when it allows a borrower to *selectively* enter into an exclusive contract. This rat race can lead to inefficient underinvestment, as we discuss in the next subsection.

### 5.3 Collateral Overhang

We now turn to the inefficiency of borrowing via secured debt, which arises for high pledgeability. If B borrows secured from  $C_0$ , B pays the collateralization cost  $(1 - \mu)X_0$ . This cost decreases the surplus to a level below the first-best and its effects can be amplified in equilibrium because, by collateralizing his project to  $C_0$ , B uses up his pledgeable cash flow and thus makes it more difficult to borrow from  $C_1$ . In other words, there is a *collateral overhang*, by which collateralizing his project at Date 0 prevents B from borrowing at Date 1. As a result, B may not undertake Project 1, even when it is efficient to do so. Figure 2 depicts which inefficiency arises for different values of the parameters  $\theta$  and  $p$ .

PROPOSITION 4. (COLLATERAL OVERHANG.) *If  $\mu \geq \mu^*$ , collateralizing Project 0 can prevent B from undertaking an efficient Project 1.*

Observe that this collateral overhang kicks in only when collateralizability is below the threshold  $\mu^*$ . This may seem to suggest that a policy maker should increase collateralizability to prevent this distortion. However, we show next that in fact decreasing collateralizability can increase the surplus.

Figure 1: INVESTMENT EFFICIENCY (FOR  $\theta^{**} > 1$ )

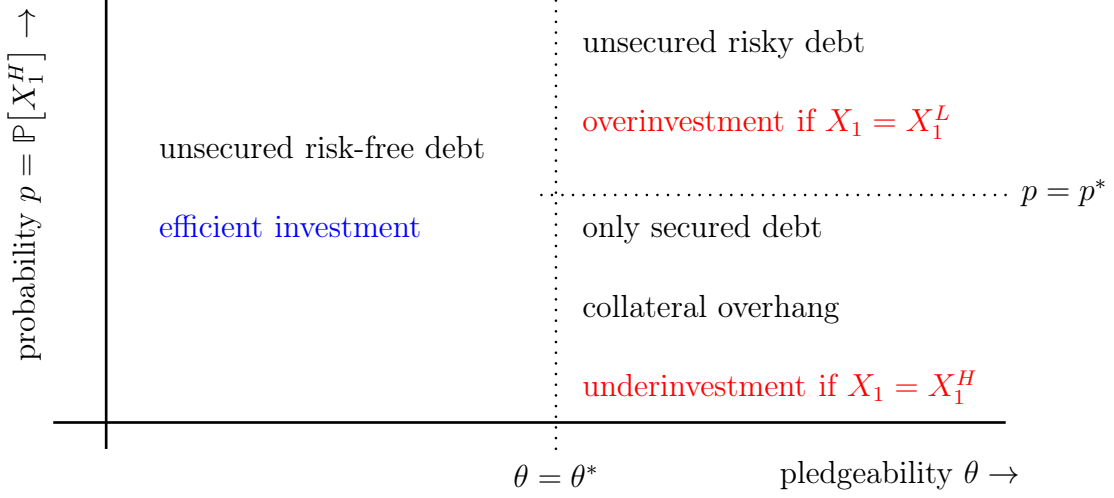


Figure 2: The figure above illustrates B's investment decisions as a function of  $\theta$  and  $p$ . For illustrative purposes, we restrict attention to the case in which  $\theta^{**} > 1$ . For  $\theta < \theta^*$ , B takes the efficient action. For  $\theta \geq \theta^*$ , B over-invests in Project 1 if  $p \geq p^*$  and underinvests in Project 1 if  $p < p^*$  (cf. Lemma 12 and Proposition 4).

#### 5.4 Collateral Shortage or Collateral Glut?

We now turn to the effects of varying the collateralizability  $\mu$  on the surplus.

**PROPOSITION 5.** *If collateralization is banned, i.e.  $\mu = 0$ , the first-best outcome is attained in equilibrium.*

The intuition is as follows. For  $\mu$  sufficiently low, B cannot collateralize his projects to borrow secured from  $C_1$ . As a result, B cannot undercut  $C_0$ 's debt and B's contract with  $C_0$  is effectively exclusive. This leads to the first-best outcome (as in Lemma 2).

This result may cast light on some aspects of the policy debate about which financial assets may be used as collateral in interbank markets as well as how such collateral should be treated in bankruptcy. Within our model, an increase in  $\mu$  corresponds to an increase in the ease with which assets can be collateralized or to an increase in the total supply of assets that can be used as collateral.<sup>22</sup>

<sup>22</sup>We view the supply of collateral in the model as the total cash flow that can be used to borrow secured. This is  $\mu\theta(X_0 + X_1)$ . This is increasing in  $\mu$ , suggesting an increase in  $\mu$  corresponds to an increase in the supply of collateral.

Notably, the special bankruptcy treatment of repo collateral, which makes it effectively super-senior in bankruptcy, corresponds to an increase in  $\mu$ , since it makes collateralized assets more valuable to creditors. The set of assets eligible for special treatment was expanded in 2005, effectively increasing the supply of repo collateral. Despite this effective increase in the supply of collateral, markets perceived a shortage of collateral. As Caballero (2006) puts it, “The world has a shortage of financial assets. Asset supply is having a hard time keeping up with the global demand for...collateral” (p. 272). Within our model, an increase in  $\mu$  can also lead to a high dependence on collateral. It makes it easier for B to borrow secured at Date 1, which triggers the collateral rat race, so he must borrow collateralized at Date 0.

## 6 Extensions and Robustness

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In this section, we analyze extensions of our model and confirm the robustness of our main results. First, we argue that covenants restricting borrowing from third parties may be ineffective, especially for banks.

Second, we analyze a model in which collateral mitigates enforcement problems both between borrowers and creditors and among creditors. Third, we show that the cost  $(1 - \mu)$  of ring-fencing has an equivalent interpretation as an exogenous haircut on secured debt. Fourth, we relax the assumption that B borrows from  $C_0$  via two-period debt. Fifth, we study how security design might affect our results, allowing for contingent contracts as well as simple debt. Sixth, we relax the assumption that existing unsecured debt is senior to new unsecured debt.

### 6.1 Covenants

In this subsection, we discuss the potential use of covenants in our model. We suggest that even though covenants may be effective to mitigate the friction of non-exclusive contracting in some circumstances, their ability to prevent a borrower from taking on new *secured* debt is limited.

The inefficiencies in our model come from the fact that the borrower cannot commit not to dilute its existing debt with new debt, i.e. that contracts are non-exclusive. In reality, debt contracts have so-called “negative pledge covenants,” by which a borrower promises its creditor not to borrow from other creditors via secured debt. If such commitments were binding, they could restore efficiency in our model. However, the effectiveness of such covenants is limited in practice. This is because an unsecured creditor holds a claim against only the borrower, not against other creditors. Thus, an unsecured creditor cannot recover

collateral that has been seized by a secured creditor. Bjerre (1999) describes these legal restrictions as follows:

the negative pledge covenant [is a covenant] by which a borrower promises its lender that it will not grant security interests to other lenders. These covenants are common in unsecured loan agreements because they address one of the most fundamental concerns of the unsecured lender: that the borrower's assets will become unavailable to repay the loan, because the borrower will have both granted a security interest in those assets to a second lender and dissipated the proceeds of the second loan. Unfortunately, negative pledge covenants' prohibition of such conduct may be of little practical comfort, because as a general matter they are enforceable only against the borrower, and not against third parties who take security interests in violation of the covenant. Hence, when a borrower breaches a negative pledge covenant, the negative pledgee generally has only a cause of action against a party whose assets are, by hypothesis, already encumbered (pp. 306–307).

The effectiveness of these negative pledge covenants in bankruptcy is especially limited for repo and derivatives liabilities, since these contracts are exempt from automatic stay in bankruptcy—i.e. creditors can liquidate collateral without the approval of the bankruptcy court, making it difficult or impossible for any third party to enforce a claim to the collateral.

Negative pledge covenants may still be useful outside bankruptcy. This is because their violation constitutes a default, and a borrower may adhere to the terms of covenants to avoid a default.<sup>23</sup> However, this may be insufficient to prevent a borrower from taking on debt in general. For example, a borrower in financial distress is likely to default anyway and is therefore willing to violate such covenants to gamble for resurrection by taking on new debt. More generally, it can be difficult to verify that a solvent firm has violated a covenant, especially for complex firms like banks, which may have thousands of counterparties. Indeed, banks effectively do not have to disclose their short-term borrowing:

There are no specific MD&A requirements to disclose intra-period short-term borrowing amounts, except for [some] bank holding companies [that must] disclose on an annual basis the average, maximum month-end and period-end amounts of short-term borrowings (Ernst & Young (2010)).

There is another reason that banks in particular may not be able to promise not to dilute existing debt with new debt: the very business of banking constitutes maturity and

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<sup>23</sup>Other theory papers have shown how such covenants can mitigate incentive problems in some contexts. E.g., Rajan and Winton (1995) show that they give creditors greater incentive to monitor and Gârleanu and Zwiebel (2009) show that they help to allocate decision rights efficiently given asymmetric information.

size transformation, which requires frequent short-term borrowing from many creditors. If a bank agrees to covenants that restrict its ability to borrow in the future, it could undermine its ability to engage in these banking activities. As Bolton and Oehmke (2015) put it:

debt covenants prohibiting the collateralization...are likely to be...costly to enforce...for financial institutions.... By the very nature of their business, financial institutions cannot assign...collateral to all depositors and creditors, because this would, in effect, erase their value added as financial intermediaries (p. 2356).

This reinforces the idea that non-exclusive contracting is an especially important friction for banks and, therefore, it may add credibility to our thesis that non-exclusive contracting is the reason that interbank markets are heavily reliant on collateral.

## 6.2 The Two Roles of Collateral

In reality, collateral serves to mitigate enforcement problems both between borrowers and creditors by providing creditors the “right to use” (i.e. to seize the assets used as) collateral and among creditors by providing some creditor the “right to exclude” others from using (i.e. seizing the assets used as) collateral. Whereas much of the finance literature has focused on the first role of collateral, we focus on the second. In this subsection, we briefly discuss a model in which collateral plays both roles. We show that the “right to use” collateral dominates for low pledgeability, whereas the “right to exclude” others from using collateral dominates for high pledgeability.

Consider the following extension of the baseline model. The proportion of pledgeable cash flows is  $\theta^s := s\theta$  if B borrows secured and  $\theta^u := u\theta$  if B borrows unsecured. We assume not only that collateralization establishes exclusivity, as in the baseline model, but also that collateralization increases pledgeability, i.e. that  $\mu\theta^s > \theta^u$  which amounts to  $\mu s > u$ .

We focus on the case in which B always has sufficient pledgeable cash flow to fund Project 0 via secured debt, i.e.  $\mu\theta^s X_0 > I_0$ . Further, for simplicity, we assume that  $p = 0$ , so  $X_1 = X_1^L$  for sure, but B wants to undertake Project 1 anyway, to benefit from diluting  $C_0$ .<sup>24</sup>

**PROPOSITION 6.** *B borrows secured from  $C_0$  whenever  $\theta$  is sufficiently small or sufficiently large, i.e.*

$$\theta < \frac{I_0}{uX_0} \quad \text{or} \quad \theta \geq \frac{I_1}{\mu s(X_0 + X_1^L)}. \quad (23)$$

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<sup>24</sup>We take B’s incentive to undertake Project 1 as an assumption here (cf. footnote 30). This is just for simplicity, however. An assumption analogous to Assumption 4 would generate this endogenously, as in the baseline model (Lemma 7).

For low  $\theta$ , B borrows with collateral to increase his pledgeable cash flow—otherwise he could not borrow from  $C_0$  to get Project 0 off the ground. For high  $\theta$ , B borrows with collateral to offer protection against the claims of other creditors—otherwise he could borrow from  $C_1$  with collateral, diluting  $C_0$ 's debt, as in the baseline model.

### 6.3 Collateralization Cost as a Haircut

So far, we have interpreted the cost of collateralization as the cost of ring-fencing assets to protect them from a third party (Subsection 2.2). This cost is important for our collateral overhang result (Proposition 4): because B must pay the cost  $(1 - \mu)X$  to collateralize  $X$ , collateralization uses up B's pledgeable cash flow. This inhibits his ability to borrow in the future. However, this mechanism is not specific to our interpretation of collateralization as costly ring-fencing. One equivalent interpretation is that B must post a haircut on collateralized debt. To see this, suppose that, in order to borrow  $I$ , B must post collateral worth  $(1 + m)I > I$ . Here,  $m$  corresponds to the “margin” and  $mI$  corresponds to the haircut. Thus, B can borrow  $I$  against a project with cash flow  $X$  if its collateral value  $\theta X$  exceeds  $I$  plus the haircut  $mI$ , i.e. if  $\theta X \geq (1 + m)I$  or

$$I \leq \frac{\theta X}{1 + m}. \quad (24)$$

This implies that having to post a haircut  $mI$  is equivalent to having to pay the cost of ring-fencing  $1 - \mu$ . In fact, if the margin  $m = (1 - \mu)/\mu$ , then the constraint becomes

$$I \leq \frac{\theta X}{1 + m} = \mu \theta X, \quad (25)$$

which is just B's constraint to borrow via secured debt in the baseline model.

This analysis implies that posting a haircut leads to the collateral-overhang problem just as costly ring-fencing does. Even though B does not pay a deadweight cost to post a haircut like he does to “build” a costly ring-fence, B uses up pledgeable cash flow to post the haircut  $mI$ , which tightens his borrowing constraints in the future, potentially leading to underinvestment.

### 6.4 Short-term Debt

Another possibility we have not considered so far is short-term debt: B could borrow from  $C_0$  via one-period debt and roll over. In this subsection, we show that if debt renegotiation-proofness implies short-term debt cannot improve upon the outcome of the baseline model.



Here we augment the model and suppose that  $C_0$  can lend to  $B$  via short-term debt maturing at the end of Date 1, i.e. after  $B$  has (potentially) borrowed from  $C_1$  and invested in Project 1. Further, we assume that the debt is subject to renegotiation at Date 1. Specifically, after the debt matures,  $B$  can either repay  $C_0$  or offer  $C_0$  an alternative repayment, e.g. he can offer a rescheduling of the debt, so that he repays at Date 2 instead of Date 1.<sup>25</sup> If  $C_0$  accepts  $B$ 's offer to renegotiate the debt, then  $B$  continues his projects. If  $C_0$  rejects  $B$ 's offer, then  $C_0$  has the right to liquidate. We assume that the Date-1 liquidation value of  $B$ 's assets is zero.

*PROPOSITION 7. Suppose  $B$  borrows from  $C_0$  via short-term debt. If  $B$  borrows from  $C_1$  via secured debt and invests in Project 1 at Date 1, then  $C_0$  prefers to accept a rescheduling of his debt than to liquidate  $B$ 's assets. I.e. renegotiation-proof short-term debt does not improve on the implementation of long-term contracts.*

## 6.5 Contingent Debt

So far we have restricted attention to debt contracts, viz. contracts in which the promised repayment is non-contingent. In this subsection, we show that our main results also hold for contingent contracts.<sup>26,27</sup> The inefficiencies in our model result from the fact that contracts are non-exclusive, not that they are incomplete (cf. the exclusive contracting benchmark in Subsection 3.2 and Subsection 3.3).<sup>28</sup> We focus on debt contracts for simplicity and realism.

Now suppose that  $B$  borrows from  $C_0$  via unsecured contingent debt, i.e.  $B$  borrows  $I_0$  from  $C_0$  in exchange for the contingent repayments  $F_0^H$  when  $X_1 = X_1^H$  and  $F_0^L$  when  $X_1 = X_1^L$ . If the payoff of Project 1 is low, i.e.  $X_1 = X_1^L$ , then  $B$  has the incentive to borrow from  $C_1$  via secured debt, diluting  $C_0$ 's debt.<sup>29</sup> In this event,  $C_0$  is not repaid in

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<sup>25</sup>If  $B$  and  $C_0$  can also renegotiate *before*  $B$  borrows from  $C_1$ , then  $C_0$  can write down  $B$ 's debt to disincentivize dilution when  $X_1 = X_1^L$ . This can implement the outcome of contingent debt, as discussed in footnote 26.

<sup>26</sup>The results in this subsection imply not only that our results are robust to contingent contracts, but also that they are robust to renegotiable debt: any outcome of renegotiation between  $B$  and  $C_0$  at Date 1 can be implemented via contracting contingent on Date-1 information (viz. on the realization of  $X_1$ ).

<sup>27</sup>It may be worth noting that we analyze only contingent repayments here, not contingent collateralization. However, our results are also robust to contingent collateralization—i.e.  $B$  would collateralize his project to  $C_0$  only if pledgeability is sufficiently high—but with the caveat that  $B$  collateralizes only when  $X_1 = X_1^L$ , not when  $X_1 = X_1^H$ . This is because  $C_0$  is effectively never diluted when  $X_1 = X_1^H$  and thus does not require collateral to protect against dilution.

<sup>28</sup>This finding that the “collateral overhang” of secured credit cannot be resolved by contingent contracting/renegotiation complements Bhattacharya and Faure-Grimaud's (2001) finding that when a firm's investments are non-contractible, renegotiation between borrowers and creditors may not resolve the debt-overhang problem.

<sup>29</sup>This will be feasible whenever pledgeability is high,  $\theta \geq \theta^*$ , as in Lemma 6, which holds independently of whether debt is contingent or not.

full (Assumption 2). In the baseline analysis,  $C_0$  must require collateral to protect against being diluted. Now, with contingent debt,  $C_0$  can protect against being diluted in another way:  $C_0$  can lower the repayment  $F_0^L$  when  $X_1 = X_1^L$ . In particular, if  $F_0^L$  is sufficiently low, then the benefits of diluting  $C_0$ —and thus avoiding repaying  $F_0^L$ —may not compensate for the costs of doing a negative-NPV investment. In other words, if B's promised repayment to  $C_0$  is sufficiently low, then it may be incentive compatible for B not to borrow from  $C_1$ .<sup>30</sup> Formally, B's payoff from not borrowing from  $C_1$  and repaying  $F_0^L$  to  $C_0$  must exceed his payoff from borrowing from  $C_1$ , diverting the fraction  $(1-\theta)$  of his cash flows, and defaulting, i.e. the following incentive constraint must be satisfied<sup>31</sup>

$$X_0 - F_0^L \geq (1-\theta)\mu(X_0 + X_1^L). \quad (26)$$

This constraint imposes an upper bound on the repayment  $F_0^L$ :

$$F_0^L \leq X_0 - (1-\theta)\mu(X_0 + X_1^L). \quad (27)$$

This expression is less than the cost  $I_0$  of Project 0. This implies that for any incentive-compatible contract,  $C_0$  is not repaid as much as it lent when  $X_1 = X_1^L$  (given that  $\theta$  is high enough that B can borrow from  $C_1$ ). So  $C_0$  is repaid in full only with probability  $p$ , i.e. in the event that  $X_1 = X_1^H$ . Hence, if  $p$  is sufficiently low,  $C_0$  will not lend to B via unsecured contingent debt, but rather will require collateral. This implies that our main results are robust to allowing for contingent contracts, as the next proposition summarizes.

PROPOSITION 8. *Suppose that  $p$  is relatively small,<sup>32</sup>*

$$p < p^{\text{c.d.}} := \frac{I_0 - \left( X_0 - (1-\theta)\mu(X_0 + X_1^L) \right)}{\theta(X_0 + X_1^H) + (1-\theta)\mu(X_0 + X_1^L) - X_0 - I_0}. \quad (28)$$

- *If  $\theta \leq \theta^*$  as defined in equation (10), then B borrows from  $C_0$  via unsecured risk-free debt with face value  $F_0^u = I_0$ ; B borrows from  $C_1$  via risk-free unsecured debt if  $X_1 = X_1^H$ , and does not borrow from  $C_1$  if  $X_1 = X_1^L$ .*

*The first-best surplus is attained in equilibrium.*

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<sup>30</sup>Note that, with the current setup, contingent contracting can only help insofar as it decreases B's incentive to undertake Project 1 when  $X_1 = X_1^L$ . However, it might also be reasonable to assume that B always wants to undertake new projects, e.g. because he gets private benefits from empire building as in Hart and Moore (1995). Under this alternative assumption, allowing for contingent debt does not change the baseline analysis.

<sup>31</sup>We restrict attention to the case in which  $I_1 < \theta\mu X_0$ , so that B must collateralize both projects to borrow from  $C_1$ . We do this just to keep the analysis streamlined and not consider two separate cases.

<sup>32</sup>The cutoff  $p^{\text{c.d.}}$  in equation (8) is always between zero and one by Assumption 3 and Assumption 4.

- If  $\theta > \theta^*$  and  $p < p^{\text{c.d.}}$ , then  $B$  cannot borrow from  $C_0$  via unsecured debt (even if the debt is contingent).

## 6.6 Pari Passu Debt

We now argue that our result that increasing pledgeability leads to more collateralized borrowing—the paradox of pledgeability—does not depend on the assumption that new unsecured debt is effectively senior to old unsecured debt. Increasing pledgeability can increase the use of collateral even if collateral is not used to establish priority over existing debt. The result obtains as long as taking on new debt has some negative effect on old debt.<sup>33</sup> We show this by considering the case of pari passu debt in detail.

Here we focus on the case in which all unsecured debt is treated equally (pari passu). Consider the following twist on the baseline model. At Date 1,  $B$  cannot borrow from  $C_1$  via secured debt, for example because it is too late to collateralize assets or because secured debt is not legally prioritized over existing debt. But  $B$  can borrow from  $C_1$  via pari passu unsecured debt, i.e. if  $B$  defaults with unsecured debt to  $C_0$  with face value  $F_0$  and unsecured debt to  $C_1$  with face value  $F_1$ , each creditor is repaid a pro rata fraction of  $B$ 's pledgeable cash flows. Thus, if  $B$  defaults after undertaking both Project 0 and Project 1, the repayment to  $C_t \in \{C_0, C_1\}$  is as follows:

$$\text{repayment to } C_t = \frac{F_t}{F_0 + F_1} \theta (X_0 + X_1). \quad (29)$$

If  $B$  undertakes Project 1 when  $X_1 = X_1^L$ ,  $B$ 's portfolio of projects  $X_0 + X_1$  does not generate sufficient pledgeable cash flow to cover the costs of the projects  $I_0 + I_1$  (Assumption 3), so  $B$  must default. However,  $B$  may still be able to borrow from  $C_1$  via unsecured debt by diluting his debt to  $C_0$ . Specifically,  $B$  can borrow from  $C_1$  whenever the repayment it receives in the event of default is greater than  $I_1$ . Using equation (29) above, this says that, given  $X_1 = X_1^L$ ,  $B$  can borrow  $I_1$  from  $C_1$  via debt with face value  $F_1$  as long as

$$\theta \geq \frac{F_0 + F_1}{F_1} \frac{I_1}{X_0 + X_1^L}. \quad (30)$$

Here,  $B$  promises  $C_1$  a high face value  $F_1$  to dilute  $C_0$ 's claim, effectively subsidizing  $B$ 's investment in Project 1, just as in the baseline case with secured borrowing. This is feasible if  $B$  can offer  $C_1$  a sufficiently high face value  $F_1$  to ensure  $C_1$  is repaid in full even in the event of default (even though  $C_1$ 's debt is not prioritized in bankruptcy). In other words,

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<sup>33</sup>Even so, we argue in Subsection 6.1 above, that our results apply most pertinently in the baseline case, in which new secured debt does have priority over old unsecured debt.

despite the fact that  $C_0$  is supposedly on equal footing with  $C_1$  in bankruptcy,  $C_1$ 's debt has diluted  $C_0$ 's debt so severely that  $C_1$ 's debt is in fact risk free. Mathematically, B can borrow from  $C_1$  as long as  $F_1$  is sufficiently high to satisfy inequality (30). Since  $(F_0 + F_1)/F_1 \rightarrow 1$  as  $F_1 \rightarrow \infty$ , inequality (30) is satisfied if and only if pledgeability  $\theta$  is sufficiently large, or

$$\theta > \theta^{\text{p.p.}} := \frac{I_1}{X_0 + X_1^L}. \quad (31)$$

Thus, if pledgeability is sufficiently high, B borrows from  $C_1$  via unsecured debt. We can solve for the face value by setting the repayment to  $C_1$  equal to  $I_1$  in equation (29):

$$F_1 = \frac{I_1 F_0}{\theta (X_0 + X_1^L) - I_1}. \quad (32)$$

Observe that B defaults on his debt to  $C_1$  and repays  $I_1 < F_1$ . However, the debt is still “risk free” in the sense that  $C_1$  has a deterministic return equal to the risk-free rate (zero).

Now turn to B's debt to  $C_0$ . Since  $C_1$  is always repaid  $I_1$ , the repayment to  $C_0$  if  $X_1 = X_1^L$  is given by the total pledgeable cash flow  $\theta(X_0 + X_1^L)$  less the repayment  $I_1$  that is made to  $C_1$  (supposing that it is positive), i.e.

$$\text{repayment to } C_0 = \theta (X_0 + X_1^L) - I_1. \quad (33)$$

This is less than  $I_0$  by Assumption 2. Thus, if B borrows from  $C_0$  via unsecured debt, B repays  $C_0$  less than  $I_0$  whenever  $X_1 = X_1^L$ . Thus, if the probability  $1 - p$  that  $X_1 = X_1^L$  is high,  $C_0$  is rarely repaid. As a result,  $C_0$  will not lend to B via unsecured debt, but only via secured debt. In other words, the paradox of pledgeability also holds with pari passu debt. This is the next proposition.

PROPOSITION 9. *Suppose that  $p$  is relatively small,<sup>34</sup>*

$$p < p^{\text{p.p.}} := \frac{I_0 + I_1 - \theta (X_0 + X_1^L)}{\theta (X_1^H - X_1^L)}. \quad (34)$$

- *If  $\theta \leq \theta^{\text{p.p.}}$  as defined in equation (31), then B borrows from  $C_0$  via unsecured risk-free debt with face value  $F_0^u = I_0$ ; B borrows from  $C_1$  via risk-free unsecured debt if  $X_1 = X_1^H$  and does not borrow from  $C_1$  if  $X_1 = X_1^L$ .*

*The first-best surplus is attained in equilibrium.*

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<sup>34</sup>The cutoff  $p^{\text{p.p.}}$  in equation (34) equals the cutoff  $p^*$  in equation (12) if collateralizability  $\mu = 1$ . This reflects the fact that pari passu debt allows B to effectively prioritize  $C_1$ 's debt without bearing the cost of collateralization. It follows from Assumption 2 that the cutoff is always between zero and one.

- If  $\theta > \theta^{\text{P.P.}}$ , then  $B$  cannot borrow from  $C_0$  via unsecured debt.

This result demonstrates that the driving force in our model is not the borrower’s ability to use collateral to establish priority over existing debt, but rather the borrower’s ability to take on new debt more generally, i.e. the fact that contracts are non-exclusive. However, in reality creditors take contractual measures to approximate exclusive relationships with their borrowers. Notably, they impose covenants in debt contracts that restrict future borrowing. These covenants offer limited protection against future *secured* borrowing, however, for reasons we discuss above.

## 7 Conclusion

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We have considered a model in which collateral serves to protect creditors against dilution with new debt. High pledgeability increases the risk of dilution, since it makes it easy to take on new secured debt and thus, paradoxically, makes creditors less willing to lend unsecured. Collateralization is required to protect against future collateralization—there is a collateral rat race.

This reliance on collateral leads to a collateral overhang problem, whereby collateralized assets are encumbered and cannot be used to raise liquidity. We find that decreasing the supply of collateral or deviating from the absolute priority rule may mitigate this problem, by preventing the collateral rat race from getting started.

## Proofs

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### Proof of Lemma 1

The argument is in the text. □

### Proof of Lemma 2

Suppose B borrows from  $C_0$  at the risk-free rate,  $F_0 = I_0$ . Since the contract with  $C_0$  is exclusive, B must borrow from  $C_0$  at Date 1. By Assumption 2, B can borrow from  $C_1 = C_0$  if and only if  $X_1 = X_1^H$ , since  $C_0$  lends at Date 1 only if its total surplus from the *two* loans increases. Thus, B can undertake Project 1 if and only if  $X_1 = X_1^H$ . In summary, B invests in Project 0 and invests in Project 1 when  $X_1 = X_1^H$ . □

### Proof of Lemma 3

The result is immediate: if the planner bans borrowing when  $X_1 = X_1^L$ , B does Project 0 unsecured and Project 1 unsecured when  $X_1 = X_1^H$  as in Lemma 2. □

### Proof of Lemma 4

Suppose (in anticipation of a contradiction) that the planner implements the efficient outcome, i.e. that B does Project 0 unsecured and does not do Project 1.

Let  $T$  be the total transfer B makes to the planner at Date 2. In order for  $C_0$  to break even, it must be that

$$T \geq I_0. \tag{35}$$

Now, B's no-private-borrowing incentive constraint reads

$$X_0 - T \geq \mu(1 - \theta)(X_0 + X_1^L), \tag{36}$$

which says that B must prefer to do only Project 0 (the efficient outcome) than to borrow secured to do Project 1 and divert the fraction  $(1 - \theta)$  of output. But combining equations (35) and (36) implies that

$$X_0 - I_0 \geq \mu(1 - \theta)(X_0 + X_1^L), \tag{37}$$

which violates Assumption 4, a contradiction. □

## Proof of Lemma 5

The argument is in the text. □

## Proof of Lemma 6

Suppose B borrows from  $C_0$  via unsecured debt with face value  $F_0$ . If  $X_1 = X_1^L$ , unsecured borrowing from  $C_1$  is impossible (by Lemma 5), but secured borrowing is possible provided condition (9) holds, i.e. if  $\theta > \theta^*$ . To prove that B borrows secured from  $C_1$  when  $\theta > \theta^*$ , we compare B's payoff from doing so with his payoff from not borrowing from  $C_1$ .

If B borrows secured from  $C_1$  the pledgeable cash flows are insufficient to repay both  $C_0$  and  $C_1$ , so he defaults (by Assumption 3). If B does not borrow from  $C_1$ , B defaults if  $\theta X_0 < F_0$  and does not otherwise, so he gets  $\max \{(1 - \theta)X_0, X_0 - F_0\}$ . Thus, B prefers to borrow from  $C_1$  via secured debt as long as

$$\mu(1 - \theta)(X_0 + X_1^L) > \max \{(1 - \theta)X_0, X_0 - F_0\}. \quad (38)$$

This is always satisfied since the LHS is always greater than  $(1 - \theta)X_0$  by Assumption 4 and it is always greater than  $X_0 - F_0$  by Assumption 4 and the fact that  $F_0 \geq I_0$ .

## Proof of Lemma 7

First, we prove a preliminary result that we employ later.

LEMMA 13. *Suppose B has borrowed from  $C_0$  via unsecured debt and that B can borrow from  $C_1$  via unsecured debt and not default, i.e.*

$$\theta(X_0 + X_1) \geq F_0 + I_1. \quad (39)$$

*B prefers to borrow from  $C_1$  via unsecured debt than via secured debt.*

*Proof.* Here we suppose that B has unsecured debt to  $C_0$  with face value  $F_0$  and we compare B's payoff from borrowing from  $C_1$  via unsecured debt and via secured debt.

If B borrows from  $C_1$  via unsecured debt, he does not default by assumption (equation (39)). Thus, his payoff is

$$\Pi_B^{\text{unsec.}} = X_0 + X_1 - F_0 - I_1. \quad (40)$$

Observe that this is larger than the payoff if B defaults and diverts the fraction  $1 - \theta$  of his

cash flow:

$$X_0 + X_1 - F_0 - I_1 = \theta(X_0 + X_1) + (1 - \theta)(X_0 + X_1) - F_0 - I_1 \quad (41)$$

$$\geq (1 - \theta)(X_0 + X_1), \quad (42)$$

since, by the no-default assumption,  $\theta(X_0 + X_1) \geq F_0 + I_1$ .

Now turn to the case in which B borrows from  $C_1$  via secured debt. In this case, he may or may not default with  $C_0$ . Denoting the total final payoff by  $W$ , as in equation (2), B's payoff is

$$\Pi_B^{\text{sec.}} = \max\{W - F_0 - I_1, (1 - \theta)W\}. \quad (43)$$

We can see immediately that this is less than  $\Pi_B^{\text{unsec.}}$  above as follows: if B borrows secured, then  $W < X_0 + X_1$ , since  $\mu < 1$ . Thus, the first term in the max function is less than the expression in equation (40) and the second term in the max function is less than the expression in equation (42).  $\square$

We now proceed with the construction of the equilibrium, given that B borrows from  $C_0$  via unsecured debt. We break the proof up for different regions of the parameter space: we analyze first the case in which  $\theta$  is low, then the case in which  $\theta$  is high and  $p$  is high, and finally the case in which  $\theta$  is high and  $p$  is low.

**Low pledgeability:**  $\theta \leq \theta^*$ . For  $\theta \leq \theta^*$ , we proceed as follows. We assume that B borrows from  $C_0$  via risk-free debt. We show that B borrows from  $C_1$  via risk-free junior debt when  $X_1 = X_1^H$  and does not borrow from  $C_1$  when  $X_1 = X_1^L$ . We confirm that B's initial debt to  $C_0$  is indeed risk free.

Suppose that  $\theta \leq \theta^*$  and that B borrows from  $C_0$  via risk-free debt, so that  $F_0 = I_0$ . If  $X_1 = X_1^H$ , then B has sufficient pledgeable cash flow to borrow from  $C_1$  via unsecured risk-free debt by Assumption 3 which says  $\theta(X_0 + X_1^H) \geq I_0 + I_1$ . By Lemma 13 above, B indeed borrows via unsecured debt rather than secured debt. If  $X_1 = X_1^L$ , B cannot borrow from  $C_1$  via unsecured debt (by Lemma 5) or via secured debt (by Lemma 6).

We now show that B's debt to  $C_0$  is indeed risk free. First observe that if  $X_1 = X_1^H$ , then B repays both  $C_0$  and  $C_1$  since  $\theta(X_0 + X_1^H) \geq I_0 + I_1 = F_0 + F_1$ , having used Assumption 3 and the fact that the risk-free rate is zero. Now observe that when  $X_1 = X_1^L$ , B repays  $C_0$  since B does not borrow from  $C_1$  (since  $\theta$  is low) and  $\theta X_0 > I_0$  by Assumption 2.

**High pledgeability and high probability that  $X_1 = X_1^H$ .** Recall that B borrows secured when  $X_1 = X_1^L$  (Lemma 6). There are three ways to borrow secured: (i) collateralize only Project 1, (ii) collateralize only Project 0, and (iii) collateralize both projects. Case (i) is infeasible because  $\mu\theta X_1 < I_1$ . Case (ii) is preferable to case (iii) because the deadweight



loss from collateralization is lower. We now show that case (ii) arises when  $\theta \geq \theta^{**}$  and  $p \geq p^{**}$  and that case (iii) arises when  $\theta^* < \theta < \theta^{**}$  and  $p \geq p^*$ .

- (ii) For  $\theta > \theta^{**}$  and  $p \geq p^{**}$ , we proceed as follows. We assume that B borrows from  $C_0$  via risky debt with face value  $F_0$ , where

$$I_0 < F_0 \leq \theta(X_0 + X_1^H) - I_1. \quad (44)$$

We then show that, given this condition, B borrows from  $C_1$  via risk-free junior debt when  $X_1 = X_1^H$  and borrows from  $C_1$  via risk-free secured debt when  $X_1 = X_1^L$ . We confirm that the face value  $F_0$  of B's initial debt to  $C_0$  is indeed in the range specified in equation (44).

Suppose that B borrows from  $C_0$  via risky debt, so  $F_0 > I_0$ . Suppose also that  $F_0$  is lower than the upper bound in equation (44) above. If  $X_1 = X_1^H$ , then B has sufficient pledgeable cash flow to borrow from  $C_1$  via unsecured risk-free debt by the hypothesis in equation (44). By Lemma 13 above, B indeed borrows via unsecured debt rather than secured debt. Thus,  $C_0$  is repaid in full if  $X_1 = X_1^H$ .

If  $X_1 = X_1^L$ , B borrows secured from  $C_1$  (collateralizing only Project 0) and invests in the negative NPV project (by Lemma 6). Thus, B defaults on his debt to  $C_0$  when  $X_1 = X_1^L$ .  $C_0$  gets the pledgeable cash flow after B has repaid  $C_1$ :

$$\text{repayment to } C_0 \text{ if } X_1^L = \theta(\mu X_0 + X_1^L) - I_1. \quad (45)$$

We now show that the face value  $F_0$  of B's debt to  $C_0$  is in the range given in equation (44). The fact that  $F_0 > I_0$  follows from the fact that B defaults when  $X_0 = X_1^L$ , since  $\theta(\mu X_0 + X_1^L) - I_1 < I_0$  by Assumption 2. We now show that  $F_0$  is less than the upper bound in equation (44). Given the analysis above,  $C_0$ 's break-even condition reads

$$I_0 = pF_0 + (1 - p)(\theta(\mu X_0 + X_1^L) - I_1) \quad (46)$$

so

$$F_0 = \frac{I_0 - (1 - p)(\theta(\mu X_0 + X_1^L) - I_1)}{p}. \quad (47)$$

Thus,  $F_0$  is less than the required upper bound whenever

$$\frac{I_0 - (1 - p)(\theta(\mu X_0 + X_1^L) - I_1)}{p} \leq \theta(X_0 + X_1^H) - I_1. \quad (48)$$

We can rewrite this condition as

$$p \geq \frac{I_0 + I_1 - \theta(\mu X_0 + X_1^L)}{\theta(X_0 + X_1^H) - \theta(\mu X_0 + X_1^L)} \equiv p^{**}, \quad (49)$$

which is satisfied by assumption.

- (iii) For  $\theta^* < \theta < \theta^{**}$  and  $p \geq p^*$ , we proceed as follows. We assume that B borrows from  $C_0$  via risky debt with face value  $F_0$ , where

$$I_0 < F_0 \leq \theta(X_0 + X_1^H) - I_1. \quad (50)$$

We then show that, given this condition, B borrows from  $C_1$  via risk-free junior debt when  $X_1 = X_1^H$  and borrows from  $C_1$  via risk-free secured debt when  $X_1 = X_1^L$ . We confirm that the face value  $F_0$  of B's initial debt to  $C_0$  is indeed in the range specified in equation (50).

Suppose that B borrows from  $C_0$  via risky debt, so  $F_0 > I_0$ . Suppose also that  $F_0$  is lower than the upper bound in equation (50) above. If  $X_1 = X_1^H$ , then B has sufficient pledgeable cash flow to borrow from  $C_1$  via unsecured risk-free debt by the hypothesis in equation (50). By Lemma 13 above, B indeed borrows via unsecured debt rather than secured debt. Thus,  $C_0$  is repaid in full if  $X_1 = X_1^H$ .

If  $X_1 = X_1^L$ , B borrows secured from  $C_1$  (collateralizing both Project 0 and Project 1) and invests in the negative NPV project (by Lemma 6). Thus, B defaults on his debt to  $C_0$  when  $X_1 = X_1^L$ .  $C_0$  gets the pledgeable cash flow after B has repaid  $C_1$ :

$$\text{repayment to } C_0 \text{ if } X_1^L = \theta\mu(X_0 + X_1^L) - I_1. \quad (51)$$

We now show that the face value  $F_0$  of B's debt to  $C_0$  is in the range given in equation (50). The fact that  $F_0 > I_0$  follows from the fact that B defaults when  $X_0 = X_1^L$ , since  $\theta\mu(X_0 + X_1^L) - I_1 < I_0$  by Assumption 2. We now show that  $F_0$  is less than the upper bound in equation (50). Given the analysis above,  $C_0$ 's break-even condition reads

$$I_0 = pF_0 + (1 - p)(\theta\mu(X_0 + X_1^L) - I_1) \quad (52)$$

so

$$F_0 = \frac{I_0 - (1 - p)(\theta\mu(X_0 + X_1^L) - I_1)}{p}. \quad (53)$$

Thus,  $F_0$  is less than the required upper bound whenever

$$\frac{I_0 - (1 - p)(\theta\mu(X_0 + X_1^L) - I_1)}{p} \leq \theta(X_0 + X_1^H) - I_1. \quad (54)$$

We can rewrite this condition as

$$p \geq \frac{I_0 + I_1 - \theta\mu(X_0 + X_1^L)}{\theta(X_0 + X_1^H) - \theta\mu(X_0 + X_1^L)} \equiv p^*, \quad (55)$$

which is satisfied by assumption.

**High pledgeability and low probability that  $X_1 = X_1^H$ .** For high  $\theta$  and low  $p$ , we proceed as follows. We first explain that the analysis above implies that B defaults when  $X_1 = X_1^L$  and therefore B must repay  $F_0 > \theta(X_0 + X_1^H) - I_1$  when  $X_1 = X_1^H$ . We then argue that this repayment is infeasible.

The analysis of cases (ii) and (iii) above implies that B borrows from  $C_1$  when  $X_1 = X_1^L$  and defaults on his debt to  $C_0$ , making a repayment less than  $I_0$  (given in equations (45) and (51)).

$C_0$ 's break-even condition implies that  $F_0$  must be larger than  $\theta(X_0 + X_1^H) - I_1$  (this is implied by equation (49) and (55) and the analysis that precedes them). Thus,  $F_0$  must be so high that B cannot borrow from  $C_1$  via unsecured debt if  $X_1 = X_1^H$ . If B borrows via unsecured debt, B defaults on his debt to  $C_0$  and  $C_0$ 's break-even condition is violated.  $\square$

## Proof of Lemma 8

The argument is in the text.  $\square$

## Proof of Lemma 9

The argument is in the text.  $\square$

## Proof of Lemma 10

The argument is in the text.  $\square$

## Proof of Lemma 11

The argument is in the text.  $\square$

### Proof of Proposition 1

The result follows immediately from comparing the expression for  $\Pi_B^u$  in equation (14) with the expression for  $\Pi_B^s$  in equation (20).

### Proof of Corollary 1

The following is an immediate result of Lemma 1.

If condition (22) is violated, secured debt and unsecured debt coexist in equilibrium as long as  $\mu \geq \mu^*$ : B borrows secured from  $C_0$  and unsecured from  $C_1$  when  $X_1 = X_1^H$ .

If condition (22) is satisfied, secured debt and unsecured debt coexist in equilibrium as long as either  $\theta < \theta^{**}$  and  $p > p^*$  or  $\theta \geq \theta^{**}$  and  $p > p^{**}$ : B borrows unsecured from  $C_0$  and secured from  $C_1$  when  $X_1 = X_1^L$ .

### Proof of Proposition 2

The argument is in the text. □

### Proof of Lemma 12

The argument is in the text. □

### Proof of Proposition 3

The argument is in the text. □

### Proof of Proposition 4

The argument is in the text. □

### Proof of Proposition 5

The argument is in the text. □

### Proof of Proposition 6

B can finance Project 0 only if his pledgeable cash flow exceeds  $I_0$ . B borrows from  $C_0$  via unsecured debt if (i) Project 0's unsecured pledgeable cash flows are sufficient to cover the

investment and (ii)  $C_0$  is not at risk of dilution by the new debt to  $C_1$ . Condition (i) says that

$$\theta^u X_0 > I_0 \quad (56)$$

and condition (ii) says that

$$\mu\theta^s(X_0 + X_1^L) \leq I_1. \quad (57)$$

Substituting  $\theta^u = u\theta$  and  $\theta^s = s\theta$  gives the conditions in the proposition.

## Proof of Proposition 9

Much of the argument is already in the text. However, there are a few gaps to fill in. Most importantly, we argued that  $C_0$  does not lend unsecured if the probability  $p$  that Project 1 has the high payoff is sufficiently small. It remains to show that any  $p < p^{p,p}$  is indeed “sufficiently small.” Below we complete the proof. We first summarize the case in which  $\theta < \theta^{p,p}$  (as defined in equation (31)) and then proceed to analyze the case in which  $\theta \geq \theta^{p,p}$ .

**Low pledgeability:**  $\theta < \theta^{p,p}$ . When  $\theta < \theta^{p,p}$ , B cannot borrow when  $X_1 = X_1^L$ , as shown in analysis leading up to equation (31). In contrast, when  $X_1 = X_1^H$ , B borrows via risk-free unsecured debt. To see this, note that B prefers to borrow via unsecured debt than via secured debt (by Lemma 13) and that B has sufficient pledgeable cash flow to borrow (by Assumption 2). Thus,  $C_0$  and  $C_1$  both lend via risk-free unsecured debt, as stated in the proposition.

**High pledgeability:**  $\theta \geq \theta^{p,p}$ . For  $\theta \geq \theta^{p,p}$ , we proceed as follows. We first analyze B’s repayments to  $C_0$  and  $C_1$  when  $X_1 = X_1^L$ . We show that B does not repay  $C_0$  in full. We then ask under what circumstances B can promise  $C_0$  a high enough repayment when  $X_1 = X_1^H$  to offset this loss when  $X_1 = X_1^L$ . This analysis gives the threshold  $p^{p,p}$  given in the proposition.

When  $X_1 = X_1^L$ , B can borrow from  $C_1$  via secured debt, as shown in analysis leading up to equation (31). Further, recall that B cannot borrow via unsecured debt (by Assumption 2) and, further, that B prefers to borrow than not to borrow (by Assumption 4). Given that  $C_1$  breaks even, B’s repayment to  $C_0$  when  $X_1 = X_1^L$  is given by B’s total pledgeable cash flow minus the repayment  $I_1$  to  $C_1$ :

$$\text{repayment to } C_0 \text{ if } X_1^L = \theta(X_0 + X_1^L) - I_1 \quad (58)$$

as shown in the text (equation (33)). This is less than  $I_0$  by Assumption 2. Thus, it constitutes a default on  $C_0$ ’s debt. We now ask whether B can promise to repay  $C_0$  enough

when  $X_1 = X_1^H$  to compensate  $C_0$  for this loss when  $X_1 = X_1^L$ .

When  $X_1 = X_1^H$ , B makes the repayment  $F_0$  to  $C_0$ .  $F_0$  must satisfy two conditions (i)  $C_0$ 's break-even condition and (ii) B's limited liability constraint if  $X_1 = X_1^H$  (where by "limited liability constraint" we mean that B's total repayment to all his creditors cannot exceed his pledgeable cash flow).  $C_0$ 's break-even condition reads:

$$I_0 = pF_0 + (1 - p)\left(\theta(X_0 + X_1^L) - I_1\right), \quad (59)$$

having substituted in from equation (58) above. B's limited liability constraint if  $X_1 = X_1^H$  reads:<sup>35</sup>

$$\theta(X_0 + X_1^H) \geq F_0 + F_1 = F_0 + I_1. \quad (60)$$

Substituting the expression for  $F_0$  implied by the break-even condition in equation (59) into this the limited liability constraint above implies that we must have

$$\theta(X_0 + X_1^H) \geq \frac{I_0 - (1 - p)\left(\theta(X_0 + X_1^L) - I_1\right)}{p} + I_1 \quad (61)$$

which can be re-written as

$$p \geq \frac{I_0 + I_1 - \theta(X_0 + X_1^L)}{\theta(X_1^H - X_1^L)} \equiv p^{p.p.}, \quad (62)$$

where  $p^{p.p.}$  is defined in equation (34). Thus, for  $\theta \geq \theta^{p.p.}$  and  $p < p^{p.p.}$ , B cannot borrow from  $C_0$ , as stated in the proposition.  $\square$

## Proof of Proposition 6

B can finance Project 0 only if his pledgeable cash flow exceeds  $I_0$ . B borrows from  $C_0$  via unsecured debt if (i) Project 0's unsecured pledgeable cash flows are sufficient to cover the investment and (ii)  $C_0$  is not at risk of dilution by the new debt to  $C_1$ . Condition (i) says that

$$\theta^u X_0 > I_0 \quad (63)$$

and condition (ii) says that

$$\mu\theta^s(X_0 + X_1^L) \leq I_1. \quad (64)$$

Substituting  $\theta^u = u\theta$  and  $\theta^s = s\theta$  gives the conditions in the proposition.

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<sup>35</sup>Here we have tacitly assumed that B undertakes Project 1 when  $X_1 = X_1^H$ . This is implied by Assumption 5. See the the proof of Lemma 7 for further explanation.

## Proof of Proposition 7

The result follows immediately from the fact that B has no cash flows at Date 0, so  $C_0$  has zero recovery value in the event of liquidation. Thus,  $C_0$  always prefers to accept a rescheduling to Date 2 than to liquidate at Date 1. Hence, renegotiation-proof one-period contracts do not improve on the two-period contracts we focus on in the baseline model.<sup>36</sup>

## Proof of Proposition 8

In this proof we argue that for high  $\theta$  the incentive constraint puts an upper bound on B's repayment to  $C_0$  when  $X_1 = X_1^L$ . This upper bound is less than the size of  $C_0$ 's loan  $I_0$ , so if  $C_0$  lends unsecured, it must take a loss when  $X_1 = X_1^L$ . If the probability  $1 - p$  that  $X_1 = X_1^L$  is sufficiently large than  $C_0$  will not lend to B via unsecured debt.

First observe that this incentive constraint can bind only if pledgeability is high. If  $\theta \leq \theta^*$  as in Lemma 7, then B cannot borrow from  $C_1$ , so  $C_0$  does not risk dilution.

For high pledgeability,  $\theta > \theta^*$ , in contrast, the incentive constraint in equation (26) puts an upper bounds on B's repayment if  $X_1 = X_1^L$ .

$$F_0^L \leq X_0 - (1 - \theta)\mu(X_0 + X_1^L). \quad (65)$$

Thus, for any feasible repayment  $F_0^H \geq I_0$ ,<sup>37</sup> we can substitute this upper bound into  $C_0$ 's break-even condition to find a necessary condition for  $C_0$  to lend to B via unsecured debt:

$$I_0 = pF_0^H + (1 - p)F_0^L \quad (66)$$

$$\leq pF_0^H + (1 - p)\left[X_0 - (1 - \theta)\mu(X_0 + X_1^L)\right]. \quad (67)$$

Observe that Assumption 4 says that the term in square brackets above is less than  $I_0$ ,

$$I_0 - \left[X_0 - (1 - \theta)\mu(X_0 + X_1^L)\right] > 0. \quad (68)$$

Thus, we can rewrite the necessary condition as

$$p \geq \frac{I_0 - \left[X_0 - (1 - \theta)\mu(X_0 + X_1^L)\right]}{F_0^H - \left[X_0 - (1 - \theta)\mu(X_0 + X_1^L)\right]}. \quad (69)$$

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<sup>36</sup>This result is subject to the caveats about the timing of renegotiation in footnote 26 and about contingent debt in Subsection 6.5.

<sup>37</sup>It is without loss of generality to restrict attention to the case in which  $F_0^H \geq I_0$ . Otherwise,  $C_0$  is repaid less than  $I_0$  not only when  $X_1 = X_1^L$  but also when  $X_1 = X_1^H$  and  $C_0$  will not lend unsecured.

Observe that the right-hand side above is positive. Thus,  $p$  must be sufficiently large in order for  $C_0$  to lend to  $B$  via unsecured debt. In other words, given that  $\theta > \theta^*$ , for small  $p$   $C_0$  lends only via secured debt, as desired.

The expression for the cutoff  $p^{\text{c.d.}}$  in equation (28) comes from considering the loosest lower bound in equation (69) above. This follows by considering the largest feasible repayment  $F_0^H = \theta(X_0 + X_1^H) - I_1$ .  $\square$



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