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The Review of Financial Studies

The Structure of Leveraged Buyouts and the Free-Rider Problem

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We study the structure of public firm buyouts in a model that features the Berle-Means problem (lack of incentives) and the Grossman-Hart problem (holdout). We find that bootstrapping, debt in excess of funding needs, and upfront fees to bidders are socially optimal and increase buyout premiums. These elements make LBO financing tantamount to a "management contract" arranged by an outside manager to receive cash and incentives to manage a firm—except the cash is funded by excess debt imposed on the firm. Our model also rationalizes why PE firms collect fees from their equity partnerships and directly from target firms. (*JEL* G34, G32)

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> "Leverage" refers to the fact that the company being purchased is forced to pay for …its own acquisition …. If this sounds like an odd arrangement, that's because it is. (Kosman 2012)

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Leveraged buyouts (LBOs) and private equity (PE) transformed the governance of public companies. Describing this transformation, Jensen (1989, p. 62) saw LBOs as undoing the "conventional model of corporate governance—dispersed public ownership, professional managers without substantial equity holdings, a board of directors dominated by management-appointed outsiders"—by (re)unifying ownership and control. A model that encapsulates this view needs diffuse ownership, scope for ownership structure to alter incentives, and debt.[1] The crux of such a model is that it features two manifestations of the free-rider problem. On the one hand, dispersed shareholders passively reap gains from anyone else's effort to improve firm value (Berle and Means 1932), which is why a buyout could help. On the other hand, each shareholder is individually disinclined to sell shares for less than the expected postbuyout value (Grossman and Hart 1980), which can frustrate the buyout.

In this paper, we show that a model that features both of these canonical free-rider problems predicts a combination of bootstrapping, "excessive" debt, and upfront fees as an efficient buyout structure. These three elements are the defining characteristics of many LBOs. Bootstrapping refers to the practice whereby the target company is forced to pay for its own acquisition through debt financing—in effect, the company being purchased funds its own takeover.[2] "Excessive" debt refers to leverage levels that exceed what would be needed to finance the acquisition, often reaching 60% to 90% of deal value. Upfront fees are substantial payments made directly to PE firms by target companies at the time of the acquisition, often exceeding the PE firms' own capital contributions to the deals. Although these features may appear to be merely financial engineering designed to extract wealth from other stakeholders, we show that they can arise as components of an efficient buyout structure.

One might think that there are obvious efficiency explanations for these three elements in the existing literature, but this is not the case. The conventional argument for LBOs—debt imposes discipline on managers and raises incentives to generate value (Jensen 1986; Innes 1990)—neither requires nor predicts them. Harnessing the incentive benefits of debt does not require bootstrapping (as noted by Müller and Panunzi 2004). Because it is not a sui generis theory of takeovers, it also does not predict buyout leverage to be generically divergent from corporate leverage outside of takeovers (as stressed by Axelson et al. 2013); in particular, it does not imply the former to be

[1] This corporate governance view of public-to-private LBOs dominates the accounts by Jensen (1988), Shleifer and Vishny (1990), Holmstrom and Kaplan (2001), and Kaplan and Stromberg (2009). The only existing analysis that incorporates all of the above elements is Section 6 in Müller and Panunzi (2003). Internet Appendix F compares their analysis with ours in detail.

[2] Coined by Jerome Kohlberg, Henry Kravis, and George Roberts, this term comes from the metaphor "pulling oneself up by one's bootstraps" for succeeding with few means, indicating that this buyout tactic allows bidders to gain control of firms with negligible funds of their own.

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systematically higher. Last, this approach does not explain deal fees either. On the contrary, it predicts that acquirers maximize their skin in the game and hence would take larger equity stakes instead. (Internet Appendix C elaborates on these points and related arguments.)

While these elements could in principle be simply irrelevant or a matter of convenience, due to their lack of footing in standard LBO theory, they are conversely often criticized as LBO features that enable PE firms to extract wealth from other stakeholders. The arguments underlying this wealth transfer theory (as articulated in, e.g., Shleifer and Summers [1988] and Perotti and Spier [1993]) indeed depend on bootstrapping.[3] Bootstrap acquisitions involve two steps: A bidder creates a shell company that issues debt to fund a takeover bid. After a successful bid, the target is merged with the shell company, thereby assuming the debt that financed its own takeover. Without this second-step merger, the shell company would be a holding company that would retain the debt.[4] The gist of the wealth-transfer theory is that the second step forces other target stakeholders to share the liability for the takeover debt, thereby transferring wealth to the bidder. To LBO critics, this is the explanation for bootstrapping, overleveraging of targets, and safe extraction of profits through fees by PE firms—that is, all three aforementioned elements (see, notably, Appelbaum [2019, p. 4], but also Appelbaum and Batt [2014, 2018] and Kosman [2009, 2012]). That none of the three elements is integral to the conventional LBO argument reinforces this suspicion.

Currently, there exists only one argument in the existing literature that offers a partial defense of bootstrapping. Müller and Panunzi (2004) show that bootstrapping reduces the Grossman-Hart free-rider problem by shifting wealth from target shareholders to bidders, thus promoting takeover activity. Still, conditional on a takeover, leveraging up is at best a zero-sum transfer—or worse with bankruptcy costs: Thus, high leverage is inefficient. Their theory moreover predicts that high leverage leads to low buyout premia and therefore that bidding competition decreases leverage. Both of these predictions are counterfactual (e.g., Jarrell, Brickely, and Netter 1988; Kaplan and Stein 1993; Andrade and Kaplan 1998; Holmstrom and Kaplan 2001). Müller and Panunzi themselves acknowledge that their theory neither justifies nor predicts LBO-style debt levels.

In this paper, we combine the theory of tender offers with the incentive theory of LBOs. Building on Grossman and Hart's (1980) tender offer setting, we incorporate two further features. First, as in Müller and Panunzi (2004), the bidder can raise external financing for the takeover bid. This can explain

[3] For empirical studies on such transfers, see Asquith and Wizman (1990), Ippolito and James (1992), Warga and Welch (1993), Brown, Fee, and Thomas (2009), Billett, Jiang, and Lie (2010), and Eisenthal-Berkovitz, Feldhütter, and Vig (2020).

[4] Debt can be held in targets (OpCo debt), PE funds (FundCo debt), or in-between holding companies (HoldCo debt). HoldCo debts allows the separation of fund-level and deal-level financing without bootstrapping.

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bootstrapping, but on its own, counterfactually predicts small takeover premia and cannot normatively justify high leverage. Second, as in Burkart, Gromb, and Panunzi (1998), the bidder exerts unobservable effort to improve the value of the target firm. This endogenous value creation alone causes the bidder to buy as few shares as possible and to minimize value creation because the value produced by her efforts is appropriated by the free-riding target shareholders. We find that the interaction between these ingredients can rationalize bootstrapping, excessive debt, and upfront fees as an efficient buyout structure. In particular, the more takeover gains the bidder wants to extract through debt, the more value do buyout creditors require her to create. As a result, there is a positive equilibrium relationship between the level of debt, the stake acquired by the bidder, and value creation. Any cap on bootstrapping or leverage hence reduces the bidder's willingness to concentrate ownership and improve firm value (by more).

Because of this incentive effect, bootstrapping can actually benefit target shareholders. The equilibrium supply of debt financing is determined by a debt overhang constraint that requires a wedge between the firm's value and its debt, such that the equity is sufficiently in the money for the bidder to find it worthwhile to provide the required effort. This wedge is the expected posttakeover share value that target shareholders extract via the takeover premium. The wedge increases with the amount of takeover debt when the incentive effect of debt is sufficiently strong to dominate its wealth-transfer effect. So, while bootstrapping shifts rents to bidders, target shareholders can benefit from its indirect effect on incentives. This squares the idea of bootstrapping as a wealth transfer away from target shareholders with the evidence on large target returns in LBOs, which has in fact been viewed as prima facie evidence against said idea (e.g., Eckbo and Thorburn 2013, Section 8.4.5).

By contrast, the equity returns cannot constitute a source of profit for the bidder since free-riding target shareholders extract those through the bid price; the equity stake merely provides her with the incentives that enable her to raise debt funding. She instead extracts her profit through "fees" that are funded by the debt levied on the firm. Hence, the bidder optimally maximizes buyout leverage and deal fees. In the optimal structure, the bidder's equity returns just equal her (opportunity) cost of effort to ensure incentive compatibility and thus debt financing, which maximizes the fees she extracts upfront. Phalippou, Rauch, and Umber (2018) document that fees collected from target firms[5] represent a sizable part of PE firms' revenues and, on average, more than 6% of the equity invested by their PE funds. This is large considering that most

[5] PE firms collect these so-called transaction and monitoring fees directly from their target companies. These fees are distinct from the carried interest and fund management fees that PE firms collect from their partnerships with outside equity investors (c.f., Phalippou, Rauch, and Umber 2018, Fig. 1).

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PE firms contribute only 1–5% of the capital in their funds; in Brown and Volckmann (2024), their average (median) contribution rate is 3.5% (2%).

The optimally financed bid in our model resembles a pitch for a management contract: A competing management team (bidder) arranges an array of contracts (bid and financing) to take over as managers of the target firm in exchange for compensation that consists of cash (fees) and equity incentives (stock or carried interest)—with the cash portion financed by imposing extra debt on the firm. These LBO properties are the same as is predicted by the wealth-transfer theory, but in our theory, they are efficient.

We provide four model extensions to check the robustness of our results and to derive additional insights. First, we show that competition among bidders forces them to lever up more, exert more effort, and create more value (Section 3). Competition thus reinforces the predicted positive link between takeover debt, bid premium, and posttakeover firm value. Second, since firm value in our baseline model is a deterministic function of bidder effort, we show that our key results are also valid when it is a stochastic function of effort (Section 4.1). Third, we formalize the moral hazard problem as private benefit extraction (Burkart, Gromb, and Panunzi 1998) instead of costly effort provision (Section 4.2). In this variation, our results are reminiscent of Jensen's (1986) free cash flow theory. Fourth, we show that our main results also hold for richer contracts between bidders, that is, PE firms/general partners, and outside equity investors, that is, limited partners (Internet Appendix G). In this extension, our theory can explain why PE firms collect fees both from their equity partnerships and directly from targets. It also shows that carried interest contracts can increase a bidder's debt capacity.

Last, we discuss to what extent our results apply to negotiated takeovers (Section 4.3). Deals negotiated with controlling owners or incumbent managements—in private targets, divisional buyouts, and takeover activism—depend less on the elements highlighted in our paper; in particular, they might involve less leverage, larger equity injections by PE firms, and more post-LBO or HoldCo debts (fn. 4). Patterns along these lines are documented in Boucly, Sraer, and Thesmar (2011) and Cohn, Hotchkiss, and Towery (2022).[6] Since these types of buyouts have grown more prevalent over time, it is also noteworthy that the use of HoldCo and FundCo debts has risen (Brown, Harris, and Munday 2021) and that the "excessiveness" of buyout leverage relative to public comparables has declined over the last decades (Liu and Xiong 2024).

Our paper unifies the incentive theory of LBOs and the theory on the free-rider problem in takeovers by combining two governance problems of widely held firms in a single model: managerial moral hazard (Berle and Means 1932;

[6] Cohn, Hotchkiss, and Towery (2022, p. 3) conclude "financial engineering is not a first-order source of value creation in private firm buyouts," and Appelbaum (2019, p. 3) notes, "smaller PE funds typically acquire small and medium-sized enterprises…[and] use relatively low levels of debt." Private firm buyouts serve different objectives than public firm buyouts (Boucly, Sraer, and Thesmar 2011; Chung 2011; Cohn, Hotchkiss, and Towery 2022; Davis et al. 2021).

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Jensen and Meckling 1976) and holdout behavior (Grossman and Hart 1980; Bradley 1980). The interaction of these theories yields an efficiency argument for controversial features of LBOs such as bootstrapping, "excess" leverage, and upfront fees.

Our theory reverses three key takeaways from Müller and Panunzi (2004), namely that bootstrapping harms target shareholders, efficient levels of bootstrapped debt are small, and bidder competition reduces bootstrapping. The analysis most closely related to ours is Section 6 in Müller and Panunzi (2003), but it is targeted at different questions, and, most importantly, does not imply that the conclusions in Müller and Panunzi (2004) are turned on their head (see Internet Appendix F).

The literature on tender offers identifies a number of mechanisms that allows bidders to exclude free-riding target shareholders from part of the takeover gains: dilution (Grossman and Hart 1980), toeholds (Shleifer and Vishny 1986), squeeze-outs (Yarrow 1985; Amihud, Kahan, and Sundaram 2004), and debt (Müller and Panunzi 2004). A natural caveat of these mechanisms is that, because they harm target shareholders conditional on a bid, the latter prefer to limit their use even as doing so deters some takeovers. We identify an exception to this principle. In our model, buyout debt induces aggregate gains and can divide them to mutual benefit, such that target shareholders oppose limiting this exclusion mechanism.

As mentioned, the conventional argument for LBOs relies on the optimality of debt in standard capital structure models. The various caveats of this perspective have motivated other theories of buyout debt based on factors beyond the individual control transaction, such as the financing of PE funds (Axelson, Stromberg, and Weisbach 2009) or the reputation of repeat acquirers like PE funds vis-à-vis lenders (Malenko and Malenko 2015). In contrast, our LBO theory remains focused on determinants at the individual transaction level. A separate strand of theories studies the role of debt in bidding contests, which we discuss in Section 3.

Metrick and Yasuda (2010, Section 2.3) discuss that PE firms collect large transaction fees and monitoring fees directly from the targets, but note that it is not exactly clear what role they play given that PE firms can also be remunerated through management fees and carried interest fees from their equity partnerships. Phalippou, Rauch, and Umber (2018, Section 2.3.1) speculate on the role of fees collected from the targets based on various contracting models, while noting that no incentive theory in the existing literature explicitly speaks to such fees (as opposed to, e.g., carried interest fees).

1. Leveraged Buyouts with Free-Riding and Moral Hazard

We study a tender offer with financing in which the source of takeover gains is an improvement in incentives, while the distribution of the gains is subject to

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free-riding behavior. It is the first model in the tradition of Grossman and Hart (1980) in which optimal financing includes both debt and outside equity.

1.1 Model

Source of takeover gains. A widely held firm (“target”) faces a potential acquirer (“bidder”). If the bidder gains control, she generates a value improvement $V(e)$ over the firm’s status quo value, which is normalized to 0. Generating value requires effort $e \in \mathbb{R}_0^+$, imposing a private cost $C(e)$ on the bidder. Effort is unobservable. Current shareholders, being dispersed, lack the coordination and individual incentives to exercise control and bring about such improvements themselves (the Berle-Means problem). It does not matter for our results whether the effort is provided after the buyout or during the preparation of the bid (such as assessing target suitability and potential improvements) as long as the effort is unobservable. Our assumption that e represents posttakeover effort is made purely for expositional convenience.

We assume a linear value improvement function $V(e) = \theta e$, where $\theta > 0$ is the marginal return to effort. The cost function is twice differentiable, strictly increasing, and strictly convex, that is, $C'(e) > 0$ and $C''(e) > 0$ for all $e \geq 0$. We assume $C(0) = 0$, $\lim_{e \to 0} C'(e) = 0$, and $\lim_{e \to \infty} C'(e) = +\infty$ to focus attention on strictly positive, finite posttakeover values. V and C are commonly known.[7] The one-to-one mapping from e to V in our model allows for indirect contracting on e. We ignore this possibility and view modeling deterministic V as a simplification. The issue is less salient if we model e as ex ante effort prior to a bid, and absent if we model V as a random variable whose distribution depends on e (which we do in Section 4.1).

Distribution of takeover gains. To gain control, the bidder must purchase at least half of the target shares by way of a tender offer. The incumbent management is assumed to be unwilling or unable to counterbid; alternatively, it may be part of the investor group that makes the offer to buy out the current shareholders.

Each target shareholder is nonpivotal for the takeover outcome. The consequent free-riding behavior frustrates the takeover unless the bidder can exclude target shareholders from part of the takeover gains (the Grossman-Hart problem). We focus on the exclusion mechanism identified by Müller and Panunzi (2004): debt collateralized by target assets. Since debt is senior, shareholders are excluded from future cash flow pledged to the lenders, while the bidder extracts the present value of those cash flows in the form of a loan prior to the bid.

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[7] Assuming linear V is without loss of generality: all results can be translated to concave V. Suppose $V : [0, +\infty) \to \mathbb{R}$ is a twice differentiable, strictly increasing, and concave function. The game we consider is isomorphic to a game in which the bidder chooses y (instead of e) with $\theta y = V(e)$. In the latter game, the bidder’s posttakeover objective function is $\alpha[\theta y - D]^+ - C(V^{-1}(\theta y))$, where V^{-1} denotes the inverse function of V. Since the inverse of a strictly increasing, strictly concave function is a strictly increasing, strictly convex function, the composition $C \circ V^{-1}$ satisfies the assumptions postulated for C in our model.

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Specifically, the bidder is wealth-unconstrained but can nonetheless raise equity or debt funding for the bid from outsiders. She can choose to pledge a fraction $(1-\gamma)\in[0,1]$ of the cash flow from the acquired target shares to outside investors in exchange for some amount F^E of equity financing, and promise outside creditors a debt repayment $D\geq 0$ in exchange for some amount F^D of debt financing. We abstract from exclusion mechanisms other than debt, so a profitable bid requires $F^D>0$ and bootstrapping. We can ignore "nonbootstrapped" debt without loss of generality.

We assume risk-neutrality and zero discount rates for all agents.

Sequence of events. There are three stages. In stage 1, the bidder makes a take-it-or-leave-it cash bid to acquire target shares at a price p per share and chooses how to finance the bid. The financing is publicly observable. The bid is conditional, that is, it becomes void if less than half of the shares are tendered.

In stage 2, target shareholders noncooperatively decide whether to tender their shares. The shareholders are homogeneous and atomistic such that no one is pivotal. Concretely, we assume that a unit mass of shares is dispersed among an infinite number of shareholders whose individual holdings are equal and indivisible. Shareholder i's tendering strategy maps the offer terms into a probability that she tenders her shares, $\beta_i:(\gamma,D,p)\rightarrow[0,1]$. It is without loss of generality to focus on symmetric strategies and drop index i. So, by the law of large numbers, β shares are traded in a successful bid.

In stage 3, if less than half the shares are tendered, the takeover fails. Otherwise, the bidder pays βp for the fraction β of shares tendered and gains control. Net of the fraction $1-\gamma$ financed by outside investors, the bidder then owns an "inside" equity stake $\alpha\equiv\gamma\beta$, and chooses her effort level $e\geq 0$ to maximize her posttakeover payoff $U(\alpha,D,e)$. So, her posttakeover strategy is a function $e:(\alpha,D)\rightarrow\mathbb{R}^{+}$. Last, firm value and all payoffs are realized (see Figure 1).

Interpretation. An LBO is carried out by a group of investors that may comprise a PE firm and incumbent management, or a consortium of PE firms. These investors take large equity positions in the target and active roles in management or on the board (Kaplan and Stromberg 2009, p. 130f). In our model, they are represented by the "bidder" whose cost of effort represents the (opportunity costs of) time and effort invested by those agents.

PE firms raise equity funding for the buyouts through PE funds. This funding typically comes from large institutional investors such as pension funds, endowments, and insurance companies (Kaplan and Stromberg 2009). These limited partners—unlike PE firms who are general partners—assume no active role in the target firms and are represented by the "outside equity investor" in our model.

When a specific buyout deal materializes, PE firms contribute some of the capital from the PE funds as equity to finance the buyout. This equity financing is complemented with debt financing. The debt makes up the lion's share of the

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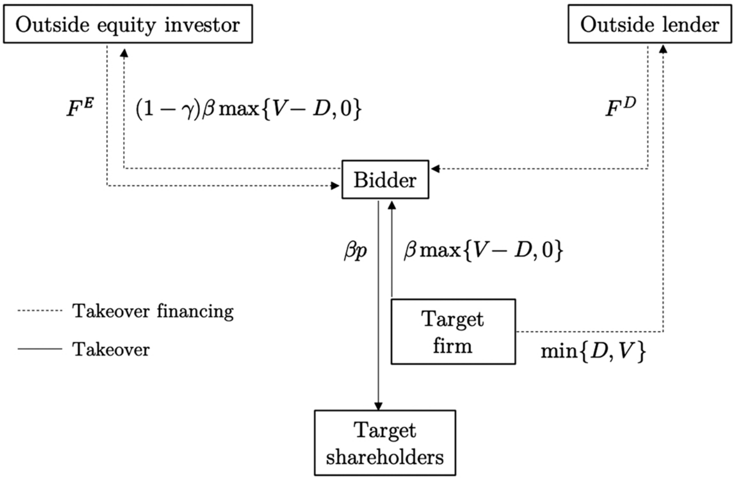

Figure 1
Bootstrap acquisition
Figure summarizing the payments vis-à-vis a successful bidder in our model. Taking a management buyout as an example, incumbent managers and a PE firm together would be the "bidder," limited partners in the buyout fund would be the "outside equity investor," and bondholders or a loan syndicate would be the "outside lender." Debt funds being disbursed to the bidder but repaid directly by the target firm is the key effect of bootstrapping.

funds, covering 60% to 90% of the buyout value (Kaplan and Stromberg 2009). The parties providing the debt funding are the "outside lender" in our model.

The debt is raised at the deal (rather than fund) level. This allows it to be collateralized by the assets of the target through a bootstrap acquisition: In a first step, a shell company is created and funded from the aforementioned sources of buyout financing to bid for a majority of the target shares. If the bid succeeds, the second step merges the target with the shell company such that the former's assets are matched with the latter's debt. Consequently, all equity investors receive, in our model notation, parts of $[V(e)-D]^+$. Without the second step, shell company shareholders and target shareholders would instead receive $[\beta V(e)-D]^+$ and $(1-\beta)V(e)$, respectively.

How much equity the active investor group acquires in the merged company depends on the fraction $1-\gamma$ of outside equity financing and the fraction β of shares tendered by the initial target shareholders: $\alpha=\gamma\beta$. Unless $\alpha=1$, the roles of β and γ are partially interchangeable; though, a given γ implies $\alpha\geq\gamma/2$, as a successful bid requires $\beta\geq 1/2$.[8] With $\gamma\in[0,1]$, the bidder can implement any $\alpha\in[0,1]$. In going-private buyouts, every initial shareholder is bought out ($\beta=1$); in cash-outs, some of them retain their shares ($\beta<1$). Distinguishing these cases is not important as only α matters for our results.

8 This is why constructing α from γ and β matters: without γ, α has a lower bound of 1/2. Not only is this counterfactual, but it creates an artificial kink at $\alpha=1/2$, which makes the model less tractable.

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Our model allows for α to be fully chosen at the deal level and for $\alpha \to 0$, which will be optimal if $D \to 0$. In practice, outside equity financing is typically raised through capital commitments to PE funds before specific deals materialize. Moreover, PE firms or general partners ("bidder") and limited partners ("outside investors") are not given simple equity shares, but the former receive contingent payments once the returns to the latter meet a prespecified threshold. Internet Appendix G shows that introducing richer contracts between the bidder and outside equity investors does not alter the central insights. Our baseline model prediction that a low D pushes the optimal α (and so the value improvement) to 0 is best interpreted to the effect that a buyout without debt is not lucrative.

Optimality of debt. We should spell out what feature of debt makes its use optimal in our model. In the second step of the bootstrap acquisition—the merger—debt reduces the target's expected share value from $V(e)$ to $[V(e)-D]^+$ by virtue of taking priority over equity. In effect, this rolls part of the debt burden otherwise carried only by the bidder and her equity coinvestors onto target minority shareholders. This dilution of the claims of those shareholders who retain shares in the first step—the tender offer—overcomes the free-rider problem. The dilution-by-priority effect of debt has also been noted in the context of bargaining between firms and labor unions (Bronars and Deere 1991; Perotti and Spier 1993). Priority is necessary and sufficient for debt to play this role. Since this is the only property of debt crucial to our results, abstracting from more complex securities (e.g., convertible debt) is without loss of generality. What matters in our setting is that, at the end of stage 3, there are buyout financiers (i.e., the lenders) who are paid out before target shareholders.

Understanding the role of debt matters for applying our model in the right context. Our result on the efficiency of buyout debt and "excessive" leverage holds to the extent that bidders rely on debt to extract takeover gains. Hence, leverage should be less excessive for private targets where price bargaining allocates gains and debt would play only its classic incentive role.

1.2 Equilibrium

We solve the model by backward induction in three subsections corresponding to the stages of the game. We focus on buyout debt D and the bidder's stake α, which characterize the postbuyout capital and ownership structure. Unlike in a standard financing model, there are no wealth constraints that call for outside funds. Still, the bidder will resort to outside funding due to an interaction between effort choice, tendering decisions, and financing (in fact, to an extent that wealth constraints would not bind, as we will show). For all lemmas and propositions throughout the paper that are not fully derived in the text, the proofs are in Appendix A.

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1.2.1 Value creation. After a successful bid, the bidder's equity stake is α and the target assumes the acquisition debt (of face value) D. The bidder then chooses effort e to maximize the value of her equity stake in the levered firm net of private effort costs, $U(\alpha, D, e) \equiv \alpha[V(e) - D]^+ - C(e)$.

This objective function is not globally concave in e. Let e_D satisfy $V(e_D) = D$. For $e \in [0, e_D)$, equity is "out of the money" because $V(e) < D$, and so $U(\alpha, D, e) = -C(e)$, which is strictly decreasing in e. For $e \geq e_D$, $U(\alpha, D, e) = \alpha[V(e) - D] - C(e)$ since equity is "in the money." Under our assumptions about V and C, this is strictly concave and the first-order condition, $\alpha V'(e) = C'(e)$, has a unique, strictly positive solution, hereafter denoted by $e^+(\alpha)$.

Because $U(\alpha, D, e)$ is not globally concave, $e^+(\alpha)$ need not be a global optimum. Specifically, given that $\frac{\partial U}{\partial e} < 0$ for $e \in [0, e_D)$, it is possible that $U(\alpha, D, e^+(\alpha)) < 0$. If so, the bidder's optimal effort is $e = 0$. To summarize the above arguments:

Lemma 1. The bidder's optimal effort is $e^*(\alpha, D) = e^+(\alpha) > 0$ if

$$\alpha[V(e^+(\alpha)) - D] - C(e^+(\alpha)) \geq 0, \tag{1}$$

where $e^+(\alpha)$ is the solution to

$$\alpha V'(e^+(\alpha)) = C'(e^+(\alpha)). \tag{2}$$

Otherwise, she makes no effort to improve target firm value, that is, $e^*(\alpha, D) = 0$.

Lemma 1 replicates established wisdom within our takeover setting. Too much leverage leads to a debt overhang problem that undermines a (controlling) shareholder's incentives to improve firm value (Myers 1977). Here, this occurs when condition (1) is violated. Value creation incentives also decrease with the fraction of equity that is dispersedly held (Berle and Means 1932; Jensen and Meckling 1976). Conversely, ownership concentration increases firm value: Conditional on (1), the optimal effort $e^+(\alpha)$ and resultant firm value $V(e^+(\alpha))$ increase in α (by the envelope theorem).

The novel element of Lemma 1 is that the two effects interact in condition (1). Whether a debt overhang problem emerges depends not only on the debt level D but also on the level of ownership concentration α. The intuition is simple: The bidder's incentives derive from a levered equity stake $\alpha[V(e^+(\alpha)) - D]$. While D lowers the total value of equity, α determines the bidder's share of that total value. Consequently, the firm can maintain more debt without eroding the bidder's incentives when the latter owns more of its equity. This interaction between α and D is key to our results.

1.2.2 Tendering decisions. As Lemma 1 indicates, the only posttakeover ownership and capital structure that ensures first-best incentives is fully concentrated ownership without any leverage: $(\alpha, D) = (1, 0)$. In an ideal market for corporate control, the bidder can restore this structure. We discuss next how free-riding by the dispersed target shareholders distorts the bidder's preferences regarding α and D.

Suppose target shareholders face a cash bid p (partly) financed with debt D. Being nonpivotal, an individual shareholder tenders only if $p \geq V(e^*(\hat{\alpha}, D))$, where $\hat{\alpha}$ denotes her beliefs about the bidder's posttakeover equity stake. Because tendering decisions depend on individual beliefs, no dominant strategy equilibrium exists. In a rational expectations equilibrium, beliefs are consistent with the outcome, so shareholders tender only if

$$p \geq [V(e^*(\alpha, D)) - D]^+. \tag{3}$$

That is, target shareholders tender their shares only if they extract at least the full increase in share value the bidder will generate. This is known as the free-rider condition.

Previous work has analyzed two special cases of (3). Müller and Panunzi (2004) study a model with exogenous posttakeover values where (3) becomes $p \geq (V - D)^+$ and show that the bidder maximizes D. Burkart, Gromb, and Panunzi (1998) study a model with endogenous posttakeover values but without debt where (3) reduces to $p \geq V(e^*(\alpha, 0))$, and show that the bidder minimizes α. These results share a common logic: the bidder aims to reduce the right-hand side of (3), that is, the posttakeover share value that target shareholders extract through the price. As we shall see, a model in which D and α are jointly chosen overturns some of the key predictions of the aforementioned papers.

Before we derive the stage-2 subgame equilibrium, note that (3) is merely a necessary condition for a successful bid; a failed bid, in which an insufficient number of shares is tendered, can always be supported as a self-fulfilling equilibrium outcome. To focus on the interesting case, we assume that shareholders tender whenever the free-rider condition is weakly satisfied, thus selecting the Pareto-dominant success equilibrium whenever it exists.

Let the posttakeover share value the bidder will create for a given stake α and debt D be denoted by $E(\alpha, D)$, and her equilibrium posttakeover equity stake by $\alpha^*(p, D)$. Since a successful bid implies that $\beta \in [1/2, 1]$ shares are tendered, the bidder's posttakeover stake α lies in the interval $[\gamma/2, \gamma]$ for a given outside equity financing share $1-\gamma$. Hence, the posttakeover share value must lie between $E(\gamma/2, D)$ and $E(\gamma, D)$. In the subsequent lemma, we omit describing the subgame equilibrium for bids that we can rule out a priori: bids that fail for any set of beliefs ($p < E(\gamma/2, D)$) and bids that could be undercut without affecting any other decision ($p > E(\gamma, D)$).

Lemma 2. Any bid $p \in [E(\gamma/2, D), E(\gamma, D)]$ succeeds, and $\alpha^*(p, D) = \alpha_p$, where α_p satisfies $p = E(\alpha_p, D)$.

Target shareholders tender shares until the expected posttakeover share value, which increases with the bidder stake, matches the bid price. Thus, as in Burkart, Gromb, and Panunzi (1998), supply is upward-sloping: the fraction

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of shares tendered increases with the bid price. In equilibrium, the bidder endogenously ends up with a stake for which the free-rider condition (3) holds with equality.

1.2.3 Bid and financing. The bidder's ex ante profit is $\alpha E(\alpha_p, D) - \beta p - C(e) + F^E + F^D$. It comprises the value of the equity stake she expects to acquire, less takeover payment and effort cost, and outside funds she raises for the bid. She maximizes this by choosing the bid p, outside equity financing $\{\gamma, F^E\}$, and debt financing $\{D, F^D\}$ subject to (1), (2), (3), and the following participation constraints: Outside equity investors demand

$$F^E \leq \beta(1-\gamma)E(\alpha_p, D). \tag{4}$$

Outside lenders demand $F^D \leq \min[D, V(e)]$. Since debt overhang constraint (1) requires $V(e) > D$, this reduces to

$$F^D \leq D. \tag{5}$$

We assume perfect competition among outside financiers such that they only break even. Hence, (4) and (5) hold with equality. Substituting these binding participation constraints in the bidder's ex ante profit yields $\beta[E(\alpha, D) - p] - C(e) + D$.

Recall from Lemma 2 that free-rider condition (3) endogenously binds; shares will be tendered until $E(\alpha_p, D) = p$. Recall further from Lemma 1 that, subject to (1), the posttakeover effort $e^+(\alpha)$ satisfies (2). To demarcate the novel element in our analysis from existing results, we first state how these two constraints—binding free-rider condition (3) and first-order condition (2) for effort—affect the bidder. Plugging these constraints into her ex ante profit gives

$$D - C(e^+(\alpha)). \tag{6}$$

This replicates the known insights that debt D enables the bidder to extract private gains and that a larger equity stake α is unattractive because it induces her to incur higher effort costs, while all gains in share value accrue to target shareholders. This also shows that the bidder's ex ante problem essentially reduces to choosing the postbuyout ownership and capital structure (α, D).[9]

The novel element is the restriction debt overhang constraint (1) imposes jointly on D and α. This constraint cannot be slack in equilibrium. The bidder could otherwise lower α while preserving D. This would increase her profit, as

[9] This is why it is without loss of generality to abstract from cash-equity bids and restricted bids. The same objective function obtains (i) for cash-equity bids with $1-\alpha$ being the fraction of posttakeover equity offered to target shareholders as payment combined with cash or (ii) for cash bids in which the number of shares the bidder offers to acquire is restricted to α.

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(6) shows. Using binding constraint (1) to replace D in (6) reduces the bidder's stage-1 choices to a univariate problem:

$$\max_{\alpha \in [0,1]} \mathcal{W}(\alpha) - \frac{C(e^{+}(\alpha))}{\alpha}, \tag{P}$$

where $\mathcal{W}(\alpha) \equiv V(e^{+}(\alpha)) - C(e^{+}(\alpha))$ is the total surplus created by the buyout. In Section 2, we use this representation of the problem to explain the role of debt. We conclude this section by establishing equilibrium existence (though not uniqueness).

Lemma 3. If the bidder's profit under (P) is negative, she makes no bid. Otherwise, she succeeds with a bid such that (1)–(5) bind and α solves (P).

2. Bootstrapping, Leverage, and Upfront Fees

Before deriving our main results, it is worth reiterating that there is no wealth constraint in our model; the bidder is capable of achieving the first-best outcome by fully self-financing the bid. Frictions in the buyout process keep her from doing so. Our results concern how financing affects this process—not only the postbuyout capital structure—making this a theory of buyout debt.

We will make statements about the causal effect of bootstrapping by using the thought experiment of an exogenous limit on bootstrapped debt (Propositions 1, 2, and 5). The main normative insight is that such a restriction is inefficient even though bootstrapping is a rent extraction strategy. The positive predictions are that buyout debt is bootstrapped, "excessive," and beneficial not only to the bidder via upfront fees but likely also to target shareholders via larger takeover premiums.

2.1 Ownership-debt relationship

We first consider how bootstrapping affects total surplus $\mathcal{W}(\alpha) = V(e^{+}(\alpha)) - C(e^{+}(\alpha))$. Although this expression depends only on the bidder's equity stake α, the latter is linked to debt D through debt overhang constraint (1). This constraint binds in equilibrium, yielding

$$D = V(e^{+}(\alpha)) - \frac{C(e^{+}(\alpha))}{\alpha}. \tag{1*}$$

As shown in the proof of the next result, (1*) defines D as a strictly increasing function of α. Intuitively, to avoid a debt overhang problem, a higher debt level D requires a larger bidder stake α. The latter leads in turn to a higher surplus $\mathcal{W}(\alpha)$.[10]

[10] The inverse interpretation is that takeover debt makes bidders willing to buy more equity. We prefer the first interpretation in light of the bidder's profit function (6), whereby she would at the margin want to increase D and decrease α (were it not for debt overhang constraint (1*)).

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Now imagine some hypothetical exogenous cap $\bar{D}$ on the amount of debt. Our formal result interprets how removing this limit affects $\mathcal{W}(\alpha)$ as the causal effect of bootstrapping on takeover surplus.

Proposition 1. Bootstrapping increases takeover surplus.

This result is not obvious, as the primary aim of bootstrapping is to transfer rents from target shareholders to bidders. In Müller and Panunzi (2004), conditional on a bid, bootstrapping is a zero-sum transfer, or inefficient when there are exogenous bankruptcy costs. The interaction of the free-rider problem with the moral hazard is key to Proposition 1.

On the equity side, the fact that owning a larger stake creates stronger incentives to create value is a disincentive to buy shares when faced with the free-rider problem. While the bidder is more incentivized to provide effort when acquiring a larger stake, the target shareholders appropriate the added value through the bid price. All else equal, the bidder hence prefers low α.

On the debt side, the supply of funds depends on the value lenders expect to be created. To raise more debt, the bidder must commit to generate more value. A larger equity stake provides that commitment, as captured in the ownership-debt function. If this demand for commitment prevails over the bidder's preference for low α, debt is used in equilibrium. A cap on takeover debt would impede this indirect benefit of bootstrapping on incentives.

Empirically, following leveraged buyouts, managers own more equity and active owners dominate boards (Kaplan 1989). Our theory posits that the lenders' willingness to provide debt depends on how much "skin in the game" such inside shareholders assume in the firm. We are unaware of empirical evidence that speaks directly to this mechanism.[11] However, there is evidence in another context consistent with it. Anderson, Mansi, and Reeb (2003) find that founding family ownership in public firms is associated with lower costs of debt, suggesting reduced debt-equity conflicts as a reason. Lagaras and Tsoutsoura (2015) find similar effects in a natural experiment. They also document that for 17% of family firms in their data, lenders explicitly require the founding family to maintain a certain percentage of ownership or control.

2.2 Debt (constraints) as sharing rule

We now turn to how the surplus $\mathcal{W}(\alpha)$ is split between the bidder and target shareholders. The ownership-debt function (1*) pins the equity value down as a

[11] This is a causal statement: in a given deal, creditors lend less if insider equity is exogenously reduced. This does not imply a positive correlation of buyout debt with post-buyout inside ownership in a cross-section of buyouts. As regards the latter, note that we do not present comparative statics. The equilibrium debt level and the division of gains between bidder and target shareholders both depend on the curvatures of V and C in non-trivial ways. Consequently, the comparative statics generate no clear-cut results. Hence, while we make clean statements about causal effects of bootstrapping, clean statements do not exist for cross-sectional correlations between takeover debt and other observables (such as, e.g., bid premia) driven by variation in V or C across deals in the data. Internet Appendix E illustrates this using an example that parametrizes V as a power function.

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"wedge" that must be kept between firm value and debt to avoid debt overhang: $V(e^+(\alpha)) - D = \frac{C(e^+(\alpha))}{\alpha}$. This reveals that the bidder's profit in (P),

$$\mathcal{W}(\alpha) - \frac{C(e^+(\alpha))}{\alpha},$$

equals total surplus less the wedge, which target shareholders extract through the price. How the wedge varies with α determines how increases in $\mathcal{W}(\alpha)$ are allocated.

There are two opposing effects. Holding the numerator fixed, $\frac{C(e^+(\alpha))}{\alpha}$ decreases in α. This reflects that blockholder incentives depend on equity concentration and total equity value: active shareholders with larger stakes can dilute total equity value more without creating debt overhang problems.

By contrast, holding the denominator fixed, $\frac{C(e^+(\alpha))}{\alpha}$ increases in α through $C(e^+(\alpha))$. That is, the increase in equilibrium effort moderates dilution. If the bidder buys a larger equity stake as an incentive to improve firm value more, any parallel increase in debt must not undermine the required higher effort.

Target shareholders benefit from bootstrapping when the latter effect dominates. This requires equilibrium effort $e^+(\alpha)$ to be sufficiently elastic, which in turn requires that the cost function C is not too convex. Our next result derives a sufficient condition for this to be the case, while considering how target shareholders would be affected by the removal of a hypothetical exogenous limit $\bar{D}$ on bootstrapped debt.

Proposition 2. Bootstrapping increases takeover premia if C is log-concave.

In Müller and Panunzi (2004), bootstrapped debt lowers takeover premia and target shareholders may want restrictions on bootstrapping (or buyout leverage). This reflects a general point in the theory of tender offers: target shareholders prefer limits to exclusion even if that frustrates some potential bids. To our knowledge, Proposition 2 identifies the only exception to this principle. Under the stated condition, target shareholders oppose any restriction on bootstrapping or takeover debt.[12]

More than of purely theoretical interest, Proposition 2 squares the idea of bootstrapping as rent extraction with empirically high target returns in LBOs (e.g., Jensen 1988). Hence, the fact that takeover premiums are large and target shareholders fare well in LBOs does not disprove Müller and Panunzi's (2004) thesis that bootstrapping is a mechanism to shift gains from target shareholders to bidders (c.f., Eckbo and Thorburn 2013, Section 8.4.5). Appendix 1 shows examples with specific C functions where high leverage ratios benefit target shareholders.

[12] Log-concavity is not a very restrictive condition and met by, inter alia, power functions $C(e) = \frac{c}{n} e^n$ and exponential functions $C(e) = \exp(e) - c$. It is tighter than needed in the sense that target shareholders can benefit even if C is not globally log-concave. When C becomes too convex, the limit $e'(\alpha) \to 0$ is a model with exogenous costs and values (Müller and Panunzi 2004). If we allow concave value improvement functions, an analogous condition exists for the concavity of the bidder's posttakeover objective function.

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Like Proposition 1, Proposition 2 is a consequence of endogenous value creation. The crux is that the incentive problem constrains debt—but this plays a different role from that in standard financing theories where the constraint measures up against a need for outside funds. Here it determines what a bidder must leave on the table for target shareholders. Intriguingly, the incentive constraints on D impose a "sharing rule" for the incentive gains from α such that bootstrapping can be Pareto-improving. This is the case when incentives are very sensitive to the change in ownership structure (i.e., when C is not so convex as to make optimal effort too inelastic with respect to changes in α).

2.3 Fees and bidder compensation structure

We trace out through what channel the bidder extracts her share of the surplus $\mathcal{W}$. This is not obvious since target shareholders receive the full increase in share value, $V-D$, on any shares they retain or sell. (Outside investors merely break even.) How can the bidder make a profit if target shareholders get the full appreciation on all sold shares? The only possibility is that she does not fully pay for her stake out of her own pocket.

The bidder's financing contribution is $I_B \equiv \beta(V-D)-F^E-F^D$, where $\beta(V-D)$ is the total takeover payment, F^E is outside equity funding, and F^D is debt funding. By (4) and (5), which are binding in equilibrium, $F^E = \beta(1-\gamma)(V-D)$ and $F^D = D$. Netting out outside equity, $I_B = \alpha(V-D)-D$, where $\alpha(V-D)$ is the value of the stake going to the bidder. Indeed, buyout debt D lets her pay less than the value of the stake she gets.

This in itself is consistent with the bidder contributing, on balance, a positive amount of funding. However, in equilibrium, it turns out that she cashes out upfront, that is, $I_B < 0$. By (1*), $I_B = C(e^+(\alpha))-D$, which is the negative of bidder profit (6).

Proposition 3. The bidder's net financing contribution is negative.

The bidder cannot extract profits through her equity stake because the value of that stake is extracted by the target shareholders through the bid price. Instead, she extracts it by cashing out upfront—a cash-out financed by taking on debt that decreases the future free cash flow to equity.

The endogenous limit to this extraction is that equity cannot be diluted so much that a debt overhang arises. Thus, the equilibrium level of dilution is such that the incentives to create value are just preserved, as captured by the binding debt overhang constraint (1*): $\alpha(V(e^+(\alpha))-D) = C(e^+(\alpha))$. This constraint shows that, in the optimal structure, the value of the bidder's equity is diluted until it just covers her effort cost—in fact, inducing that effort is the sole purpose of the equity stake. The bidder must in equilibrium get that stake for free to break even. Thus, for her to find the takeover profitable, outside funding must exceed the acquisition price to further finance upfront payouts to the bidder. These upfront fees are her profit from accepting the incentives provided by the equity stake.

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As a result, the bidder's compensation structure has two components: (i) target equity she is given for free, akin to stock compensation, incentivizing her to exert the effort that outside investors bank their participation on, plus (ii) upfront fees, akin to a fixed salary, that are equal to her equilibrium rent. In Internet Appendix G, where we allow for richer contracts between the bidder and outside equity investors, this translates into a dual-fee structure under which the bidder collects performance-based fees from its partnership with outside equity investors (which depend on the equity returns), and separately, fees directly from the target (which reduces the equity returns), for example, through transaction or monitoring fees. In some ways, this is a wash. Metrick and Yasuda (2010, p. 2320) write,

While it may seem odd that funds are effectively paying themselves a fee to run companies that they own, the sharing rules with LPs can make this an indirect way for the LPs to pay the GPs for their services. From the perspective of the LPs, it should not matter whether these payments come directly through management fees or indirectly through monitoring fees, as long as the GP can create sufficient value to justify them.

Consistent with this, in practice, the fees PE firms collect directly from the target firms are sometimes partially offset by reductions in the management fees they collect from their equity partnerships. Indeed, it matters little to the outside equity investors in our model, incentive compatibility provided. However, the dual-fee structure is crucial for the bidder's ability to profit. The equity-based performance fee provides her with the incentives needed to attract outside funding. This, in turn, enables her to use debt financing to extract gains from target shareholders through upfront fees. Crucially, the ability to profit through the latter set of fees is a prerequisite for the bidder to self-impose incentives through the former set of fees. (A cap on upfront fees, like a cap on bootstrapping, is therefore inefficient.)

The LBO financing the bidder puts together thus amounts to a "management contract" whereby she gets herself "hired" by passive (debt and equity) investors to take over as the manager of the target firm for performance fees plus upfront fees. The fact that the bidder profits despite contributing no net financing is analogous to a manager earning returns to human capital, and the upfront fees (or equilibrium rent) can be interpreted as a price for her talent.

Empirically, upfront fees are common in leveraged buyouts. Müller and Panunzi (2004) cite the 1986 Revco deal where the upfront fees of $54.4 million exceeded the acquisition company's equity of $35 million (Wruck 1997), and the 1989 RJR Nabisco deal where fees amounted to $780 million (Burrough and Helyar 1990) while KKR & Co., the buyout firm behind the deal, was said to have contributed only $15 million to the deal (Knight 1988). The most comprehensive study of fees paid to PE firms directly by target companies comes from Phalippou, Rauch, and Umber (2018). As mentioned earlier, their findings imply that these fees make up a significant portion of PE firms' revenues and are substantial compared both to PE firms' own

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capital commitments and to the fees they collect from their equity partnerships. Metrick and Yasuda (2010, Section 2.3) discuss transaction and monitoring fees and estimate that transaction fees alone typically amount to 1–2% of total deal value. Again this is sizable considering that equity usually covers only 20–40% of total deal value, and PE firms tend to contribute only 1–5% of that equity.

3. Bootstrapping and Bidding Competition

In Müller and Panunzi (2004), buyout leverage decreases when multiple bidders compete, a result that hightlights its role as a mechanism to extract gains from target shareholders. In our model, this result is reversed because the ability to extract gains increases bidders' willingness to create value. Competition induces a bidder to adopt stronger value-creation incentives along with more debt.

Consider two bidders who may differ in their value improvement or cost functions. To gain control of the target in this setting, a bidder must outbid her rival with an offer price that satisfies the free-rider condition.

3.1 Bootstrapping increases reservation prices

Without loss of generality, consider bidder 2. If she succeeds, her effort will satisfy first-order condition (2) and target shareholders will tender such that free-rider condition (3) strictly binds (Sections 1.2.1 and 1.2.2). Thus, (6) still applies; bidder 2's profit can be written as $D_2 - C_2(e_2^+(\alpha_2))$.

We can characterize all offers under which bidder 2 would break even by

$$D_2 = C_2(e_2^+(\alpha_2)). \tag{7}$$

By definition, target shareholders receive the whole surplus under a break-even offer, so the break-even prices are equal to $\mathcal{W}_2(\alpha_2)$. As $\mathcal{W}_2(\alpha_2)$ is strictly increasing, bidder 2's reservation price p_2^o is the break-even price under the largest (α_2, D_2) that is both feasible and satisfies (7), hereafter denoted by (α_2^o, D_2^o).

To state the causal effect of bootstrapping on the bidder's reservation price, consider an exogenous limit $\bar{D}$. If $\bar{D} < D_2^o$, the limit moves the reservation price from $\mathcal{W}_2(\alpha_2^o)$ to $\mathcal{W}_2(\bar{\alpha}_2)$, where $\bar{\alpha}_2$ solves (7) for $D_2 = \bar{D}$. Since α_2 and D_2 are positively linked in (7), the new reservation price is lower, making bidder 2 a "weaker" competitor.

Proposition 4. Bootstrapping strengthens competition.

Recall that neither bidder is wealth-constrained; the role of debt financing here is not that it makes it possible to pay more. Its role in break-even condition (7) is to compensate bidder 2 for costs. The bidder's ability to recoup costs drives how much value she is willing to create, which in turn determines her reservation price.

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3.2 Competition increases buyout debt

Without loss of generality, consider bidder 1. We will first show that she does not exhaust her debt capacity in the absence of competition. Without competition, she maximizes (6) subject to (1*), that is, she solves

$$\max_{\alpha_1 \in [0,1]} D_1(\alpha_1) - C(e_1^+(\alpha_1)), \tag{8}$$

where $D_1(\alpha_1)$ is her ownership-debt function, as defined by (1*). Her maximum debt capacity, by contrast, is found by maximizing α_1 subject to $D_1(\alpha_1) - C(e_1^+(\alpha_1)) = 0$ or is the corner value $D_1(1)$. Hence, when the solution to (8) involves $\alpha_1^* < 1$ and a strictly positive profit, bidder 1 raises less debt than she maximally could without making a loss. This is, for example, always the case when C is a power function (see Appendix 1).

Lemma 4. Absent competition, bidders do not generally exhaust their debt capacity.

Intuitively, this is a consequence of Proposition 2: If target shareholders capture part of the incentive gains due to takeover debt, bidders will generally not maximize their debt capacity. This begs the question how they adjust debt in response to competition.

Let bidder 1's optimal bid $(\alpha_1^*, D(\alpha_1^*), p_1^*)$ absent competition be profitable and feature $\alpha_1^* < 1$, so she has unused debt capacity. Without loss of generality, let bidder 1 have the higher reservation price and win. Under competition, her optimal bid must jointly satisfy debt overhang constraint (1), effort optimality condition (2), free-rider condition (3), and the competition constraint:

$$p_1 \geq \overline{p}_2. \tag{9}$$

We assume $\overline{p}_2 > p_1^*$, so competition is effective.

Suppose her optimal bid exactly matches bidder 2's reservation price, so (9) binds.[13] Focusing on interior solutions, where bidder 1 gets $\alpha_1 < 1$ shares, recall from Lemma 2 that free-rider condition (3) binds endogenously. (We cover corner solutions in the proof of the next result.) Substituting (2) and a binding (9) into a binding (3) yields

$$D_1 = V(e_1^+(\alpha_1)) - \overline{p}_2. \tag{10}$$

This identifies (α_1, D_1)-pairs that take into account every optimality condition except (1). With target shareholders' payoff fixed at $\overline{p}_2$, bidder 1's profit subject to (10) is

$$\mathcal{W}_1(\alpha_1) - \overline{p}_2.$$

As this strictly increases in α_1, bidder 1 optimally matches $\overline{p}_2$ with the highest α_1 subject to (10) and (1). Intuitively, if limiting target shareholders

[13] Since the objective function in (P) can be nonmonotonic in α, it is possible that bidder 1 wants to pay strictly more than $\overline{p}_2$. The arguments that follow in the text can also be applied to such cases with $\overline{p}_2$ replaced by $\overline{p}_2^+ = \overline{p}_2 + \Delta$ for some $\Delta > 0$.

to $\overline{p}_2$ ((9)), she should maximize surplus subject to the other constraints. This requires increasing α to improve incentives to generate value ((2)) and increasing D to keep the posttakeover share value at $\overline{p}_2$ (due to (3))—until further increases are infeasible due to debt constraints ((1)) or because the corner solution is reached ($\alpha_1 = 1$). This logic leads to the next result, which refers to an increase in $\overline{p}_2$ as "stronger" competition.

Proposition 5. Stronger competition increases bootstrapping and takeover surplus.

Both parts of Proposition 5 are novel. In Müller and Panunzi (2004), where postbuyout values are exogenous, competition curbs bootstrapping. In incentive models with wealth constraints, competition raises the need for outside financing, which pushes the outcome further away from first-best incentives. In our model, bidders generally do not maximize their own incentives as much as is feasible due to the free-rider problem. Competition pushes them towards first-best incentives, and as they generate more value, they also extract more through debt.

The effect of competition on profits is the conventional one: The added constraint (9) lowers bidder profits. Given total surplus increases, target shareholders gain. Proposition 5 thus reconciles bidding competition with high takeover leverage as well as high takeover leverage with low bidder returns—consistent with the effect competition had on premia, bidder gains, and leverage towards the end of the 1980s LBO wave (see, e.g., Holmstrom and Kaplan 2001, p. 128f). If the bidders are equally competitive in our model, the winner raises her maximum feasible debt amount but all of the surplus goes to target shareholders, even though the debt serves to dilute the latter.

To sum up, in our theory, bootstrapping makes bidders more competitive, pushes them to use more debt, raises efficiency, and benefits target shareholders. These procompetitive effects contrast with the role of debt in other models of bidder competition. In Chowdhry and Nanda (1993), debt financing serves to deter rivals. In DeMarzo, Kremer, and Skrzypacz (2005), which extends results in Hansen (1985) and Rhodes-Kropf and Viswanathan (2000), competing bidders prefer debt to equity funding (or equivalently, paying in cash rather than in stock) because doing so lowers the seller's expected revenue.

4. Model Extensions

This section discusses model variations in which (1) the value improvement is a stochastic function of bidder effort and (2) the moral hazard problem is private benefit extraction instead of costly effort provision. We also discuss at the end what bearing our analysis has on payoffs and leverage choices in negotiated deals as opposed to tender offers. In Internet Appendix G, we consider a third model variation in which the sharing rule between bidders and outside equity investors can deviate from straight equity stakes. We show there

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that our results hold for richer equity-based compensation structures and that fine-tuning such structures can relax bidders' debt constraints, enabling them to use more buyout debt and thereby increasing their willingness to create more value. That extension also distinguishes explicitly between fees paid by the target (which dilutes equity returns) and fees paid from the equity partnerships (which depend on equity returns), and highlights why it is optimal for the PE firm to collect both in our model.

4.1 Stochastic value improvement

Building on Müller and Panunzi (2003, Section 6), we consider a setting in which the value improvement is a binary random variable. We focus here on the robustness of our results. Internet Appendix F provides an in-depth comparison with Müller and Panunzi's analysis.

The firm value in the absence of a takeover is normalized to 0. If a bid succeeds, the firm value increases to $v>0$ with probability $q(e)$ and stays at 0 otherwise, where $e\in\mathbb{R}_0^+$ is effort provided by the bidder at a private cost $C(e)\geq 0$. We adopt the same success probability function $q(e)=e$ as Müller and Panunzi (2003), but instead of their quadratic cost function $C(e)=\frac{\xi e^2}{2}$, allow for a more general effort cost function $C(e)$ that satisfies $C'(e)\geq 0, C''(e)\geq 0$ for all $e\geq 0$.[14] We impose Inada-style conditions $\lim_{e\to 1} C'(e)=\infty$ and $C'(0)=0$ to abstract from corner solutions.

Value creation. If the bidder gains control, she chooses her effort to solve

$$\max_{e\in[0,1]} q(e)\alpha[v-D]^+ - C(e),$$

where α is her equity stake and D is the firm's debt. Given interior solutions, the optimal effort is pinned down by the first-order condition

$$C'(e)=\alpha(v-D). \tag{11}$$

It is instructive to define $Z\equiv\alpha(v-D)$ to stress that only the amount Z the bidder gets in the success state matters for incentives. Any $Z\in[0,v]$ and associated effort level can be implemented via infinitely many payoff-equivalent α-D-pairs. Debt and equity financing affect incentives in the same way. (This is a well-known property of financing models with binary v-or-0 structures). Still, as we will show, the main results from our baseline model go through.

Denote the effort that solves (11) by $e(Z)$. There is an increasing differentiable function f such that $e(Z)=f(Z)$ (given $C''(e)>0$ and the inverse function lemma).

[14] Given our general cost function $C(e)$, assuming a linear $q(e)$ is without loss of generality. We use a general cost function to demonstrate that some distinctive predictions of this model variant are driven by the binary outcome structure rather than the quadratic cost function.

Tendering decisions. The target shareholders' free-riding behavior equalizes, in equilibrium, the expected postbuyout share value with the bid price:

$$p = f(Z)(\upsilon - D), \tag{12}$$

where $f(Z)$ is the probability that the firm value is υ given the rationally expected effort.

Bid and financing. The bidder's ex-ante problem is to choose p, α, and D to maximize $f(Z)Z - C(f(Z)) - p + f(Z)D + (1-\alpha)f(Z)(\upsilon - D)$, where $f(Z)Z$ is the expected value of the equity stake she acquires, $C(f(Z))$ is her effort cost, p is the cash paid to target shareholders, $f(Z)D$ is the amount of debt funding, and $f(Z)(1-\alpha)(\upsilon - D)$ is the amount of outside equity funding. Using (12) in the objective function reduces the problem to

Lemma 5. In equilibrium, $\alpha^* = 1$, $D^* = \frac{\upsilon}{2}$, and $p^* > 0$.

We now show that analogs of Propositions 1 and 2 from our baseline model hold in this model variant with uncertainty. Recall that $\bar{D}$ denotes an exogenously imposed limit on (bootstrapped) takeover debt.

Proposition 6. Any limit $\bar{D} < \frac{\upsilon}{2}$ reduces takeover surplus. For $C(e) = \frac{c}{2}e^2$ and $c > \upsilon$, it also reduces takeover premia.

The first part replicates the result that bootstrapping is socially optimal. As for the second part, recall that the effect of bootstrapping on target shareholders depends on the sensitivity of the bidder's effort to the financing structure, which in turn is determined by the curvature of effort cost function C (Section 2.2). Here, we show that for the quadratic cost function—used by Müller and Panunzi (2003, Section 6)—bootstrapping benefits target shareholders.

Propositions 3 and 5 of our baseline model do not have analogues in this model variant; this is not a general consequence of introducing uncertainty but an artifact of the binary outcome structure, as we explain in Internet Appendix F.

4.2 Private benefit extraction

Private benefits are another source of bidder gains that, already without buyout leverage, reduces the free-rider problem (Grossman and Hart 1980; Burkart, Gromb, and Panunzi 1998).

Let V be the potential value improvement the bidder can create upon completion of a takeover. As before, we normalize the value under incumbent management to 0. As in Burkart, Gromb, and Panunzi (1998), the bidder chooses an allocation $\phi \in [0,1]$ that generates security benefits $(1-\phi)V$, which are distributed among all shareholders, and private benefits $d(\phi)V$ for herself. Let $d(\phi)$ be twice continuously differentiable, strictly increasing, and

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strictly concave with $d(0)=0$ and $d'(0)=1$. Thus, private benefit extraction is inefficient. Both V and $d(\phi)$ are common knowledge.

Extraction choice. If the bid succeeds, the target firm assumes the buyout debt D and the bidder's equity stake is α. The bidder then chooses ϕ to maximize the combined value of her equity stake and her private benefits. Define $U(\alpha,D,\phi)\equiv\alpha[(1-\phi)V-D]^{+}+d(\phi)V$. The bidder's posttakeover decision problem is

$$\max_{\phi\in[0,1]} U(\alpha,D,\phi).$$

Let $\phi^{*}(\alpha,D)$ denote the optimal extraction rule for the bidder. A unique $\phi^{*}(\alpha,D)$ exists due to our assumptions.

The bidder's objective function U is not globally concave in ϕ. Let $\bar{\phi}\in[0,1]$ be such that $(1-\bar{\phi})V=D$, that is, $\bar{\phi}=\frac{V-D}{V}$. For $\phi>\bar{\phi}$, equity is "out of the money," and $U(\alpha,D,\phi)=d(\phi)V$, which is strictly increasing in ϕ. Thus, the bidder optimally extracts the maximum ($\phi=1$). For $\phi<\bar{\phi}$, equity is "in the money," and $U(\alpha,D,\phi)=\alpha[(1-\phi)V-D]+d(\phi)V$, which is strictly concave in ϕ. Here, the first-order condition, $d'(\phi)=\alpha$, has a unique, strictly positive solution, which we denote $\phi(\alpha)$. The next result follows directly from these observations.

Lemma 6. The bidder's optimal diversion choice is $\phi^{*}(\alpha,D)=\phi(\alpha)>0$ if

$$\alpha[(1-\phi(\alpha))V-D]+d(\phi(\alpha))V\geq d(1)V, \tag{13}$$

where $\phi(\alpha)$ is the solution to

$$d'(\phi(\alpha))=\alpha. \tag{14}$$

Otherwise, she chooses $\phi^{*}(\alpha,D)=1$.

Tendering decisions. As in the other model variants, target shareholders' free-riding behavior equalizes the expected posttakeover share value with the bid price:

$$p=[(1-\phi^{*}(\alpha,D))V-D]^{+}\equiv E(\alpha,D), \tag{15}$$

where $\phi^{*}(\alpha,D)$ is the bidder's optimal extraction choice as rationally anticipated by the target shareholders.

Bid and financing. The bidder's ex ante profit is $\alpha E(\alpha,D)+d(\phi)V+F^{E}+F^{D}-\beta p$. It comprises the value of her expected equity stake, her expected private benefits, and the outside funding she receives for the bid less the takeover payment. She maximizes this by choosing bid p, debt financing $\{D,F^{D}\}$, and outside equity financing $\{\gamma,F^{E}\}$ subject to (13), (14), (15), and investors' participation constraints. We assume that outside investors are competitive and merely break even:

$$F^{E}=\beta(1-\gamma)E(\alpha,D)\quad\text{and}\quad F^{D}=D. \tag{16}$$

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Substituting these constraints as well as (14) and (15) into the bidder's profit yields

$$D + d(\phi(\alpha))V. \tag{17}$$

This shows that there are *two* exclusion mechanisms in this setting: leverage and private benefit extraction. But these mechanisms endogenously conflict with each other, as per debt overhang constraint (13). Lenders only agree to a proposed $\{\alpha, D\}$ that satisfies (13). If (13) is violated, lenders rationally anticipate the bidder to choose $\phi = 1$ and hence do not finance the bid. In parallel to the effort model, (13) defines an α-D-relationship for feasible financing. To raise more debt financing, the bidder must take on more equity to improve her incentives—here, to extract fewer private benefits—such that debt repayment is feasible. In short, extracting rents through debt requires forgoing private benefits.

The debt overhang constraint cannot be slack at the optimum. Otherwise, the bidder can lower α while preserving D and so raise her profit (17). Using the binding constraint (13) to replace D in (17) reduces the bidder's stage-1 choices to the univariate problem

$$\max_{\alpha \in [0,1]} \mathcal{W}(\alpha) - \frac{d(1)V - d(\phi(\alpha))V}{\alpha}, \tag{P$_\phi$}$$

where $\mathcal{W}(\alpha) \equiv (1-\phi(\alpha))V + d(\phi(\alpha))V$ is the total surplus generated by the takeover conditional on the bidder's optimal extraction choice. We can establish equilibrium existence (though not uniqueness without further specifying private benefit function d).

Lemma 7. The bidder succeeds with a bid such that (13)–(16) hold and α solves (P$_\phi$). If the solution is $\alpha^* = 0$, then $\phi^* = 1$, $D^* = 0$ and the bidder's profit is $d(1)V$.

Parameters for which solutions identified by Lemma 7 involve $D^* > 0$ and $\alpha^* > 0$ are easy to find, so takeover leverage generally plays a role. To understand why the solution to (P$_\phi$) is often interior, that is, why neither exclusion mechanism dominates the other, note that both are costly to the bidder. On one hand, private benefit extraction entails deadweight losses. On the other hand, the use of buyout leverage requires the bidder to leave a positive post-buyout equity value (to avoid debt overhang), which target shareholders extract via the takeover premium. In choosing her optimal exclusion strategy, the bidder trades off larger deadweight losses against a larger premium. Target shareholders hence benefit from bootstrapping as an alternative to private benefit extraction. Without bootstrapping, the bidder implements $\phi = 1$ and the target shareholders' payoff (i.e., the takeover premium) is 0.

While takeover premia are costly to the bidder, they are merely redistributive from a social perspective. Imposing a limit on bootstrapping—which shifts the bidder's exclusion strategy towards private benefit extraction—is thus weakly

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inefficient and strictly so if the unconstrained solution to (P_ϕ) is $\alpha^* > 0$ and the exogenous limit $\overline{D}$ would create a binding constraint. We summarize the above arguments in the below result for which we formally consider the effect of removing such an exogenous limit.

Proposition 7. When $\alpha^* > 0$, bootstrapping increases takeover surplus as well as takeover premia, and the bidder's net financing contribution is negative.

Proposition 7 replicates the insights from the effort model in Section 2 for parameters under which the bidder at least partly prefers buyout leverage to private benefit extraction. To offer more intuition for when this is likely to be the case, consider a specification for d. Let d belong to the following class of power functions:

$$d(\phi) = \left(\phi - \frac{\kappa \phi^n}{n}\right) V, \tag{18}$$

where $n \geq 2$ and κ parametrizes the inefficiency, or deadweight loss, of diversion. For this class of functions, the solution in Lemma 3 is unique and allows us to conduct comparative statics with respect to the inefficiency of diversion.

Proposition 8. For (18), the optimal debt level is increasing in κ.

When diversion entails larger deadweight losses, the bidder's exclusion strategy relies more on debt. That is, a buyout is more highly levered and improves incentives more when private benefit extraction is more inefficient. High leverage corrects severe inefficiencies.

The model variant with private benefit extraction maps well into narratives of LBOs reducing managerial agency problems such as empire-building and diversion of free cash flow (Jensen 1986). Under this interpretation, ϕ denotes how much of the firm's resources managers misuse and $\phi - d(\phi)$ how much value is thereby wasted. By Propositions 7 and 8, if the deadweight loss of such misuse is large, the optimal disciplinary takeover is a highly leveraged, bootstrapped buyout that disburses part of the efficiency gains to the bidder in upfront fees.

It is noteworthy that debt is not necessary to make buyouts feasible in this alternative model with private benefit extraction. In contrast to both Müller and Panunzi (2003, 2004) and our effort model, private benefit extraction already makes a bid profitable for bidders. Here, the social gains of buyout debt originate purely from improved incentives. The crux is that bootstrapping provides bidders with rents from improving (as opposed to reducing) postbuyout value.

4.3 Negotiated buyouts

In our model, there are no wealth constraints and it is free-riding behavior that prevents the first-best outcome. Absent the free-rider problem, such as when

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a merger is negotiated with the target management, bargaining would lead to some merger price that implements the first-best outcome and splits the surplus to mutual benefit.

Yet, the ability to extract gains through debt in a tender offer may affect the division of merger gains since resorting to a tender offer is the bidder's threat in the negotiations. Having the LBO structure in her arsenal would shift bargaining power to the bidder in the negotiations, even if the resulting merger need not be as highly leveraged as a threatened tender offer would have been. That said, the threat of the tender offer may lack credibility unless the bidder has procured requisite financing agreements from lenders (who have to conduct their own due diligence). If so, it could be that such agreements find their way into the merger deal. Suppose the optimal tender offer (threat) involves lending agreements that would generate a debt-to-value ratio of $\frac{D^*}{V^*}$ in our model (e.g., as the solution to (P)). The negotiated merger may then end up with a debt-to-value ratio of $\frac{D^*}{V^{fb}}$.

Whether or not the tender offer threat requires lending agreements that influence the eventual merger deal, our theory predicts that leveraged buyouts consummated through tender offers are more highly leveraged and rely more on bootstrapping, that is, debt raised at the target level ("OpCo debt") rather than at the level of private equity funds ("FundCo debt") or intermediary holding companies ("HoldCo debt"). Or put conversely, we would expect that leverage ratios are lower for negotiated buyouts of public companies and for buyouts of private companies. As these types of buyouts have become more common over the last decades, buyout leverage ratios should have decreased and the use of HoldCo and FundCo debt should have increased.

5. Conclusion

This paper combines the incentive theory of buyout debt with the theory on the free-rider problem in takeovers of dispersedly held firms. This combined theory predicts "excessive" levels of debt (beyond financing needs) raised via bootstrapping, paired with upfront fees collected by bidders directly from the target firms, as a financing structure that is socially optimal and increases buyout premiums.

Our analysis expands on a prominent line of reasoning in corporate governance theory. Set against Berle and Means's (1932) thesis that dispersed ownership empowers managers, Manne (1965) proposed a direct remedy: the threat of a takeover to reunify ownership and control. Such takeovers must not only reconsolidate ownership to improve incentives but also overcome the holdout behavior among the dispersed target shareholders (Jensen and Meckling 1976; Grossman and Hart 1980). Bootstrapping targets (to such a degree that PE firms cash out early) is, as we show, a buyout design that achieves both objectives simultaneously, immune even to the usual caveat that target shareholders want to limit the means bidders use to extract gains. This

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makes bootstrapped debt a silver bullet against free-riding and possibly crucial to implementing Manne's vision of disciplinary takeovers.

Surely, this does not dispel concerns that extreme buyout leverage can entail costs, such as a higher risk of financial distress or negative externalities borne by other stakeholders. But we offer efficiency arguments for controversial LBO features to counterbalance some of the concerns. In fact, we can explain why some takeovers are so extremely leveraged based on arguments that combine two canonical strands of takeover theory, and importantly, do not apply to capital structure choice outside of takeovers.

Appendix A. Proofs Omitted in the Text

Proof of Lemma 2. For every $p \in [E(\gamma/2, D), E(\gamma, D)]$, there exists a unique $\alpha_p \in [\gamma/2, \gamma]$ such that $E(\alpha_p, D) = p$. Every shareholder tenders for $\hat{\alpha}_i < \alpha_p$, retains her shares for $\hat{\alpha} > \alpha_p$, and is indifferent between tendering and retaining for $\hat{\alpha} = \alpha_p$. ■

Proof of Lemma 3. The objective function is continuous in α and its domain is compact. Hence there exists an $\alpha \in [1/2, 1]$ that solves (P). If the profit under this solution is positive, the bidder makes a successful bid. Otherwise, she abstains from a takeover. ■

Proof of Proposition 1. The proof is composed of two lemmas. One establishes that a binding debt overhang constraint entails a positive relationship between α and D. The other shows that the debt overhang constraint binds in equilibrium also when an exogenous cap $\bar{D}$ limits the bidder's choice of D.

Lemma 8. A binding debt overhang constraint defines D as a strictly increasing function of α.

Proof. As per (1*), define $D(\alpha) \equiv V(e^+(\alpha)) - \frac{C(e^+(\alpha))}{\alpha}$. We have:

$$D'(\alpha) = V'(e^+(\alpha))e^{+'}(\alpha) + \frac{1}{\alpha^2}C(e^+(\alpha)) - \frac{1}{\alpha}C'(e^+(\alpha))e^{+'}(\alpha)$$

$$= \left(V'(e^+(\alpha)) - \frac{1}{\alpha}C'(e^+(\alpha))\right)e^{+'}(\alpha) + \frac{1}{\alpha^2}C(e^+(\alpha))$$

$$= \frac{1}{\alpha^2}C(e^+(\alpha)) > 0.$$

The third equality holds because $\alpha V'(e^+(\alpha)) - C'(e^+(\alpha)) = 0$ by (2). The fact that $D(\alpha)$ is strictly increasing implies the same for its inverse function. □

Let $\overline{D}$ be an exogenous upper bound on debt, that is, the bidder is only allowed to issue $D \in [0, \overline{D}]$. Let (α^*, D^*) denote the optimal posttakeover bidder stake α^* and debt level D^* in the absence of the exogenous upper bound on D.

Since the exogenous debt limit is nonbinding for $\overline{D} > D^*$, we restrict attention to $\overline{D} \leq D^*$. The next lemma shows that the debt overhang constraint is always binding in equilibrium even when there is an exogenous cap on debt.

Lemma 9. In equilibrium, the bidder chooses (α, D) such that $D \leq \overline{D}$ and $\alpha D = \alpha V(e(\alpha)) - C(e(\alpha))$.

Proof. First suppose $D < \overline{D}$. By the endogenous debt overhang constraint, $\alpha D \leq \alpha V(e(\alpha)) - C(e(\alpha))$. If $\alpha D < \alpha V(e(\alpha)) - C(e(\alpha))$, the bidder can increase D by some $\varepsilon > 0$ so that $D + \varepsilon < \overline{D}$ and $\alpha(D + \varepsilon) < \alpha V(e(\alpha)) - C(e(\alpha))$, which strictly increases the bidder's profit. Thus, this yields a contradiction.

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Now suppose $D = \overline{D}$ but $D < \bar{D}(\alpha)$ where, for said α, $\bar{D}(\alpha) = V(e(\alpha)) - \frac{C(e(\alpha))}{\alpha}$ is the endogenous debt capacity where the debt overhang constraint would be binding. Since $\bar{D}'(\alpha) > 0$ by Lemma 8 and $D < \bar{D}(\alpha)$, there is an $\varepsilon > 0$ such that $\alpha' = \alpha - \varepsilon$ satisfies $D < \bar{D}(\alpha') = V(e(\alpha')) - \frac{C(e(\alpha'))}{\alpha'}$. Because $C(e(\alpha))$ is increasing in α, it then follows that $D - C(e(\alpha')) > D - C(e(\alpha))$, so the bidder obtains a strictly higher profit. Thus, this too leads to a contradiction. □

Lemma 9 implies that the imposition of a binding exogenous cap $\bar{D}$ causes the debt overhang constraint (1*) to be binding at some lower level of debt $D \leq \bar{D} < D^*$. Lemma 8 consequently implies that the imposition of $\overline{D}$ leads to a smaller bidder stake α. We will use these lemmas also in the proof of Proposition 2.

To conclude this proof, note that $\mathcal{W}(\alpha)$ is strictly increasing in α. By lowering α, the imposition of a binding exogenous cap hence reduces takeover surplus. ■

Proof of Proposition 2. For reference, we state a result from one variable calculus (e.g., Rudin 1964, p. 114):

Lemma 10. Let $f:(0,+\infty) \to \mathbb{R}$ be a differentiable function such that $f'(x) > 0$ for all $x \in (0,+\infty)$. Then f is strictly increasing on $(0,+\infty)$ and has a differentiable inverse function g with

$$g'(f(x)) = \frac{1}{f'(x)}$$

for all $x \in (0,+\infty)$. If $f:(0,+\infty) \to \mathbb{R}$ is twice differentiable and such that $f''(x) > 0$ for all $x \in (0,+\infty)$, then its inverse g is also twice differentiable and we have

$$g''(f(x)) = -\frac{f''(x)}{(f'(x))^3}$$

for all $x \in (0,+\infty)$.

We turn to the main proof. As in the proof of Proposition 1, suppose the bidder may issue $D \in [0, \overline{D}]$, where $\overline{D}$ is an exogenous limit. We restrict attention to $\overline{D} \leq D^*$ where the limit matters.

We know that debt overhang constraint (1) binds in equilibrium with or without a limit on D and that such a limit causes a decrease in the bidder's postbuyout stake α (Lemmas 8 and 9 in the proof of Proposition 1). For the current proposition, it hence suffices to establish whether or when target shareholders benefit from larger α, conditional on (1) binding.

As shown in the main text, when (1) binds, target shareholders' payoff is $\frac{C(e^+(\alpha))}{\alpha}$. Target shareholders benefit from larger α if

$$\frac{\mathrm{d}}{\mathrm{d}\alpha}\frac{C(e^+(\alpha))}{\alpha} = \frac{C'(e^+(\alpha))e^{+'}(\alpha)}{\alpha} - \frac{C(e^+(\alpha))}{\alpha^2}$$
$$= \frac{\theta}{\alpha}\left[\frac{C'(e^+(\alpha))}{C''(e^+(\alpha))} - \frac{C(e^+(\alpha))}{C'(e^+(\alpha))}\right] \geq 0.$$

The second equality above holds by Lemma 10, whereby if $e^+(\alpha) > 0$, then $e^{+'}(\alpha) = \frac{\theta}{C''(e^+(r))}$. A sufficient condition for the last inequality to hold globally is log-concavity of C, that is, $C(e)C''(e) \leq [C'(e)]^2$ for all $e > 0$.[15]

Finally, we want to verify that there are log-concave C for which $D^* > 0$, that is, for which the bidder is inclined to use debt (make a bid) such that the exogenous debt limit could be binding. In

15 Note that $\frac{C(e^+(\alpha))}{\alpha}$ is an average cost per share, but α is not the direct argument in C. If C were a direct function of α, a sufficient condition for the average cost to be increasing is that marginal cost exceeds average cost. Log-concavity matters for first-order condition (2) to ensure that $e^+(\alpha)$ is sufficiently elastic with respect to α.

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Appendix Appendix B. Examples with Specific Functional Forms for C , we show that this is the case, for example, for power functions.[16] ■

Proof of Proposition 5. Interior solution

Equation (10) defines bidder 1's debt as a strictly increasing function of her equity stake. We denote this function by

$$D_1^c(\alpha_1) \equiv V(e_1^+(\alpha_1)) - \overline{p}_2.$$

It represents (α_1, D_1) that take into account all optimality conditions except (1), or more specifically, for which (2) holds and (3) and (9) strictly bind.

Recall that, as per (1*),

$$D_1(\alpha_1) \equiv V_1(e_1^+(\alpha_1)) - \frac{C_1(e_1^+(\alpha_1))}{\alpha_1}$$

represents all (α_1, D_1) for which (1) strictly binds.

As established in the main text, bidder 1 optimally matches bidder 2's reservation price by maximizing α subject to (1) and (10). The solution is the highest α_1 where

$$D_1^c(\alpha_1) \leq D_1(\alpha_1),$$

which we hereafter denote by α_1^{**}.

The previous inequality is slack at the single-bidder optimum α_1^*:

$$D_1^c(\alpha_1^*) = V_1(e^+(\alpha_1^*)) - \overline{p}_2 < V_1(e^+(\alpha_1^*)) - p_1^* = D_1(\alpha_1^*),$$

where the inequality follows from $p_1^* = \frac{C_1(e_1^+(\alpha_1^*))}{\alpha_1^*}$ and effective competition ($\overline{p}_2 > p_1^*$). Thus, $\alpha_1^{**} > \alpha_1^*$. That is, competition increases bidder 1's takeover debt compared to the single-bidder case.

For a given $\overline{p}_2$, suppose $\alpha_1^{**} < 1$. Does bidder 1 use even more takeover debt when bidder 2's reservation price increases to $\overline{p}_2^\epsilon > \overline{p}_2$? One can show that this is the case by relabeling α_1^{**} as α_1^*, $\overline{p}_2$ as p_1^*, and $\overline{p}_2^\epsilon$ as $\overline{p}_2$ and retracing the previous arguments. In doing so, an important observation is that debt overhang constraint (1) binds for any optimal noncorner winning bid; for $\alpha_1^{**} < 1$, $D_1^c(\alpha_1^{**}) = D_1(\alpha_1^{**})$.

Corner solution. Suppose bidder 1 matches bidder 2's reservation price with a bid that leads to $\alpha_1 = 1$. At $\alpha_1 = 1$, the free-rider condition can be slack. Still, as bidder 1 buys all shares at a price equal to $\overline{p}_2$, her profit is $\mathcal{W}(1) - \overline{p}_2$, which is the maximum value of the profit function $\mathcal{W}(\alpha) - \overline{p}_2$ used in the arguments in the text. Thus, the result that bidder 2's presence increases bidder 1's takeover debt, if $\alpha_1^* < 1$, is valid also when the winning bid is a corner solution. Once in the corner solution, bidder 1 can meet further increases in $\overline{p}_2$ by reducing debt but, equivalently, also by raising p_1 without a change in debt. ■

Proof of Lemma 5. Using (12) again, this time to replace $f(Z)$, the problem can be rewritten

$$\begin{aligned} \underset{p,D}{\text{maximize}} \quad & \tfrac{pD}{v-D} - C\left(\tfrac{p}{v-D}\right) \\ \text{subject to} \quad & \\ & \alpha \in [0,1] \\ & p = f(Z)(v-D). \end{aligned}$$

[16] One can also find conditions under which the bidder's equilibrium profit is globally increasing in α. A sufficient condition for this is that C is log-convex (see Internet Appendix D). That said, global conditions on C are much more restrictive than needed for bootstrapping to create Pareto gains. For example, it is simple to construct such a setting with cost functions that have alternating log-convex and log-concave segments.

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Partially differentiating w.r.t. p and D yields

$$\frac{d\Pi}{dp}=\frac{D}{v-D}-C'\left(\frac{p}{v-D}\right)\frac{1}{v-D},$$

and

$$\frac{d\Pi}{dD}=\frac{p}{v-D}+\frac{Dp}{(v-D)^2}+C'\left(\frac{p}{v-D}\right)\frac{p}{(v-D)^2}.$$

The first-order condition $\frac{d\Pi}{dp}=0$ implies

$$C'\left(\frac{p}{v-D}\right)=D. \tag{A1}$$

Inserting this in the partial w.r.t. D gives

$$\frac{d\Pi}{dD}=\frac{p}{v-D}+\frac{2pD}{(v-D)^2}>0. \tag{A2}$$

The four conditions (11)–(A2) pin down the optimal financing choice. First, if we rewrite (11) as $C'(f(Z))=Z$, we see that (11) and (A1) imply $f(D)=\frac{p}{v-D}$, or

$$p=f(D)[v-D].$$

Combining the latter equation with (12) implies $f(D)[v-D]=f(Z)[v-D]$. Since f is invertible, this implies $D=Z$. As $Z\equiv\alpha[D-v]$, this defines α as an increasing function of D, that is, $\alpha=\frac{D}{D-v}$. By (A2), the upper bound $\alpha=1$ is optimal. If $\alpha=1$, then $D=\frac{v}{2}$ and $p=f\left(\frac{v}{2}\right)\frac{v}{2}>0$. ■

Proof of Proposition 6. *First part*: As shown in the proof of Lemma 5, the bidder's optimal strategy is to maximize D and set $\alpha=\frac{D}{D-v}$. Absent an exogenous debt limit, the optimum is hence given by the upper bound on α, that is, $\alpha=1$ and the associated debt level $D=\frac{v}{2}$. With the exogenous debt limit $\bar{D}<\frac{v}{2}$, the optimum is instead given by the upper bound on D, that is, $D=\bar{D}$ and the associated equity share $\bar{\alpha}\equiv\frac{\bar{D}}{\bar{D}-v}$. The decreases in D and α have opposite effects on the bidder's incentives. To see the net effect, insert $\bar{D}$ and $\bar{\alpha}$ into the first-order condition for the optimal effort (11). This yields

$$C'(e)=\bar{\alpha}[\bar{D}-v]=\bar{D}, \tag{A3}$$

and so $e(\bar{D})=f(\bar{D})$ where f is increasing in $\bar{D}$.

Second part: Continuing from above, for any given $\bar{D}\in(0,\frac{v}{2})$, we have $D=\bar{D}$ and $\bar{\alpha}\equiv\frac{\bar{D}}{\bar{D}-v}$. Retracing steps from the proof of Lemma 5, we then have $p=f(\bar{D})[v-\bar{D}]$ in equilibrium. For the present proof, we must determine the sign of

$$\frac{dp}{d\bar{D}}=f'(\bar{D})(v-\bar{D})-f(\bar{D}).$$

Now assume $C(e)=\frac{ce^2}{2}$, and let $c>v$ to focus on (ensure) an interior solution to the effort problem. Then $C'(e)=ce$. The inverse f of C' is $f(x)=\frac{x}{c}$. With this,

$$\frac{dp}{d\bar{D}}=f'(\bar{D})(v-\bar{D})-f(\bar{D})=\frac{1}{c}(v-\bar{D})-\frac{1}{c}\bar{D}.$$

Hence $\frac{dp}{d\bar{D}}\geq 0$ if and only if $v-\bar{D}\geq\bar{D}$, which holds if and only if $\bar{D}\leq\frac{v}{2}$. Recall that the optimal debt level in the absence of a limit is $D^*=\frac{v}{2}$. It follows from $D^*=\frac{v}{2}$ and $\frac{dp}{d\bar{D}}>0$ for all $\bar{D}\leq\frac{v}{2}$ that any debt limit $\bar{D}<\frac{v}{2}$ (i.e., any limit that would be binding) reduces target shareholder wealth. ■

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Proof of Lemma 7. The objective function is continuous in α and its domain is compact. Hence there exist $\alpha \in [0,1]$ that solve (P_ϕ). If the solution is $\alpha = 0$, it follows from (13) that $D = 0$ and from (14) that $\phi = 1$. The bidder's profit in this case is $d(1)V$. ■

Proof of Proposition 7. The proof of the first part builds on two lemmas. One establishes that a binding debt overhang constraint entails a positive relationship between α and D. The other shows that the debt overhang constraint binds in equilibrium also when an exogenous cap $\bar{D}$ limits the bidder's choice of D.

Lemma 11. A binding debt overhang condition (13) defines debt as an increasing function of the ownership stake α.

Proof. Let (13) hold with equality and rearrange to $D = (1-\phi(\alpha))V + \frac{d(\phi(\alpha))V - d(1)V}{\alpha}$. Differentiating with respect to α yields

$$\begin{aligned} D'(\alpha) &= -\phi'(\alpha)V + \frac{d'(\phi(\alpha))\phi'(\alpha)V}{\alpha} - \frac{d(\phi(\alpha))V - d(1)V}{\alpha^2} \\ &= \frac{d'(\phi(\alpha))\phi'(\alpha)V - \alpha\phi'(\alpha)V}{\alpha} + \frac{d(1)V - d(\phi(\alpha))V}{\alpha^2} \\ &= \frac{d(1)V - d(\phi(\alpha))V}{\alpha^2} > 0. \end{aligned}$$

Let (α^*, D^*) denote the optimal bidder stake α^* and debt level D^* in the absence of the exogenous upper bound on D. Assume the exogenous limit binds: $\overline{D} < D^*$.

Lemma 12. In equilibrium, the bidder chooses (α, D) such that $D \leq \overline{D}$ and $\alpha D = \alpha(1-\phi(\alpha))V + d(\phi(\alpha))V - d(1)V$.

Proof. First suppose $D < \overline{D}$. By the endogenous debt overhang constraint, $\alpha D \leq \alpha(1-\phi(\alpha))V + d(\phi(\alpha))V - d(1)V$. If $\alpha D < \alpha(1-\phi(\alpha))V + d(\phi(\alpha))V - d(1)V$, the bidder can increase D by some $\varepsilon > 0$ so that $D + \varepsilon < \overline{D}$ and $\alpha(D+\varepsilon) < \alpha(1-\phi(\alpha))V + d(\phi(\alpha))V - d(1)V$, which strictly increases the bidder's profit. Thus, this yields a contradiction.

Now suppose $D = \overline{D}$ but $D < \bar{D}(\alpha)$ where, for said α, $\bar{D}(\alpha) = (1-\phi(\alpha))V + \frac{d(\phi(\alpha))V - d(1)V}{\alpha}$ is the endogenous debt capacity where the debt overhang constraint would be binding. Since $\bar{D}'(\alpha) > 0$ by Lemma 11 and $D < \bar{D}(\alpha)$, there is an $\varepsilon > 0$ such that $\alpha' = \alpha - \varepsilon$ satisfies $D < \bar{D}(\alpha') = (1-\phi(\alpha'))V + \frac{d(\phi(\alpha'))V - d(1)V}{\alpha'}$. Since $d(\phi(\alpha))$ is a decreasing function of α, it then follows that $D + d(\phi(\alpha'))V > D + d(\phi(\alpha))V$, so the bidder obtains a strictly higher profit. Thus, this too leads to a contradiction. □

Finally, to prove the first part of Proposition 7, note that

$$\mathcal{W}'(\alpha) = d'(\phi(\alpha))\phi'(\alpha)V - \phi'(\alpha)V = V\phi'(\alpha)[d'(\phi(\alpha)) - 1] > 0.$$

The last inequality follows because $\phi'(\alpha) < 0$ and because $d'(\phi(\alpha)) < 1$ for all $\phi(\alpha) > 0$ due to the strict concavity of d. Thus, as imposing the debt limit $\overline{D}$ reduces the bidder's optimal α (as per Lemmas 11 and 9), total surplus decreases because the bidder resorts to more private benefit extraction, which leads to more deadweight losses.

We now prove the second part of the proposition. Absent takeover debt, $\phi^* = 1$ and the takeover premium is $p^* = 0$. By contrast, if $D > 0$ and $\alpha > 0$ in equilibrium, $\phi(\alpha) < 1$ and the binding debt overhang constraint (13) implies a posttakeover share value of $(1-\phi(\alpha))V - D = \frac{d(1) - d(\phi(\alpha))}{\alpha} V > 0$. By the free-rider condition (15), this equals the takeover premium.

Last, we prove the third part of the proposition. The stage-1 external financing flows to the bidder net of the (cash) acquisition price are $F^E + F^D - \beta E(\alpha, D)$. Using the outside investors' break-even constraints from (16), this reduces to $D - \alpha E(\alpha, D)$ as outside equity financing and the

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value of the outside equity stake cancel out (recall $\alpha = \gamma\beta$). The debt overhang constraint (13) holds with equality in equilibrium. Subtracting D on both sides and rearranging the binding constraint yields

$$\underbrace{D^* - \alpha^*((1-\phi^*)V - D^*)}_{D^* - \alpha^* E(\alpha^*, D^*)} = d(\phi^*)V + D^* - d(1)V. \tag{A4}$$

(with * indicating equilibrium values). The left-hand side is equal to the net external financing flows from above. On the right-hand side, $d(\phi^*)V + D^*$ equals the bidder's profit when $\alpha^* > 0$ and $D^* > 0$ (cf. (17)), whereas $d(1)V$ is her profit for $\alpha = D = 0$. If $\alpha^* > 0$, the right-hand side is positive by revealed preference, in which case (A4) implies that the external financing flows net of the acquisition price are positive (i.e., the bidder's net financing contribution is negative). ■

Proof of Proposition 8. We begin by showing that the bidder's ex-ante problem has a unique solution under the diversion function specified in (18).

Lemma 13. Let $f:(a,b) \to \mathbb{R}$, $g:[a,b) \to \mathbb{R}$ and $h:(a,b) \to \mathbb{R}$ be functions such that $f(x) = g(x)h(x)$ for all $x \in (a,b)$, where $h(x) > 0$ for all $x \in (a,b)$ and $g(a) \geq 0$ and $\lim_{x \to b} f(x) < 0$. Assume there is an $x^* \in (a,b)$ such that $g'(x^*) = 0$ and $g'(x) > 0$ for all $x \in (a, x^*)$ and $g'(x) < 0$ for all $x > x^*$. Then there is a unique $y \in (a,b)$ with $f(y) = 0$ and $f(x) > 0$ for all $x < y$, and $f(x) < 0$ otherwise.

Proof. We first show that $f(x) > 0$ for all $x \in (a, x^*]$. To see this, note that $g(x) > 0$ for all $x \in (a, x^*]$ since $g(a) \geq 0$ and g is strictly increasing on (a, x^*). Thus, since $h(x) > 0$ for all $x \in (a,b)$, it follows that $f(x) = g(x)h(x) > 0$ for all $x \in (a, x^*]$. Further, since $f(x^*) > 0$ and $\lim_{x \to b} f(x) < 0$ there is an $y \in (x^*, b)$ with $f(y) = 0$, and since g is strictly decreasing on $(x^*, 1)$, it follows that $f(x) > 0$ for all $x < y$ and $f(x) < 0$ for all $x > y$. □

We now establish uniqueness.

Lemma 14. For the diversion function defined in (18), the bidder's ex ante problem has a unique solution $\alpha^* \in (0,1)$.

Proof. From the calculations above, it follows that for all $\alpha \in (0,1)$

$$\Pi'(\alpha) = D'(\alpha) + d'(\phi(\alpha))\phi'(\alpha)V$$

$$= \frac{V}{\alpha^2}\left[d(1) - d(\phi(\alpha)) + \alpha^3\phi'(\alpha)\right].$$

Now define

$$g(\alpha) \equiv d(1) - d(\phi(\alpha)) + \alpha^3\phi'(\alpha)$$

$$h(\alpha) \equiv \frac{V}{\alpha^2}$$

so that $\Pi'(\alpha) = g(\alpha)h(\alpha)$ for all $\alpha \in (0,1)$. We will show that $g(\cdot)$ and $h(\cdot)$ satisfies the premises of Lemma 13. It is clear that $h(\alpha) > 0$ for all $\alpha \in (0,1)$ and that $g(0) = d(1) - d(\phi(0)) \geq 0$ (since $d(\cdot)$ is increasing and $\phi(0) \leq 1$). Note also that

$$\lim_{\alpha \to 1} \Pi'(\alpha) = \lim_{\alpha \to 1} \frac{V}{\alpha^2}\left[d(1) - d(\phi(\alpha)) + \alpha^3\phi'(\alpha)\right] < 0$$

since $\lim_{\alpha \to 1}\phi'(\alpha) = -\infty$. We next compute the first derivative of g.

$$g'(\alpha) = -d'(\phi(\alpha))\phi'(\alpha) + 3\alpha^2\phi'(\alpha) + \alpha^3\phi''(\alpha)$$

$$= [3\alpha^2 - \alpha]\phi'(\alpha) + \alpha^3\phi''(\alpha)$$

$$= \phi'(\alpha)\frac{\alpha}{1-\alpha}\left[(3\alpha - 1)(1-\alpha) + \alpha^2\frac{n-2}{n-1}\right].$$

It is only in the last equality that we use the explicit functional form of d from (18) and the resultant $\phi(\alpha)=\left(\frac{1-\alpha}{\kappa}\right)^{\frac{1}{n-1}}$ from the bidder's ex post diversion choice. More specifically, we use that

$$\phi'(\alpha)=\frac{1}{n-1}\left(\frac{1-\alpha}{\kappa}\right)^{\frac{1}{n-1}-1}\left(-\frac{1}{\kappa}\right)$$

and hence that

$$\begin{aligned}\phi''(\alpha)&=\phi'(\alpha)\left(\frac{\kappa}{1-\alpha}\right)\left(\frac{1}{n-1}-1\right)\left(-\frac{1}{\kappa}\right)\\&=\phi'(\alpha)\left(\frac{1}{1-\alpha}\right)\left(\frac{n-2}{n-1}\right).\end{aligned}$$

Next, define $m(\alpha)\equiv[3\alpha-1][1-\alpha](n-1)+\alpha^2(n-2)=[(n-2)-3(n-1)]\alpha^2+4(n-1)\alpha-(n-1)$ and $l(\alpha)\equiv\phi'(\alpha)\frac{\alpha}{(1-\alpha)(n-1)}$. We show that there is a unique $\beta\in(0,1)$ such that $m(\beta)=0$ and $m(\alpha)<0$ for all $\alpha<\beta$ and $m(\alpha)>0$ for all $\alpha>\beta$.

First, note that $m(0)=-(n-1)<0$ and $m(1)=(n-2)>0$, so the (polynomial) function m has at least one zero β in $(0,1)$. Second, since $(n-2)<3(n-1)$, it follows that m is strictly concave. Since m is a quadratic polynomial (and is strictly concave), it cannot have both of its zeros in the interval (0,1), as $m(0)<0$ would then imply that $m(1)<0$, which is a contradiction. Hence, it must be the case that there is a $\beta\in(0,1)$ such that $m(\beta)=0$ and $m(\alpha)<0$ for all $\alpha<\beta$ and $m(\alpha)>0$ for all $\alpha>\beta$.

Thus, since m satisfies the property established in the previous paragraph, and since $l(\alpha)<0$ for all $\alpha\in(0,1)$, it follows that $g'(\beta)=l(\beta)m(\beta)=0$ and $g'(\alpha)=l(\alpha)m(\alpha)>0$ for all $\alpha<\beta$ and $g'(\alpha)=l(\alpha)m(\alpha)<0$ for all $\alpha>\beta$.

Finally, since $\Pi'(\alpha)=g(\alpha)h(\alpha)$ for all $\alpha\in(0,1)$ and since the premises of Lemma 13 are satisfied (as established above), it follows that there is a unique $\alpha^*\in(0,1)$ such that $\Pi'(\alpha^*)=0$ and $\Pi'(\alpha)>0$ for all $\alpha<\alpha^*$ and $\Pi'(\alpha)<0$ for all $\alpha>\alpha^*$. □

With uniqueness established, we analyze how the solution depends on κ. Using $d(\phi)=\phi-\frac{\kappa\phi^n}{n}$ we get

$$\begin{aligned}\Pi'(\alpha)&=D'(\alpha)+d'(\phi(\alpha))\phi'(\alpha)V\\&=\frac{V}{\alpha^2}\left[d(1)-\left(\frac{n-1+\alpha}{n}\right)\left(\frac{1-\alpha}{\kappa}\right)^{\frac{1}{n-1}}-\left(\frac{\alpha^3}{1-\alpha}\right)\left(\frac{1}{n-1}\right)\left(\frac{1-\alpha}{\kappa}\right)^{\frac{1}{n-1}}\right].\end{aligned}$$

To stress the dependence of $\Pi'(\alpha)$ on κ, we denote it as $\Pi'_\kappa(\alpha)$. We rewrite the expression above as follows

$$\Pi'_\kappa(\alpha)=A(\alpha)-B(\alpha)\kappa^{-\frac{1}{n-1}},$$

where $A(.)$ and $B(.)$ are defined as $A(\alpha)\equiv\frac{Vd(1)}{\alpha^2}$ and

$$B(\alpha)\equiv\frac{V}{\alpha^2}\left[\left(\frac{n-1+\alpha}{n}\right)(1-\alpha)^{\frac{1}{n-1}}+\left(\frac{\alpha^3}{1-\alpha}\right)\left(\frac{1}{n-1}\right)(1-\alpha)^{\frac{1}{n-1}}\right].$$

Note that $B(\alpha)>0$. It follows that

$$\frac{d\Pi'_\kappa(\alpha)}{d\kappa}=\frac{B(\alpha)}{n-1}\kappa^{-\frac{n}{n-1}}>0. \tag{A5}$$

Let $\alpha^*(\kappa)$ be the unique solution to the bidder's ex ante problem, that is, satisfy $\Pi'_\kappa(\alpha^*(\kappa))=0$. By (A5), $\kappa<\kappa'$ implies $\alpha^*(\kappa)<\alpha^*(\kappa')$ and, because $D(\alpha)$ increases in α, also $D(\alpha^*(\kappa))<D(\alpha^*(\kappa'))$. That is, the more inefficient diversion is, the more the bidder resorts to debt financing. ■

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Appendix B. Examples with Specific Functional Forms for C

We consider two specific functional forms for cost function C: power functions and exponential functions. Power functions serve as an example of log-concave functions for which the bidder uses a strictly positive amount of debt, but not the maximum feasible amount of debt in the absence of competition (i.e., $\alpha^* \in (0,1)$ while her profit is strictly positive).[17] Exponential functions serve as an example of log-convex functions, under which a corner solution obtains: the bidder takes on the maximum stake $\alpha^*=1$, accordingly exhausting her debt capacity even absent competition. Under either class of functions, bootstrapping is Pareto-improving (though in the case of exponential functions, target shareholders gain only weakly).

Example 1 (Power functions). Let $V(e) \equiv \theta e$ and $C(e) \equiv \frac{c}{n} e^n$, where $\theta > 0$, $c > 0$ and $n \in \mathbb{N}$ are exogenous parameters. These functions satisfy all our assumptions. It can also be shown that they generate unique solutions to (P) (proof available upon request). So, if the bidder's profit is positive under the solution to (P), there exists a unique $\langle D, \alpha, p, e \rangle$ such that $\alpha V'(e) = C'(e)$, $p = V(e) - D$, $\alpha D = \alpha V(e) - C(e)$, and $\alpha \in [1/2, 1]$ satisfying $\alpha \in \{1/2, 1\}$ or the ex ante first-order condition for (P),

$$\frac{1}{\alpha^2} C(e^+(\alpha)) = C'(e^+(\alpha)) e^{+'}(\alpha). \tag{A6}$$

The specific functional form allows us to express $\langle D, \alpha, p, e \rangle$ in closed form. The first-order condition for effort $\alpha V'(e) = C'(e)$ yields $e = \left(\frac{\alpha\theta}{c}\right)^{\frac{1}{n-1}}$. The equilibrium stake α solves (A6). One can show that this condition holds if and only if

$$\theta e^{+'}(\alpha) \left(\frac{n-1}{n} - \alpha \right) = 0,$$

which in turn holds if and only if $\alpha = 0$ (since $e^{+'}(0) = 0$) or $\alpha = \frac{n-1}{n}$. Of these, only $\alpha = \frac{n-1}{n}$ is admissible as a solution to (P). It is straightforward to verify that

$$D = \frac{(n-1)\theta}{n} \left(\frac{(n-1)\theta}{nc} \right)^{\frac{1}{n-1}}$$

and

$$p = \frac{\theta}{n} \left(\frac{(n-1)\theta}{nc} \right)^{\frac{1}{n-1}}.$$

Furthermore, the bidder's profit under the solution to (P) is positive since

$$D - C(e^+(\alpha)) = \frac{(n-1)\theta}{n} \left(\frac{(n-1)\theta}{nc} \right)^{\frac{1}{n-1}} - \frac{(n-1)\theta}{n^2} \left(\frac{(n-1)\theta}{nc} \right)^{\frac{1}{n-1}}$$

$$= \theta \left(\frac{n-1}{n} \right)^2 \left(\frac{(n-1)\theta}{nc} \right)^{\frac{1}{n-1}} \geq 0.$$

To sum up, there is a unique equilibrium in which

$$\langle D, \alpha, p, e \rangle = \left\langle \frac{(n-1)\theta}{n} \left(\frac{(n-1)\theta}{nc} \right)^{\frac{1}{n-1}}, \frac{n-1}{n}, \frac{\theta}{n} \left(\frac{(n-1)\theta}{nc} \right)^{\frac{1}{n-1}}, \left(\frac{\frac{n-1}{n}\theta}{c} \right)^{\frac{1}{n-1}} \right\rangle.$$

As power functions are log-concave for all $n \in \mathbb{N}$, (more) debt always increases posttakeover share value and target shareholder wealth (Proposition 2). The equilibrium debt-equity ratio is $D/p = n-1$. For $n=5$, the ratio equals 4.

[17] These equilibrium properties obtain under all power functions except the linear one.

Example 2 (Exponential functions). Let $V(e) \equiv \theta e$ and $C(e) \equiv \exp(e)$ with $\theta > \exp(2)$. These functions satisfy all our assumptions, and can be shown to entail unique solutions to (P) (proof available upon request). If the bidder's profit is positive under (P), there is a unique $\langle D, \alpha, p, e \rangle$ such that $\alpha V'(e) = C'(e)$, $p = V(e) - D$, $\alpha D = \alpha V(e) - C(e)$, and $\alpha \in [1/2, 1]$ either satisfying the ex ante first-order condition (A6) or $\alpha \in \{1/2, 1\}$. The posttakeover first-order condition $\alpha V'(e) = C'(e)$ yields $e^+(\alpha) = \ln(\alpha\theta)$, which is stictly positive given $\alpha\theta > \frac{\exp(2)}{2} > 1$. Substituting $e^+(\alpha)$ into the profit function of (P) yields

$$\theta \ln(\alpha\theta) - (1 + 1/\alpha)\alpha\theta.$$

Differentiating with respect to α yields $\theta(1/\alpha - 1)$, which is strictly positive for all $\alpha \in [1/2, 1)$. Thus, $\alpha = 1$ is the unique solution to (P). It is straightforward to verify that

$$D = \theta \ln(\theta) - \theta$$

and

$$p = \theta.$$

Furthermore, the bidder's profit is

$$D - C(e^+(1)) = \theta(\ln(\theta) - 2),$$

which is positive since $\theta > \exp(2)$ implies $\ln(\theta) > 2$. To summarize, there is a unique equilibrium in which

$$\langle D, \alpha, p, e \rangle = \langle \theta \ln(\theta) - \theta, 1, \theta, \ln(\theta) \rangle.$$

As exponential functions are weakly log-concave, leverage is weakly Pareto-improving. With $\alpha = 1$ in equilibrium, first-best incentives are restored. The equilibrium debt-equity ratio is $D/p = \ln(\theta) - 1$. For example, if $\theta = \exp(5)$, the ratio is 4.

Code Availability: No new code was generated in support of this research.

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