A General Theory of Holdouts[*]

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Abstract

This paper develops a principal-multi-agent framework for the holdout problem, a pervasive phenomenon in which value-creating deals fail because agents free ride on others' participation. The analysis highlights the role of the principal's commitment: Whereas a unanimity rule solves the problem under commitment, no such panacea exists under limited commitment. In that case, outcomes depend on agents' preexisting claims in a way consistent with observed patterns: senior debt used in restructurings and cash in takeovers. An increase in (partial) commitment can exacerbate the problem, generating a non-monotonicity that sheds light on contradictory findings in the literature and various policies. *JEL codes:* G34, G38, C78, D86.

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> [The] effectiveness [of punishment] is seen as resulting from its inevitability.
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> Michel Foucault, *Discipline and Punish*

1   Introduction

Holdout problems are pervasive. They occur whenever a socially beneficial transaction fails because one of the parties in the transaction free-rides on the participation of the other parties, *holding out* for a larger payoff later on. Sovereign debt renegotiations, corporate debt restructuring, and corporate takeovers are some scenarios where holdout problems arise. The social costs of these problems can be quite sizeable. For instance, in the recent Argentinian sovereign debt restructuring, Elliot Management and five other funds held out on the Argentinian government's proposal to restructure its debt after the country defaulted on its $132 billion debt in 2001, preventing it from accessing world financial markets for fifteen years.[1,2] It has cost Argentina an estimated 30% loss in the equity value of all the Argentine firms listed in the US (Hébert and Schreger, 2017).

Theoretically, it could be surprising that hold-out problems exist at all. The reason is that the textbook problem has a simple solution: require unanimous consent. Requiring consent by all parties eliminates the incentive for any party to free ride by rendering the decision of each pivotal.[3] This easy fix to the holdout problem has almost never been observed except in land assembly.[4] Instead, we see different solutions in different contexts. For instance, the Argentinian government settled on a cash payment of $4.65 billion with the holdouts. AMC

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[1]The six funds were Aurelius, Bracebridge Capital, Davidson Kempner, EM Ltd. (A hedge fund held by Kenneth Dart, who was dubbed "el enemigo número uno de Argentina"), Montreux Partners, and NML Capital, an off-shore unit of Elliott.

[2]Argentina's exclusion from the international capital market is largely attributed to the lawsuits with the holdout creditors and the legal risk associated (Schumacher et al., 2021). On the other hand, it is argued that the exclusion lasted for 15 years because Argentina "had the economic and political resources to fight distressed debt fund" and had "no urgency to access the international credit market." (Guzman, 2020, p.733)

[3]Indeed, the effectiveness of the unanimity rule has been known for decades and discussed extensively, e.g., in Kalai and Samet (1985) and Segal (1999). Grossman and Hart (1980, fn 3, p.43) argues that unanimity is impractical because the holdout would anticipate a secret payment from the raider to bribe him into the offer, and there might be sleeping investors. Now, the best-price rule (Exchange Act Rule 10d-10, see 17 CFR § 240.14d-10) forbids such bribes, and holdouts are usually financial experts in these high-stakes transactions, so the idea of making them pivotal by deploying contingency should address the issue, were it the only concern.

[4]In certain jurisdictions such as Pennsylvania, Maine, and some European regions, the raider, whenever reaching a controlling stake, is required by the *mandatory bid rule* to proceed with 100% of the shareholders before she can allocate assets away from or losses to the acquired firm, as a protection for the minority shareholders. (Burkart and Panunzi (2003) and Betton et al. (2008)). In class actions, "blow provisions" are sometimes used to allow the defendant to terminate the settlement if a certain number of investors hold out.

Entertainment, the world's largest movie theater chain, restructured its dispersedly-held bonds and solved the holdout problem by using high-priority debt, reducing its outstanding debt by over \$500 million.[5] In contrast, Elon Musk took over Twitter with an all-cash offer. None of these solutions uses unanimity!

Why is the theoretically "perfect" solution, unanimity, not used in practice? Why do we see different solutions to problems with the same economic structures?

Overview   In this paper, first, I offer a general framework that nests the classical holdout models such as takeovers (Grossman and Hart, 1980), corporate debt restructuring (Gertner and Scharfstein, 1991), bond buybacks (Bulow et al., 1988), and the leverage ratchet effect (Admati et al., 2018). Then I explain why, in these models and in practice, we observe different solutions to the holdout problem despite the underlying problem being the same, and why we don't see unanimity rules being used.

The model features a principal and multiple agents with various contractual claims on an underlying asset.[6] There are gains from trade if the principal can exchange outstanding claims for new ones, but agents want to free-ride on others' participation and hold out. The principal can punish the holdouts, diluting their payoffs, subject to two constraints. The first, which I call *weak consistency*, says that the principal cannot selectively dilute a holdout. The second, which I call *renegotiation-proofness*, says that she cannot commit to any proposed punishment if it is not ex post optimal.

The paper's new insight is that variations in the initial contractual claims shape the principal's ability and credibility to dilute holdouts. This gives rise to the observed heterogeneity in the solutions to the holdout problem.

In the model, the contracts' payoffs are jointly determined i) by the asset value and ii) by the contractual holding structure, that is, who holds what contracts. The principal has a residual claim on the asset, which affects her incentive to propose new contracts. Each agent's payoff depends on his decision to accept the principal's proposal, or to hold out, as well as the asset value and other agents' contracts. Each agent benefits from others' participation even when he holds out. But this benefit can be diluted by other agents' contracts. The principal aims to design a new set of contracts that all agents accept.[7] The holdout problem restricts the set of contracts the principal can offer.

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[5]In AMC's case, the creditors received secured second-lien notes in exchange for their unsecured senior subordinated notes, and the holdouts, which previously had seniority in-between, were promoted to first-lien.

[6]In the Argentinian case, the agents are creditors, the asset is Argentina's tax revenue, and the contracts are the general-obligation government bonds issued under New York law. The principal is the Argentinian government, which would like to commit to never making a second offer to discourage holdouts.

[7]Note this is not the unanimity rule, which requires the threat of calling off the entire transaction when anyone holds out. Here, the principal may nevertheless continue the deal when someone holds out.

This participation constraint of the agents is not hard to satisfy alone: The principal can threaten to punish the holdouts severely. But there is another constraint: The principal cannot commit to executing the threat she has promised when any agent holds out, i.e., she has the incentive to renegotiate. This lack of commitment further restricts the set of feasible contracts. Indeed, without limited commitment, the holdout problem can be easily solved.

Full-Commitment Benchmark   In this benchmark, the holdout problem can be easily solved. The principal can offer each agent a contract that awards him slightly more than his current value, conditional on the new contracts being unanimously agreed upon by all agents. Indeed, unanimity renders each agent pivotal. In this case, the principal can always extract the full surplus associated with the value enhancement of the underlying asset.[8] But this works only if the principal can commit to punishing holdouts. This benchmark does not explain the observed cross-sectional heterogeneity in contracts and the absence of a unanimity requirement, which I will turn to next.

Result 1: Initial Contracts Sensitive to Dilution are Easier to Restructure
Heterogeneity in outcomes arises once I relax the principal's commitment to punishing holdouts, an assumption more realistic in practice. Intuitively, the principal wants to offer a new contract with a punishment off path, to dilute and deter any potential holdouts, but the punishment is credible only if it does not hurt the principal herself. This depends on how sensitive the principal's claim is to the punishment: It is credible if the dilution is fully borne by the holdout, and not credible if the principal also bears the dilution. Specifically, the latter occurs whenever the payoff of the holdout's initial contract moves less than one-to-one with the underlying value (i.e., if it has a "dilution sensitivity" smaller than one).

To illustrate this mechanism, consider two canonical examples. First, consider a corporate debt restructuring in which agents' initial contracts are debt contracts. The principal (the firm in distress) punishes holdout agents by granting priority to tendering creditors, thereby diluting the holdouts. This threat is credible because dilution harms only the holdouts and not the principal herself, who is paid only after all creditors are paid in full. Indeed, this is the solution proposed in the literature (e.g., Gertner and Scharfstein, 1991) and widely used in practice. Next, consider a takeover in which all agents hold equity claims, as does the principal (the raider). In this case, granting priority to tendering shareholders would

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[8]In fact, she can extract not just the surplus but the full value of the asset. She does this by using a contingent contract that resembles "consent payment" in practice, giving the tendering agents a penny and nothing to the holdouts. A consent payment "effectively bribes bondholders to vote in favor of a restructuring, thereby trapping them in a prisoner's dilemma." (Donaldson et al., 2022, p.2) It survived judicial scrutiny in the US and is also ruled legal by the English High Court in *Azevedo v. Imcopa (2012)*, provided that it is i) openly disclosed, ii) offered to all creditors, and iii) on an equal basis.

also harm the principal, since she has the same priority as the holdouts. As a result, the punishment is not credible: the principal would have an incentive to renegotiate and undo it. The optimal solution instead involves offering cash—albeit at a premium—which resolves the holdout problem without relying on punishment.

This result explains both the heterogeneity of solutions across applications and the absence of more sophisticated contractual solutions in takeovers. Unlike corporate debt restructuring—where over 66% of exchange offers involve offering seniority (Bratton and Levitin, 2018)—takeovers overwhelmingly rely on cash or stock offers.[9] Indeed, Malmendier et al. (2016) find that more than 92% of the successful takeovers use cash or stock offers with an equal split and pay an average premium of about 50% (Also see Betton et al., 2008).

My model rationalizes these findings: In corporate debt restructuring, dilution constitutes a credible punishment because it harms only holdout agents. In takeovers, by contrast, dilution is not credible because it also hurts the principal. As a result, the optimal instrument in takeovers is simply cash.

Given that the lack of commitment limits the private solutions, one might speculate that policies enhancing commitment can solve the problem. This is only partially true.

Result 2: Higher Commitment Might Backfire   When the policymaker can choose the degree of commitment, full commitment is always optimal: Absent full commitment, the principal could simply commit to the actions she would take under limited commitment. A naïve generalization is that greater commitment is always beneficial. I show that this intuition is incorrect. Higher partial commitment can backfire, impeding restructuring, and this insight helps shed light on recent policy interventions.

The non-monotonicity arises from the interaction of two forces. Higher commitment enables the principal to impose more severe punishments on holdouts, potentially increasing her value (a direct effect). At the same time, higher commitment also enables the principal to obtain a higher value in renegotiation when an agent actually deviates off-path. This increases her incentive to renegotiate, thereby weakening the punishment that can be credibly imposed (an indirect effect). When the principal starts from a low level of commitment, this indirect effect can dominate the direct effect, reducing the principal's value and generating a non-monotonic relationship between commitment and outcomes. This mechanism cautions policymakers that partial increases in commitment may exacerbate, rather than alleviate, holdout problems.

This result resonates with evidence that policies increasing commitment can either alleviate

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[9]Stock offers are often used in the presence of financial constraints or relative overvaluation (See Rhodes-Kropf and Viswanathan, 2004). In my framework, there is no distinction between acquirer equity and cash offers, as both are non-contingent on the target asset value and capital structure.

or exacerbate holdout problems. Indeed, there are seemingly contradictory findings about CACs. Almeida (2020) suggests that the introduction of CACs would give the sovereign too much commitment[10] to punishing the holdouts ex post, leading to a higher borrow cost ex ante. However, Chung and Papaioannou (2021) finds it actually lowers the borrowing cost. The difference is that the latter looks at a partial inclusion of CACs, a small increase in commitment, while the former looks at a full inclusion. The contradictory findings are reconciled in my model: A small increase in commitment can make restructuring harder. Also consistent with this result, Carletti et al. (2021) finds the mandatory replacement of unanimity with supermajority voting lowers the yields of the sovereign bonds, whereas Donaldson et al. (2022) finds making one class of bonds easier to restructure increases the yields. Similarly, in takeovers, Chen et al. (2022) finds that the inclusion of a bidder termination clause, which slightly strengthens the raider's commitment to calling off the deal,[11] increases the offer premium, making takeovers more costly.

Extension on Property Rights The solutions to the holdout problems, by and large, are achieved by deploying *dilution*: the principal designs new contracts to exert a *contractual externality* on the holdouts off path, reducing the incentive to hold out. There are cases where agents' interests or claims are protected by property rights, which cannot be diluted by contractual externalities,[12] e.g., houses in land assembly and debt secured by collateral.

Usually, property rights protections are perceived to exacerbate the holdout problems.[13] But this is true only under full commitment: Each agent needs to be compensated more in order for him to tender, since the value protected by property rights cannot be diluted by new contracts. However, when the commitment is limited, the relationship can be overturned: Stronger property rights protection also makes renegotiation harder for the principal. Indeed, the incentive to renegotiate is reduced when the principal's benefit from renegotiation is reduced, which is the case when agents' rights are well protected in renegotiation. This allows the principal to commit to imposing stronger punishment initially, which, on the contrary, facilitates restructuring.

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[10]Their original phrase is that it *weakens* the sovereign's commitment to fulfilling the debt service.

[11]The bidders would nevertheless have the fiduciary or regulatory rights to termination even without the provisions.

[12]I adopt the notions of contractual rights and property rights as defined in Ayotte and Bolton (2011) that contractual right is a right against the contracting party whereas property right against everyone.

[13]For example, Demiroglu and James (2015) finds that loans held more by collateralized loan obligations (CLOs) exhibit greater holdout problems and are more difficult to restructure. Holland (2022) shows using survey data in Colombia that greater property rights protection exacerbates holdout problems in real estate development.

Contribution   The general framework nests classic contributions on the holdout problems, such as Grossman and Hart (1980), Bulow et al. (1988), and Gertner and Scharfstein (1991), by including arbitrary existing contracts. It also goes beyond this literature in two dimensions: A more general contracting space and a flexible commitment assumption. Absent an ad-hoc restriction on the contracting space, the holdout problem disappears, as contracts can be made contingent on all agents' actions and thereby render them pivotal. While limited commitment is often allowed in the sovereign debt literature, typically with respect to debt repayment and new borrowing, this literature generally abstracts from optimal contracting. For example, Pitchford and Wright (2012) studies the delay arising from negotiations over cash settlement. By contrast, the main insight of this paper—that optimal exchange offers depend on the interaction between commitment and the payoff sensitivity of existing contracts—emerges only when all three elements are jointly considered: existing contracts, a rich contracting space, and limited commitment. Notably, Segal (1999) also provides a general framework for contracting with externalities, but he mainly considers optimal allocation *given* the externalities, while designing externalities is part of the principal's problem in this paper. Most analysis in his paper only concerns non-contingent transfers, except in the general commitment mechanism section, in which the optimality of unanimity is reaffirmed. He also alludes to the inefficiency of limited commitment and shows how it compares with the commitment case with non-contingent transfers[14] but leaves the contractual design in the face of the limited commitment to future research, and that's my focus.

Readers should note that the solutions discussed above are private arrangements devised by the principal to overcome agents' incentives to hold out, taking the institutional environment as given. Optimal institutional design must address a broader set of objectives. In particular, it must balance ex ante financing incentives with ex post restructuring efficiency, which may either conflict with (Bolton and Jeanne, 2009) or complement (Donaldson et al., 2020) one another. While this paper does not undertake optimal institutional design, it provides a unifying framework for understanding the ex post dimension.

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[14]The notion of limited commitment assumed is that the principal cannot commit in public offers but can commit in subsequent private renegotiation. This corresponds to the strong credibility I develop later in Section 4.1. I also relax it and consider the case when the principal cannot commit even in subsequent renegotiation.

2   Model Setup

2.1   Baseline Setup

Agents, Asset, and Actions.   The economy consists of N agents (A_i), indexed by $i \in \mathcal{N} := \{1, 2, ..., N\}$, and a single principal (P). Each agent is initially endowed with a *security*, representing a claim on an asset with an endogenous value. The principal seeks to enhance this asset value by restructuring the claims. To achieve this, she extends an *exchange offer*: she proposes new securities, along with a cash payment, in exchange for the existing claims. Each agent then independently chooses whether to accept the offer or to *hold out*.[15]

Let $v(h)$ denote the value of the asset as a function of the *holdout profile* $h = (h_1, h_2, ..., h_N)^\top \in H \equiv \prod_{i=1}^{N} H_i$ where $h_i \in H_i := \{0, 1\}$ represents the holdout decision chosen by A_i: $h_i = 1$ if A_i rejects the offer and *h*olds out; and $h_i = 0$ otherwise.[16] Let $e_i = (0, 0, \ldots, 1, \ldots, 0)^\top \in \mathbb{R}^N$ denote the unit vector of length N, whose ith element is 1 and all others are 0. Finally let $\xi(h) = \{i \in \mathcal{N} : h_i = 0\}$ denote the set of agents who tender at h.

Assume $v(h)$ is a *weakly decreasing* function of h, such that $v(h^a) \leq v(h^b)$ if and only if $h^a \geq h^b$.[17,18] Intuitively, holding out destroys the asset value, and the more the worse.[19]

Securities and Payoffs   There are two sets of contracts: the *O*riginal contracts, denoted by $R^O(w, h)$, and the new ones, denoted by $R(w, h)$. Both are functions $\mathbb{R}_+ \times [0, 1]^N \to \mathbb{R}_+^N$ that map a distributable value $w \geq 0$ and the agents' holdout profile h to the agents' payoffs, conditional on the specific securities (new or original) held by the agents. The payoff function

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[15]Coalition formation and side contracting as in Jackson and Wilkie (2005) are ruled out, as the essence of the holdout problem lies in the absence of collective bargaining.

[16]The model could allow each agent to accept a fraction $1 - h_i \in [0, 1]$ of the offer, but this could be achieved by offering a combination of a fraction $1 - h_i$ of the offered contract and a fraction h_i of the original contract. Similarly, if the principal wants to exclude some agent A_i from the exchange offer, she can simply offer the existing contract A_i holds. This extension requires modifying the function $v(\cdot)$, as demonstrated in Section OA.1.2 of the Appendix. Furthermore, we do not allow v to depend on the new contracts offered. While adding this dependence would influence how dilution affects the asset's remaining value, it does not alter the relative allocation between the principal and the holdouts, and thus does not interfere with the credibility constraint.

[17]Standard notation is used where $h^a \geq h^b$ implies $h_i^a \geq h_i^b$ for all i with strict inequality for some i. This assumption captures many scenarios. For example, projects that naturally require the participation of k agents can be encoded as a step function $v(h) = v_0 + \Delta v \mathbb{1}_{\{h^\top \mathbf{1} \leq N-k\}}$, treating unanimous participation as the special case where $k = N$. Note that this formulation differs from a unanimity or majority rule specified by P in the exchange offer. I discuss the microfoundations of this assumption in Section 7.1.

[18]Since $v(\cdot)$ is only weakly decreasing, it may not be optimal to require every agent's participation. However, full participation is optimal in the full-commitment case (Proposition OA.2), and in the limited-commitment case with some regularity conditions. We focus on the implementation of $h = \mathbf{0}$ also for expositional purposes.

[19]In the baseline model, $v(h)$ is assumed to be a deterministic function of the holdout profile h. However, the analysis extends to the case of random functions, where $v(h)(\omega)$ denotes the explicit dependence on the state ω. For example, a firm may face uncertainty after restructuring and end up in bankruptcy, as in Donaldson et al. (2020).

of the original contracts, R^O, encodes both the original set of claims and the underlying system of conflict resolution among securities, such as a bankruptcy code. In contrast, the payoff function of the new contracts, R, implicitly encodes R^O, as the new contracts are structured while R^O remains in place. Finally, let $t_i(h) \geq 0$ denote the cash paid to agent A_i at h.

Let $R_i^O(w, h)$ denote the ith entry of the payoff vector. We assume that payoffs are, trivially: i) feasible, meaning $h \cdot R^O(w, h) := \sum_{i=1}^N h_i R_i^O(w, h) \leq w$ for all w; and ii) non-negative, such that $R_i^O(w, h) \geq 0$ for all w, h and i. Analogous conditions hold for $R_i(w, h)$. For convenience, we index the principal[20] by 0 and define her payoff from the residual claim as $R_0^O(w, h) := w - h \cdot R^O(w, h)$.

The function R^O does not automatically capture the effects on payoffs resulting from the new securities offered by the principal as these securities were unknown at the time R^O was created. In other words, the original contracts were incomplete because it was impossible to enumerate all potential future exchange offers, which could further depend on the initial contracts and lead to infinite regress. To address this issue, I introduce an additional requirement termed *weak consistency* (defined and discussed in Section 2.2) Under this condition, the payoff of the new security is simply $R(v(h), h)$, in the spirit of direct mechanism, and the payoffs of the original security holders can be written as

$$R^O(v(h), h | R) = R^O(v(h) - x(h), h) \tag{1}$$

where $x(h) = (\mathbf{1} - h) \cdot R(v(h), h)$ represents the total amount paid to the new security holders, a quantity I refer to as "dilution".[21] Note that the dependence of R^O on R now operates solely through the first argument in a linear fashion. Table 1 shows how this notation encompasses classic models.

Renegotiation   The principal cannot commit to not renegotiating her initial exchange offer. Consequently, the analysis focuses on renegotiation-proof exchange offers (defined in Section 4). Specifically, the principal retains the option to withdraw the offer entirely; in this case, payoffs are evaluated at $h = \mathbf{1}$, as if all agents held out.

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[20]The principal need not have an explicit claim on the asset, as her identity as the residual claimant is determined by the contractual relationship with the agents.

[21]This terminology is motivated by the offering of senior debt in debt restructuring, which dilutes the payoff of holdouts possessing junior claims. However, the model itself does not necessarily require the notion of priority, and the new securities could well have a payoff of zero. (According to Moulin (2000), priority can only be defined in conjunction with two other axioms: lower and upper composition, which are absent here.)

	$v(h)$	$R_i(v, h)$	$R_i^O(w, h)$
Takeover	Threshold	(Cash t_i)	Equity $\alpha = (\alpha_i)_i$
(Grossman and Hart, 1980)	$v_0 + \Delta v \cdot \mathbb{1}_{\{h^\top \mathbf{1} \leq \bar{h}\}}$	0	$\alpha_i w$
Bond buyback	Decreasing	(Cash t_i)	Debt $D = (D_i)_i$
(Bulow et al., 1988)	$v(h)$	0	$\min\left\{\frac{wD_i}{h^\top D}, D_i\right\}$
Debt Restructuring	Constant	Senior Debt D^S	Junior Debt D^J
(Gertner and Scharfstein, 1991)	v_0	$\min\left\{\frac{vD_i^S}{(\mathbf{1}-h)^\top D^S}, D_i^S\right\}$	$\min\left\{\frac{wD_i^J}{h^\top D^S}, D_i^J\right\}$

Table 1: Classic Applications: In a takeover, the asset value jumps from v_0 to $v_0 + \Delta v$ if the number of holdouts is less than $\bar{h}$. The existing securities are equities and only a cash offer is considered so the securities portion is zero. The bond buyback model allows the asset value to have a component $v(h)$ decreasing in the holdout profile and the existing securities are debt. In the debt restructuring case, a senior debt offer is considered while the asset value is fixed. In each, $v = v(h)$ and $w = v(h) - (\mathbf{1} - h) \cdot R(v, h)$.

Cost The principal faces a (random) cost c, which is realized before the exchange offer is announced but incurred only if the plan is executed (i.e., $h \neq \mathbf{1}$). This parameter can be interpreted as the principal's outside option or the transactional costs of implementation (e.g., investment, legal fees). Consequently, the principal is willing to proceed if and only if her benefit from the plan exceeds the cost c. While the randomness of this cost is not central to the theoretical mechanism, it captures unobserved heterogeneity that helps explain variation in outcomes across otherwise similar situations.

Principal's Simplified Problem I present the principal's simplified problem below, relegating the formal definition and complete problem formulation to Section OA.1 in the Online Appendix.

With a slight abuse of notation, we express the payoff associated with the new exchange offer and the original contract in a conditional form: I let $(h_i, h_{-i}) := h = (h_1, \ldots, h_i, \ldots, h_N)^\top$ and write $R_i(h_i|h_{-i}) := R_i(v(h), (h))$ and $R_i^O(h_i|h_{-i}, R) := R_i^O(v(h) - (\mathbf{1} - h) \cdot R(v(h), h), h)$ to highlight the incentives and actions of a particular agent. The payoff of A_i is given by

$$u_i(h_i|h_{-i}, R) := h_i R_i^O(h_i|h_{-i}, R) + (1 - h_i)[R_i(h_i|h_{-i}) + t_i(h_i|h_{-i})] \qquad (2)$$

and the set of all incentive-compatible contracts at h is denoted by

$$\mathcal{I}(h) := \left\{ R : [\underline{v}, \bar{v}] \times H \to [0, \bar{v}]^N \,\middle|\, h_i \in \arg\max_{h_i' \in H_i} u_i(h_i'|h_{-i}, R) \; \forall i \in \mathcal{N} \right\}. \qquad (3)$$

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The principal's value at h, from the exchange offer R combined with cash payment t is[22]

$$J(h|R) := R_0^O(v(h) - (\mathbf{1} - h) \cdot R(v(h), h)) - (1 - h) \cdot t(h). \tag{4}$$

Given the feasible set of contracts $\mathcal{R}(h) \subset \mathcal{I}(h)$, the principal's problem is to select a contract $R \in \mathcal{R}$ and a cash transfer $t \geq \mathbf{0}$ to maximize her value $J(h|R)$

$$J(h|\mathcal{R}) := \max_{R \in \mathcal{R}, t \geq \mathbf{0}} J(h|R). \tag{SP}$$

When $\mathcal{R}$ is clear from the context, we omit the explicit dependence and write $J(h)$. We are particularly interested in $J(\mathbf{0})$, which corresponds to the outcome where all agents tender.

The main analysis considers the case in which the principal lacks commitment power; consequently, the principal faces an additional credibility constraint. This constitutes the central focus of the paper and is analyzed in Section 4. The following discussion addresses the origin, interpretation, and role of weak consistency within the model, and demonstrates how the complexity of the full model can be reduced without loss of generality.

2.2   Weak Consistency and the Problem Simplification

While the generality of the proposed framework presents challenges for characterization, the problem can be simplified as follows. First, we impose a condition preventing the principal from altering the existing contractual relationships among holdout securities via the new securities proposed in the exchange offer. In other words, the *relative* payments and priority between any two holdouts must remain unchanged. For instance, while the principal might seek to contract with a tendering agent to subordinate one holdout to another, the assumption of *weak consistency* precludes this. Second, without loss of generality, it suffices for the principal to focus on exchange offers in which all agents tender. Formal details are provided in Sections OA.1.1 and OA.1.2 of the Online Appendix.

We begin with the concept of weak consistency, defined as follows.

Definition 1 (Weak Consistency)**.** *An exchange offer is* weakly consistent *if the payoff for each holdout equals the payoff derived from the original securities, evaluated at the asset value net of the portion accruing to tendering agents. Formally, let $x := \sum_{i=1}^{N}(1 - h_i)\, R_i(v, h)$ denote the cumulative value distributed to tendering agents given R and h (i.e., the "dilution"). An*

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[22]For most of our analysis other than Section 3.1, the cash component is assumed to be 0 because it is costly for the principal. Consequently, we suppress the explicit dependence on t in the notation.

exchange offer is weakly consistent *if each holdout receives*

$$R_i^O(v, h|R) = R_i^O(v - x, h) \ \forall i = 0, 1, .., N. \tag{5}$$

Weak consistency[23] captures the intuition that while the principal can impose externalities on holdouts by diluting them through new contracts, this dilution cannot be *selective*. For example, consider a principal with a senior creditor A and two junior creditors, B and C. If both A and B hold out, the principal can offer C a claim that is: i) senior to both A and B; ii) junior to both; or iii) junior to A but senior to B. However, weak consistency precludes a claim that is senior to A but junior to B, as this would invert the relative priority between A and B, creating circularity. Furthermore, since the principal is part of the existing contractual nexus, she cannot contract with C to prioritize herself over A or B, as this would invert the priority between herself and the existing creditors. Consequently, she cannot structure an exchange offer that dilutes holdouts without simultaneously diluting her own residual claim. Absent this constraint, she could simply issue herself a super-senior claim to eliminate the holdout problem.[24,25] Note that weak consistency does not restrict the principal's ability to dilute per se (e.g., even secured debt can be diluted, as seen in an uptier transaction).

The second simplification establishes that it suffices for the principal to focus on exchange offers in which all agents tender. This relies on a straightforward intuition: if it is optimal for an agent to retain a fraction or the entirety of the initial contract, the principal can equivalently propose the specific claim the agent would otherwise retain post-restructuring. Consequently, the agent finds accepting the whole exchange offer weakly optimal.[26]

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[23]This concept is a weaker version of the consistency axiom widely applied in cooperative game theory literature regarding bankruptcy problems (e.g., Aumann and Maschler (1985) and Moulin (2000)). It has also been utilized in the study of multilateral bargaining games (Krishna and Serrano, 1996). It serves a role similar to the more commonly known Independence of Irrelevant Alternatives axiom. The standard consistency axiom requires the condition to hold for *any* subset of securities, whereas I require it to hold only between the new and old contracts. Informally, consider an allocation rule $R^O(\cdot, \cdot, \cdot)$, which maps from the set of N agents $\mathcal{N}$, the total value available $v > 0$, and a vector of claims $\boldsymbol{d} \in \mathbb{R}_+^N$, to an allocation vector $R^O(\mathcal{N}, v, \boldsymbol{d}) \in \mathbb{R}_+^N$ where agent A_i receives $R_i^O(\mathcal{N}, v, \boldsymbol{d})$. The rule is consistent if, for any subset $\mathcal{N}_0 \subset \mathcal{N}$, the allocation among the agents in the subset is identical to the original allocation, provided that the total resource available equals the total resource allocated to $\mathcal{N}_0$ under the original allocation, and that the agents in $\mathcal{N}_0$ hold the exact same claims $\boldsymbol{d}|_{\mathcal{N}_0}$. Formally, $R^O(\mathcal{N}_0, v - \sum_{j \notin \mathcal{N}_0} R_j^O(\mathcal{N}, v, \boldsymbol{d}), \boldsymbol{d}|_{\mathcal{N}_0}) = R^O(\mathcal{N}, v, \boldsymbol{d})|_{\mathcal{N}_0}$. Thomson (1990) provides a comprehensive survey on this topic.

[24]In practice, the principal could effectively divert value to herself with the assistance of a third party. Müller and Panunzi (2004) studied *freezeout merger*, or *bootstrap acquisition*, where the acquirer uses the target as collateral to raise senior debt from a third-party lender, retaining the borrowing proceeds. This action expropriates value from existing shareholders and facilitates the takeover. The legality of this practice has been challenged but not overturned.

[25]Cash offers cannot be viewed as securities because they violate weak consistency in the opposite direction: they allow the principal to receive less than the holdouts, a flexibility we intend to preserve.

[26]Two technical caveats exist: i) the new offers may introduce actions not initially available; and ii) since the asset value increases when the agent accepts, the value of the outside option rises. These issues are

3 Optimal Exchange Offer with Full Commitment

In this section, I provide two distinct benchmark results to illustrate the power of a rich contract space. First, I reproduce the classic results by showing that holdout problems occur whenever i) the principal is restricted to cash offers, and ii) the cost of implementing the exchange offer c is not negligible.[27] Second, if the contracts are instead fully contingent, the principal can uniquely implement an equilibrium that extracts the full value of the assets. These two benchmarks bound the principal's potential payoff, representing the minimum and maximum achievable values in the transaction.

3.1 Optimal Non-Contingent (Cash) Exchange Offers

Suppose first that the principal is restricted to cash offers, consisting of a single payment $t_i(h_i) \geq 0$ to agent A_i. This payment depends solely on A_i's decision to hold out h_i and is independent of v and h_{-i}. Cash offers are widely utilized and entail no dilution. For simplicity, I will assume that the principal has deep pockets[28] and disburses payment immediately upon an agent's participation. To focus on the most relevant scenarios, I also assume

Assumption A1 (Moderate Cost)**.** *The cost lies within an intermediate range:*

$$v(\mathbf{0}) - v(\mathbf{1}) > c > v(\mathbf{0}) - \sum_{i=1}^{N} R_i^O(v(e_i), e_i). \tag{A1}$$

The first inequality ensures that implementing $h = \mathbf{0}$ is socially efficient. The second inequality implies that if the principal were required to compensate each agent for the payoff they would receive under the original contract by holding out, she would find it unprofitable

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to initiate the exchange offer.[29],[30] Otherwise, the holdout problem would not impede efficient transactions.

Observe that if agent A_i holds out while all other agents tender, he receives $R^O(v(e_i), e_i)$. Consequently, the principal must offer at least this amount to induce participation. This observation immediately implies the following result:

Proposition 1 (Holdouts with cash offers). *Under Assumption A1, the first-best outcome $h = \mathbf{0}$ cannot be implemented via an exchange offer consisting solely of non-contingent cash.*

The proposition states that under Assumption A1 Moderate Cost the classic holdout problem arises: A simple cash transfer is insufficient to compensate each agent for his reservation value upon deviation, $R_i^O(v(e_i), e_i)$. The driving force behind the typical holdout problem is that the incentive compatibility constraint for any single agent becomes increasingly difficult to satisfy as the participation of other agents rises[31]—a force illustrated in the example below. Consequently, resolving the holdout problem via cash transfers becomes prohibitively costly, preventing the realization of efficient value enhancement.

Example 3.1. *Suppose a scenario with 3 creditors, each holding an outstanding debt claim with a face value of $D_i = 6$. Assume that the asset value is given by $v(h) = 9 + \sum_i (1 - h_i)$. Absent any restructuring (i.e., if everyone holds out), each creditor receives $9/3 = 3$. If all agents tender, the total value increases to 12, allowing for a potential payout of 4. If the principal can renegotiate with all creditors collectively, then she could offer any price between 3 and 4 to each claimant, thereby achieving the first-best outcome. However, when collective bargaining is infeasible, a holdout problem arises. Specifically, if all but one agent tender, the single holdout is paid in full (receiving 6 from the asset value of 11). This leaves the principal with a residual value of 5, implying she can pay each tendering agent at most 2.5 to remain profitable—a payoff lower than their initial value of 3. Consequently, since each agent anticipates being the marginal holdout and demands 6, the holdout problem cannot be resolved via a simple cash offer.[32]*

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[29]Notice that the RHS of inequality (A1) could be negative, for instance, when outstanding claims consist of debt (See Example 3.1). In this case, holdout problems arise even in the absence of transaction costs. Conversely, when outstanding claims consist of equity, as in Grossman and Hart (1980), he term is always non-negative and converges to zero as the number of agents approaches infinity, provided that a single holdout does not affect the asset value.

[30]Notably, the practice of establishing a toehold would violate the second inequality, as a greater portion of the surplus accrues to the raider through share accumulation, thereby reducing the value that must be distributed to dispersed shareholders without dilution.

[31]The argument alludes to the slightly more restrictive assumption A2 that the value of original securities increases with the underlying asset value. However, Proposition 1 holds even without this assumption.

[32]Observe that the RHS of the Equation (A1) is $12 - 6 \times 3 = -6$; thus, a positive cost is not required to generate the holdout problem in this context.

Intuitively, as the number of tendering agents increases, inducing the remaining agents to tender becomes progressively more difficult. Two forces drive this strategic substitutability among agents: first, the asset value increases as more agents tender; and second, the number of competing claims on the asset decreases. For instance, if three agents hold out, each receives 3 *from an asset value of* 9*. However, if two agents hold out, each receives* 5 *from an asset value of* 10*. Thus, as participation increases, the value of the outside option grows faster than the asset value itself* □

3.2   Optimal Contingent Exchange Offers

In diametric contrast, if the principal is permitted to offer *contingent contracts*—securities whose payoffs depend on both the asset value and the agents' participation decisions (and thus indirectly on the distribution of old versus new contracts)—she can not only resolve the holdout problem but also extract the full asset value, implementing this outcome as a unique equilibrium. Furthermore, we set all cash transfers to zero in the analysis below, as the principal can provide equivalent value to tendering agents at a lower cost by granting them a priority claim on the asset.

Example 3.2. *Continuing example 3.1. Suppose that in exchange for the existing junior debt, the principal offers each creditor a contract consisting of: i) a cash payment of 1 cent if all agents tender; and ii) an option convertible into senior debt with a face value of* 6 *if at least one holdout remains. Full participation (everyone tendering) constitutes an equilibrium, as any unilateral deviation to hold out triggers the conversion option for the tendering agents, leaving the holdout with a payoff of zero. By the same logic, a profile with a single holdout cannot be an equilibrium. If there are two holdouts, each receives* $(10 - 6)/2 = 2$*; however, deviating to tender yields* $\min\{6, 11/2\} = 5.5$*, so this outcome is also not an equilibrium. Similarly, if everyone holds out (yielding* 3 *each), any agent deviating to tender receives* 6*. Therefore, full participation is the unique equilibrium. This yields the principal a payoff of* $12 - 0.03$*, where the on-path payment of* 0.01 *can be made arbitrarily small.*

Formally, recall the definition of unique implementation from Segal (2003) and Halac et al. (2020).

Definition 2 (Unique Implementation)**.** *The principal uniquely implements an action profile* h *and guarantees a value* w *if: i) there exists a weakly consistent exchange offer* (H, h, R) *such that* h *is an equilibrium in the subgame played by the agents; and ii) for any* $\varepsilon > 0$*, there exists a weakly consistent exchange offer* $(H^\varepsilon, h, R^\varepsilon)$ *such that* h *is the unique equilibrium in the subgame, yielding the principal a payoff of at least* $w - \varepsilon$*.*

The introduction of the perturbation ε is a technical necessity, as the set of exchange offers admitting a unique equilibrium is not necessarily closed.[33] Based on this definition, we derive the following result:

Proposition 2 (Extreme Gouging). *If $v(\mathbf{1} - e_i) > 0$ for some $i \in \mathcal{N}$, then with contingent contracts, the principal* uniquely *implements the profile $h = \mathbf{0}$ and guarantees a value of $v(\mathbf{0})$.*

To understand the intuition underlying the proof,[34] observe that the incentive compatibility (IC) constraint requires that an agent's on-path payoff from tendering exceed the off-path payoff from holding out:

$$R_i(v(\mathbf{0}), \mathbf{0}) \geq R_i^O \left(v(e_i) - x(e_i), e_i \right). \tag{6}$$

In the off-path payoff—the right-hand side of inequality (6)—the total payment to all other agents, $x(e_i) = \sum_{j \neq i} R_j(v(e_i), e_i)$, dilutes the claimable value for A_i. If the principal can commit to making high payments to tendering agents, she can punish holdouts by exhausting the full asset value $v(e_i)$. Consequently, the equilibrium involves the principal offering an arbitrarily small fraction of the asset to each agent. If any single agent deviates to hold out, the contract dictates that the entirety of the asset be distributed to the tendering agents. This distribution occurs only off the equilibrium path. The principal's ability to commit is crucial here: by assigning the entire asset value to tendering agents, she simultaneously dilutes her own residual claim. However, absent commitment, the principal would have an incentive to renegotiate, rendering such an exchange offer non-credible.

4 Optimal Exchange Offer with Limited Commitment

What occurs when the principal lacks the commitment power to punish holdouts off the equilibrium path and is instead tempted to renegotiate? Rather than explicitly modeling the renegotiation process, we focus on contracts that are *renegotiation-proof*:[35] the principal

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[33]Consider the equilibrium described below: if the principal offers $\varepsilon/N > 0$ to everyone, the incentive to accept is strict, thereby ensuring unique implementation. However, if zero is offered, agents only weakly prefer acceptance. Consequently, the principal can secure a payoff of $v(\mathbf{0}) - \varepsilon$ for any $\varepsilon > 0$ in a unique equilibrium, but cannot guarantee this for $\varepsilon = 0$. For a detailed discussion, see Section 4 in (Segal, 2003, fn.9).

[34]The condition "$\exists i : v(\mathbf{1} - e_i) > 0$" ensures the principal retains sufficient leverage to induce tendering, thereby preventing the "all-holdout" outcome from becoming an equilibrium. While this implies that A_i's participation contributes to value (since $v(\mathbf{1} - e_i) > v(\mathbf{1})$), it does not preclude scenarios where significant participation is required to generate value improvements.

[35]Specifying the exact renegotiation protocol can be intractable, potentially involving infinite bargaining rounds where agreement is never reached, as shown in Anderlini and Felli (2001). Furthermore, absent private information, if the principal finds it ex post optimal to offer an alternative, she could have anticipated this and included it in the original exchange offer.

prefers to execute the proposed contracts as written, even in the event of an agent's deviation. This requirement strictly constrains the contract space[36] available to the principal ex ante, effectively ruling out non-credible off-path threats. The central challenge lies in specifying the set of feasible contracts the principal can offer during renegotiation.

We impose a regularity condition on the existing contracts before defining credibility.

Assumption A2 (Increasing and 1-Lipschtiz)**.** *The sum of the payoffs to the agents who do not tender at h, denoted by $h \cdot R^O(\cdot, h)$, is increasing and 1-Lipschitz continuous for all h.*

This standard assumption in the security design literature[37] says that the payoff function has a non-negative "slope" no greater than 1: For every dollar increase in the underlying asset value, the incremental payoff to the existing contracts cannot exceed one dollar. Most standard financial instruments, such as equity, debt, and call options, satisfy this condition.[38] The condition rules out cases in which punishing holdouts rewards the principal. Coupled with weak consistency, this assumption facilitates the definition of a tractable measure:

Definition 3 (Dilution Sensitivity)**.** *The* dilution sensitivity *of contract $R_i^O(\cdot, h)$ at w_0 is defined to be the left derivative of the payoff function with respect to dilution at w_0*

$$S_i(w_0; h) := -\frac{\mathrm{d}}{\mathrm{d}x}\bigg|_{x\downarrow 0} R_i^O(w_0 - x, h) \geq 0 \quad \forall i \in \mathcal{N}, \tag{7}$$

We denote the aggregate sensitivity of all holdouts by $S(w_0; h) = \sum_i h_i S_i(w_0; h)$, and the principal's sensitivity by $S_0(w_0; h) := 1 - S(w_0; h)$. The average dilution sensitivity over the interval $[\underline{w}, \bar{w}]$ is given by $S_i([\underline{w}, \bar{w}]; h) = \frac{1}{\bar{w}-\underline{w}} \int_{\underline{w}}^{\bar{w}} S_i(w; h)\mathrm{d}w$ for $i = \emptyset, 0, 1, ..., N$ where $i = \emptyset$ denotes the aggregate case.

The *left* derivative captures the marginal loss incurred by the claim holder (or residual claimant) resulting from a unitary increase in dilution.

Credibility concerns arise specifically when agents deviate. Throughout this analysis, we restrict our attention to *unilateral deviations*. A profile $\hat{h}$ constitutes a unilateral deviation from h if and only if $\hat{h} = h \pm e_i$ for some agent i, or equivalently, $||\hat{h} - h|| = 1$. We define $\mathcal{B}(h) = \{\hat{h} \in \{0, 1\}^N : ||\hat{h} - h|| = 1\}$ as the set of unilateral deviations from h, representing the discrete unit "ball" centered at h.

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[36]A large contractual space is not necessarily desirable: it allows a wider range of potential deviations, as articulated in Brzustowski et al. (2023).

[37]For example, DeMarzo et al. (2005) require the payoff to each party to be increasing, a condition equivalent to 1-Lipschitz continuity.

[38]A notable exception involves contingent securities that admit jumps, such as the Additional Tier 1 (AT1) bonds wiped out during the Credit Suisse crisis. Holdout problems are less of a concern for such securities because the potential for discrete downward jumps makes severe punishment more credible.

Finally, we introduce the concept of δ-domination, which characterizes the principal's incentive to deviate by comparing the payoff from executing the current exchange offer R against a fraction $\delta \in [0,1]$ of the payoff from an alternative offer $\tilde{R}$ at h.

Definition 4 (δ-domination)**.** *Given a scalar $\delta \in [0,1]$, a contract R (weakly) δ-dominates another contract $\tilde{R}$ (denoted by $R \succeq_\delta \tilde{R}$) at h, if $J(h|R) \geq \delta J(h|\tilde{R})$.*

The parameter δ admits two isomorphic interpretations: i) as a delay cost equivalent to a discount factor as in Rubinstein and Wolinsky (1992); or ii) as the exogenous probability that the current contract is voided, allowing the principal to propose a new offer, as modeled in Crawford (1982) and Dovis and Kirpalani (2021).[39] Under either interpretation, δ parametrizes the principal's lack of commitment power: a higher δ renders renegotiation more attractive, spanning the spectrum from full commitment ($\delta = 0$) to costless renegotiation $\delta = 1$. We focus primarily on the lowest-commitment case ($\delta = 1$), suppressing the explicit notation of δ except when analyzing its comparative statics of δ. We also omit the qualifiers "weakly" or "at h" whenever no confusion arises.

4.1 Strongly Credible Contracts

4.1.1 Strongly Credible Contracts and the Principal's Problem

We first define what we refer to as *Strongly Credible Contracts* to illustrate how the lack of commitment interacts with the initial securities to yield a variety of solutions to the holdout problem. Later, in Section 4.2, we present a weaker notion simply termed *Credible Contracts* to highlight why increased commitment power is not necessarily beneficial for the principal. Crucially, strong credibility is not necessary to establish our two main results; the weaker definition suffices. We introduce the stronger concept primarily for clarity, tractability, and intuition. All strongly credible contracts are, by definition, credible.

Definition 5 (Strong δ-credibility)**.** *A contract $R : [\underline{v}, \bar{v}] \times H \to [0, \bar{v}]^N$ is strongly δ-credible at h if*

(a) It is incentive compatible at h, that is, $R \in \mathcal{I}(h)$ (see expression (3) above).

(b) Upon any unilateral deviation $\hat{h} \in \mathcal{B}(h)$, it weakly δ-dominates any IC contracts $\tilde{R}$ at $\hat{h}$.

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[39] To see this explicitly, let $\hat{\delta}$ be the discount rate instead, and the principal is allowed to delay the payoff and re-propose a new contract $\tilde{R}$ with some exogenous probability p, then the current proposed contract is preferred if $J(h|R) \geq (1-p)\hat{\delta}J(h|R) + \hat{\delta}pJ(h|\tilde{R})$. Rearranging the terms, the current proposed contract R δ-dominates contract $\tilde{R}$ at h for $\delta = \frac{\hat{\delta}p}{1-(1-p)\hat{\delta}}$, which is a strictly increasing in p for all $\hat{\delta} \in (0,1)$ since $\frac{\partial}{\partial p}\frac{\hat{\delta}p}{1-(1-p)\hat{\delta}} = \frac{\hat{\delta}(1-\hat{\delta})}{(1-(1-p)\hat{\delta})^2} > 0 \,\forall \hat{\delta} \in (0,1)$. Thus, for a fixed $\hat{\delta}$, a higher probability of renegotiation corresponds to a higher δ.

Intuitively, condition (a) requires that strongly credible contracts be incentive compatible. Condition (b) means that ensures that, even if an agent deviates, it remains in the principal's interest to "stick with" the initial offer R rather than switching to any alternative incentive-compatible contract $\tilde{R}$. We denote the set of strongly δ-credible contracts by

$$\mathcal{S}^{\delta}(h) := \left\{ R \in \mathcal{I}(h) : \ R \succeq_{\delta} \tilde{R} \text{ at } \hat{h} \quad \forall \tilde{R} \in \mathcal{I}(\hat{h}), \quad \forall \hat{h} \in \mathcal{B}(h) \ \right\}. \tag{8}$$

As before, we suppress δ and refer to the contract simply as *strongly credible* when $\delta = 1$.

The principal's value function on the set $\mathcal{S}^{\delta}(h)$ is defined as

$$J(h|\mathcal{S}^{\delta}(h)) := \sup_{R \in \mathcal{S}^{\delta}(h)} J(h|R). \tag{9}$$

Observe that $\mathcal{S}^{\delta}(h) \subseteq \mathcal{I}(h)$, so the problem is more constrained than the full-commitment benchmark, due to the imposition of the principal's credibility constraint (cf. (SP) in Section 2.2).

4.1.2 Commitment and Diversity of Exchange Offers: A Characterization

To characterize the solution to the principal's problem in Equation (9),[40] we first demonstrate that the problem can be equivalently expressed as a single-dimensional optimization problem. Specifically, the principal seeks to minimize the total payout to all agents triggered by a single holdout's deviation, while simultaneously maximizing the punishment imposed on that holdout. Subsequently, we show that the extent to which punishment can be credibly increased depends on the holdout's dilution sensitivity (Lemma 1 below). This insight, combined with Lemma 2 regarding the renegotiation disagreement point–where strong credibility plays a central role–generates the diversity of exchange offers characterized in Proposition 3.

When agent A_i deviates, the principal aims to minimize his payoff to the greatest extent possible. She achieves this by directing a penalty payment x to the tendering agents, subject to the constraint that executing this punishment remains weakly preferred to renegotiation. Formally, she solves the optimization problem:

$$\min_{x \geq \underline{x}(e_i)} R_i^O(v(e_i) - x, e_i) \quad \text{s.t.} \quad v(e_i) - x - R_i^O(v(e_i) - x, e_i) \geq \delta J(e_i|\mathcal{S}^{\delta}(e_i)) \tag{10}$$

where $\underline{x}(e_i)$ denotes the minimum payment required to prevent other agents from deviating

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[40]Note that while it is convenient to look at the implementation of $h = 0$, Proposition OA.2 in the Appendix does not guarantee renegotiation-proofness. However, implementing $h = \mathbf{0}$ remains optimal under mild additional conditions R^O and v; therefore, for expositional clarity, we focus on the implementation of this profile.

from the profile e_i.[41] The term $x + R_i^O(v(e_i) - x, e_i)$ in the constraint illustrates the principal's trade-off: increasing the penalty x reduces the payout to the holdout A_i, but simultaneously increases the transfer to the tendering agents. Consequently, an excessive penalty could reduce the principal's residual claim to a level where renegotiation becomes attractive.

While the solution to this problem may not be unique (as $R_i^O(\cdot, e_i)$ may be flat with respect to x), it is without loss of generality to select the largest x satisfying this constraint. Furthermore, the feasible set is non-empty due to the incentive compatibility condition inherent in the definition of $\mathcal{S}^\delta(e_i)$: specifically, the inequality in (10) is necessarily satisfied when the left-hand side is evaluated at $\underline{x}(e_i)$. Moreover, since $R_i^O(\cdot, e_i)$ is 1-Lipschitz, the LHS of Inequality (10) is non-increasing in x. Consequently, there exists a threshold $\bar{x}(e_i)$ such that the constraint (10) holds if and only if $x \leq \bar{x}(e_i)$. This threshold is given by

$$\bar{x}(e_i) := \max\{x \geq \underline{x}(e_i) : v(e_i) - x - R_i^O(v(e_i) - x, e_i) \geq \delta J(e_i | \mathcal{S}^\delta(e_i))\}. \tag{11}$$

The following lemma presents the structure of the optimizer of a 1-Lipschitz function in a more general setting, considering a generic deviation set $\mathcal{R}$ rather than $\mathcal{S}^\delta(e_i)$.

Lemma 1. *Given $h \in H$ and $\mathcal{R} \subset \mathcal{I}(h)$ a non-empty set of feasible IC contracts, let $x(R) := (\mathbf{1} - h) \cdot R(v(h), h)$ denote the dilution imposed at h by contract $R \in \mathcal{R}$, $g(x) := v(h) - x - h \cdot R^O(v(h) - x, h)$ a continuous function of x under Assumpton A2, and $\mathcal{X} := \{x \geq 0 : g(x) = J(h | \mathcal{R})\}$ the set of dilutions that attains the optimum. I claim*

- *$\mathcal{X}$ is a closed interval or a singleton and $S(v(h) - x; h) = 1$ for all $x \in \mathcal{X}$.*

- *Let $\underline{x}(h; \mathcal{R}) \geq 0$ be the minimum element in $\mathcal{X}$. The set of credible dilutions $\mathfrak{X} = \{x \geq \underline{x}(h) : g(x) \geq \delta J(h | \mathcal{R})\}$ admits an attainable supremum $\bar{x}(h; \mathcal{R}) := \sup \mathfrak{X}$.*

- *Moreover, the maximum additional dilution beyond the minimum $\bar{x}(h; \mathcal{R}) - \underline{x}(h; \mathcal{R})$ satisfies (argument $(h; \mathcal{R})$ omitted for brevity)*

$$(\bar{x} - \underline{x}) \cdot S_0([v(h) - \bar{x}, v(h) - \underline{x}]; h) = (1 - \delta) J(h | \mathcal{R}) \tag{12}$$

- *In particular, when $\delta = 1$, either $\bar{x} = \underline{x}$ or $S_0([v(h) - \bar{x}, v(h) - \underline{x}]; h) = 0$, and thus the maximum credible dilution is characterized as*

$$\bar{x}(h; \mathcal{R}) = \inf\{x \geq \underline{x}(h; \mathcal{R}) : S(v(h) - x; h) < 1\}. \tag{13}$$

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[41]This threshold may technically depend on the credible punishment available for other agents under a weaker definition of credibility. However, A_i's outside option is ultimately determined by the *maximum* credible punishment the principal can inflict, rather than this minimum bound.

This lemma establishes a direct link between commitment power and dilution sensitivity. Although the sets of contracts that are immune to deviations or optimal under deviation are difficult to characterize directly, they admit a straightforward characterization in terms of the dilution they impose: (i) the sets of admissible dilutions are connected and compact;[42] and (ii) dilution sensitivity remains constant for contracts that are optimal under deviation and for renegotiation-proof contracts lacking commitment.[43] Moreover, the additional dilution must satisfy a simple relationship:

Dilution magnitude × P's Average dilution sensitivity = Renegotiation loss.

Generally, this relationship does not admit a closed-form solution, except in the limiting case of lowest commitment: in this scenario, dilution becomes non-credible the moment the principal exhibits positive dilution sensitivity.

The following lemma characterizes the maximum payoff the principal can secure *upon deviation*. Since the principal is restricted to renegotiating with tendering agents and cannot renegotiate with the holdout, her optimal strategy is to offer nothing to the tendering agents (recall that, under strong credibility, she retains commitment power regarding subsequent renegotiations). Consequently, she captures the residual asset value remaining after the holdout has been compensated according to his initial contract.

Lemma 2. *Under Assumption A2, the highest payoff the principal can obtain at the deviating profile e_i with an IC contract $\tilde{R} \in \mathcal{I}(e_i)$ is $v(e_i) - R_i^O(v(e_i), e_i)$.*

Does Lemma 2 imply there is no additional credible dilution under the deviation? No. As established in Lemma 1, the credibility of dilution depends on the dilution sensitivity of the holdout's original contract. The subsequent proposition synthesizes these two lemmata to establish the conditions under which dilution is credible and to demonstrate how it determines the optimal exchange offer.

Proposition 3. *When $N \geq 2$, under Assumption A2, the principal cannot secure a strictly higher value at $h = \mathbf{0}$ with a strongly credible contingent contract than offering cash if and only if for all $i \in \mathcal{N}$, $S_i(v(e_i); e_i) < 1$. Consequently, if this condition is satisfied, holdout problems cannot be solved with any strongly credible contingent offers under Assumption A1.*

Recall that under the full-commitment and Assumption A1, Proposition 1 demonstrates that cash offers cannot implement the first-best outcome. Conversely, if the principal is

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[42]Absent 1-Lipschitz continuity, connectedness is not guaranteed. For example, the maximizer of $1 - x - \sqrt{1-x}$ on $[0,1]$ is $\{0\} \cup \{1\}$, such disconnectedness would significantly complicate the subsequent analysis.

[43]This regularity holds because dilution sensitivities, as derivatives, possess the intermediate value property (Darboux's theorem). They cannot exhibit jump or removable discontinuities, allowing us to extend many "almost everywhere" arguments to "everywhere".

permitted to propose unrestricted exchange offers, she can extract the full asset value. Proposition 3 establishes a sharp contrast: absent commitment, access to arbitrary contingent contracts yields no improvement over simple cash offers whenever agents' sensitivity to dilution is not perfect (i.e., strictly less than one).[44] The following section illustrates two practical examples distinguishing scenarios where the principal can outperform cash offers from those where she cannot.

4.1.3 Commitment and Diversity of Exchange Offers: Debt vs. Equity

Consider two canonical examplesdebt restructuring and corporate takeovers. In the former, agents hold debt contracts; in the latter, the target's equity. First, consider debt contracts. The dilution sensitivity of a debt claim is unity when the issuer is in default, as the value of the holdout's claim moves one-to-one with the asset value (recall that we restrict attention to unilateral deviations). Conversely, the sensitivity is zero if the claim is either worthless or fully satisfied. In the case of equity, the dilution sensitivity is unity only if the holdout possesses the entire residual claim after all senior obligations are met. It is zero when the firm is insolvent and strictly between zero and one in the presence of other shareholders. Because these instruments exhibit distinct payoff sensitivities, they induce different commitment constraints for the principal, leading to divergent solutions for debt restructurings versus takeovers. The following corollary follows immediately from Proposition 3.

Corollary 1. *When agents' initial contracts are debt, the principal can secure a higher value using a strongly credible contingent contract than by offering cash. Conversely, when agents' initial contracts are equity, no strongly credible contingent contract yields a higher value to the principal than a simple cash offer.*

As this corollary is a direct application of Proposition 3 and is of independent empirical interest, we present the proofs directly within the discussion of the following examples.

Example 1: Debt. Let's consider the case when the holdout A_i has debt $D_i \geq 0$. His payoff function is $R_i^O(w, e_i) = \min\{w, D_i\}$ and the maximum credible threat is $\bar{x}(e_i) = \mathbb{1}_{\{v(e_i) \leq D\}} v(e_i)$.

The next proposition shows how the different sizes of the agents' claims change the nature of the holdout problem when the principal cannot commit not to renegotiate with the holdouts.

Proposition 4. *When existing securities are debt contracts $D = \{D_i\}_i$, the principal's value function is $J(\mathbf{0}) = v(\mathbf{0}) - \sum_{i=1}^{N} D_i \mathbb{1}_{D_i < v(e_i)}$ under the strong δ-credibility constraint.*

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[44]In the same spirit, the threat to burn money is not credible, whereas burning money ex ante might be.

A comparison with the full-commitment benchmark clarifies the underlying mechanism. Under full commitment, the principal extracts the asset's entire value by credibly threatening to transfer the full asset value to tendering agents, thereby punishing any holdout. In contrast, under limited commitment, the principal cannot credibly threaten punishment if executing that threat reduces her own payoff. This constraint binds whenever the holdout possesses a "small" debt claim, specifically when $D_i < v(e_i)$. In such cases, because the holdout expects full repayment,[45] aany attempt to punish him comes directly at the principal's expense, thereby triggering the commitment problem. Indeed, as established in Definition 3, the principal's dilution sensitivity here is unity: any increase in punishment causes a one-for-one reduction in her residual claim. Consequently, the principal's payoff is reduced by exactly $\sum_{i=1}^{N} D_i \mathbb{1}_{D_i < v(e_i)}$. Conversely, if the holdout is a "large" creditor, $D_i > v(e_i)$, he is not fully repaid, as his dilution sensitivity is unity. In this scenario, the principal can credibly commit to punishment because her own payoff remains unaffected (her dilution sensitivity is zero). This distinction illuminates the differential treatment of bank debt versus public bonds in typical restructurings. Small creditors (dispersed bondholders) are difficult to punish credibly and thus often receive preferential treatment. Large creditors (banks), conversely, can be punished credibly and are therefore more likely to compromise. While existing literature attributes this difference to the pivotality of large versus small creditors, our analysis demonstrates that the credibility of punishment is a crucial determinant.

Example 2: Equity.   Suppose now that the holdout A_i possesses an equity claim representing a share $\alpha_i < 1$. His payoff function is $R_i^O(w, e_i) = \alpha_i w$, implying a constant dilution sensitivity of α_i everywhere. Consequently, the maximum credible dilution is $\bar{x}(e_i) = 0$. No punishment is strongly credible! Any punishment imposed on the holdout inevitably results in a net loss for the principal. This occurs because punishing the holdout reduces the holdout's payoff by only a factor of $\alpha_i < 1$ whereas the payoff of the principal is instead reduced by the complementary factor $1 - \alpha_i > 0$ (see Def. 3). Therefore, the principal always has an incentive to renegotiate in the presence of holdouts. Thus, contingent offers yield no improvement over simple cash offers. This result rationalizes the empirical rarity of senior debt exchange offers in takeovers, despite the persistently high premiums associated with

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[45]To understand why, recall that punishing the holdout requires transferring value to tendering agents. However, this transfer is costly due to the 1-Lipschitz property of the holdout's payoff. Furthermore, since the principal retains commitment power during renegotiation (under strong credibility), she minimizes payments to tendering agents (following the "Extreme Gouging" logic of Proposition 2). We relax this assumption in the next section; under the weaker credibility constraint, the principal may not pay a small creditor in full.

such transactions:[46] contingent contracts simply cannot outperform cash.[47]

The following proposition characterizes how the principal's payoff varies with the degree of commitment when agents hold equity.

Proposition 5. *When existing securities are equities $\alpha = \{\alpha_i\}_i$, the principal's value function on the set of strongly δ-credible contracts is $J(\mathbf{0}) = v(\mathbf{0}) - \delta \sum_{i=1}^{N} \alpha_i v(e_i)$, which is higher when the commitment is higher (δ is smaller).*

Consider first the benchmark of full commitment ($\delta = 0$). In this case, the principal can extract the full value of the asset (as established in Proposition 2). Consider now thethe opposite extreme of no commitment ($\delta = 1$). Here, the principal has to yield to the holdout the full value of his equity claim at the deviation profile, $\alpha_i v(e_i)$. For intermediate levels of commitment, the principal captures a fraction $1 - \delta$ of the value of the agent's equity stake. The intuition for the role of discounting is straightforward: as the principal places greater weight on the future—the timeframe in which renegotiation occurs—her ability to commit to the current exchange offer diminishes. Consequently, the more the principal values the renegotiation stage, the more value she must concede to the agents in the initial exchange offer to maintain credibility.

In fact the result that the payoff of the principal is decreasing in δ is more general than Proposition 5 may suggest. Within the framework of strong credibility, we establish the following general monotonicity result:

Proposition 6. *The principal's value function $J(\mathbf{0})$ on the set of strongly δ-credible contracts is weakly decreasing in δ for any existing contracts R^O.*

We specify that the function is "weakly decreasing" because, in certain instances—such as when agents hold debt contracts—the value function is invariant with respect to δ as in Proposition 4.

A defining characteristic of strong credibility is the asymmetry it posits: the principal possesses limited commitment power regarding the initial proposal, yet retains the ability to commit fully to alternative offers during the renegotiation stage. Empirically, this assumption is plausible under several conditions: distinct legal frameworks may govern on-path negotiation versus off-path renegotiation; agents may lack the sophistication to anticipate recurrent renegotiation; the principal may operate within a statutory exclusivity window for proposing offers, as seen in the U.S. Bankruptcy Code; or renegotiations may be conducted privately, as

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[46]Malmendier et al. (2016) finds that more 92% successful takeovers involve non-contingent offers (cash or acquirer stock), with an average premium of 46.24%.

[47]Non-contingent contracts are also optimal in Rubinstein and Wolinsky (1992) and Segal and Whinston (2002) albeit for different reasons.

modeled in Segal (1999).[48] Nevertheless, in contexts such as sovereign debt restructuring, the principal's capacity to commit is likely invariant across negotiation stages. Accordingly, the following section develops a definition of credibility that accounts for commitment consistency.

4.2 Credibility: A recursive definition

4.2.1 Credible Contracts: Definition, Existence, and Uniqueness

In this section, we refine the notion of a *credible* contract. We impose the requirement that any alternative contract the principal proposes to replace the initial offer must itself be *credible*. We discuss the rationale for this recursive definition and its connection to the literature in Section 7. We begin by modifying the definition of strongly credible contracts, which yields a bargaining protocol analogous to the framework in Stole and Zwiebel (1996).

Definition 6 (δ-Credible Contracts). *A contract R is a δ-credible contract for some $\delta \in [0,1]$ at an action profile h if and only if*

(a) it is incentive compatible for the agents at the action profile h; and

(b) upon any unilateral deviation $\hat{h}$, it weakly δ-dominates all δ-credible contracts at $\hat{h}$

Similarly, $\mathcal{C}^\delta(h)$, the set of δ-credible contracts at h, can be denoted by

$$\mathcal{C}^\delta(h) := \left\{ R \in \mathcal{I}(h) : R \succeq_\delta \tilde{R} \text{ at } \hat{h} \quad \forall \tilde{R} \in \mathcal{C}^\delta(\hat{h}) \quad \forall \hat{h} \in \mathcal{B}(h) \right\}. \tag{14}$$

Recall that in the definition of strong credibility, we considered renegotiation offers restricted only by incentive compatibility, that is, $\tilde{R} \in \mathcal{I}(\hat{h})$. By contrast, the current definition imposes the additional requirement that renegotiation offers be "credible going forward," meaning $\tilde{R} \in \mathcal{C}^\delta(\hat{h})$.[49] Because the set of credible alternative offers is a subset of all incentive-compatible offers, the condition for the original contract to dominate alternative offers is less stringent here than under strong credibility. Therefore, the set of strongly credible contracts is contained in the set of $\delta-$credible contracts, that is, $S^\delta(h) \subset \mathcal{C}^\delta(h)$.

Given the recursive definition of the set of $\delta-$credible contracts, we must establish its existence and uniqueness before proceeding with the characterization. The following

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[48]Segal (1999) adopts a slightly different structure where the principal lacks commitment in public offers but achieves it during private, bilateral renegotiations with individual agents. Secrecy is not the primary mechanism here, as private renegotiation can be anticipated even absent private information. The crucial distinction lies in the trigger: in our model, the principal seeks to renegotiate only *after* holdouts emerge. While the principal might theoretically profit from bilateral deviations that dilute other creditors (via super-seniority), such actions are typically precluded by legal mandates (e.g., equal treatment clauses).

[49]It is shown in the Section OA.8 in the appendix that this notion is the limiting case when the number of rounds of renegotiation extends to infinite.

proposition guarantees the existence and uniqueness of $\mathcal{C}^\delta(h)$. (Section OA.3 of the Online Appendix provides the proof of both Propositions 7 and 8)

Proposition 7 (Existence and Uniqueness). *The set of δ-credible contracts* $\{\mathcal{C}(h)\}_h$ *exists, it is non-empty and unique.*

A central finding is that δ-credibility implies a non-monotonic relationship between the principal's payoff and the degree of commitment, δ. We demonstrate the intuition behind this result using a specific example below, deferring the general characterization of δ-credible contracts to Section 4.2.3.

4.2.2 Non-monotonicity of Commitment: A Numerical Example

In contrast to Proposition 6, when the principal can deviate sequentially (under δ-credibility), increased commitment (a lower δ) does not always benefit the principal. Two competing forces are at play. First, *conditional* on a fixed continuation payoff, stronger commitment improves the principal's payoff today. However, the continuation payoff is endogenous: stronger commitment also strengthens the principal's position in any subsequent renegotiation, thereby increasing her expected payoff from renegotiating. This heightened temptation to renegotiate reduces her commitment to punishment today *unconditionally.* Consequently, if this second effect dominates, greater commitment can be detrimental. This "curse of commitment" is a recurrent theme in repeated games; for instance, a similar dynamic appear in the bilateral settings of Pearce (1987) and Kovrijnykh (2013). This suggests that the non-repeated multilateral interaction modeled here exhibits dynamics analogous to those found in repeated environments.

Example 4.1. *Consider a setting with three agents (N = 3), each endowed with an equity share* $\alpha_i = 1/3$ *for* $i \in \{1,2,3\}$. *The asset value is given by* $v(k) = 5 + k$ *where* $k \in \{0,1,2,3\}$ *is the number of tendering agents, and normalized to* $v(0) = 0$ *if all agents hold out.*

We calculate the principal's value function using backward induction. Suppose two agents, A_1 and A_2, hold out. The principal can credibly transfer up to $6(1-\delta)$ *to the sole tendering agent, A_3. Although A_3 requires no payment to participate (since his outside option at $v(0) = 0$ is zero), the principal can issue senior debt $x_3 > 0$ to A_3 purely to punish the holdouts. To see why, note that if the principal renegotiates, she offers zero to A_3 (as minimizing punishment maximizes her surplus), securing a payoff of* $\frac{1}{3}(6-0)\delta = 2\delta$. *Absent renegotiation, her payoff is* $\frac{1}{3}(6 - x_3)$. *Comparing these scenarios, the principal prefers not to renegotiate (i.e., the punishment is credible) if* $x_3 \le \bar{x}_3 := 6(1-\delta)$. *By symmetry, this represents the maximum credible punishment against two holdouts. Consequently, each holdout receives a residual equity value of* $\frac{1}{3}(6 - \bar{x}_3) = 2\delta$.

Next, consider the case where only one agent, A_1, holds out. To prevent A_2 and A_3 from deviating to the "two-holdout" subgame, the principal must offer them at least their outside option, which we established above as 2δ each. Suppose the principal initially promises A_2 and A_3 a total payment x. By renegotiating this amount down to their outside option minimum (4δ), she secures a discounted payoff of $\frac{2}{3}\delta(7-4\delta)$. Absent renegotiation, her payoff is $\frac{2}{3}(7-x)$. The condition for credibility implies: $x \leq \bar{x}_{12} := 7(1-\delta) + 4\delta^2$. Each holdout would obtain a value of $(7 - \bar{x}_{12})/3 = (7 - 4\delta)\delta/3$. And this is the payoff the principal has to promise them. The principal's value is thus $8 - 3 \times \frac{1}{3}(7 - 4\delta)^2 = 8 - 7\delta + 4\delta^2$. Plotted out in Figure 1, the principal's value is decreasing in commitment (increasing in δ) when $\delta > 7/8$.
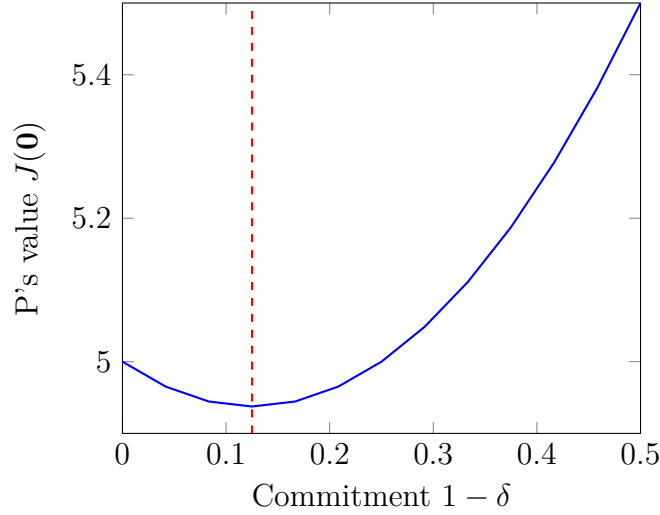

Figure 1: Principal's value function $J(\mathbf{0}) = v(\mathbf{0}) - \delta v_1 + \frac{2}{3}\delta^2 v_2$ when $v(\mathbf{0}) = 8, v_1 = 7, v_2 = 6$

4.2.3 Credible Contracts: General Characterization

In parallel with the proof of existence and uniqueness, we derive a recursive characterization of the solution expressed in terms of the principal's value function and the maximum credible punishment. The primary obstacle to a direct solution is the high dimensionality of the contract space. We overcome this challenge by reducing the analysis to a single-dimensional optimization problem: finding the maximum credible punishment at each holdout profile h.

Proposition 8. *The pair of vectors $\{J^*(h), \bar{x}^\delta(h)\}_{h \in \{0,1\}^N}$ is the pair of the principal's value function J^* and the maximum punishment $\bar{x}^\delta$ at each node h if and only if they satisfy the following recursive relation*

$$J^*(h) = v(h) - \underline{x}(h) - h \cdot R^O\left(v(h) - \underline{x}(h), h\right) \tag{15}$$

where the minimum punishment to implement h is

$$\underline{x}(h) := \sum_{i \in \xi(h)} R_i^O \left(v(h + e_i) - \bar{x}^\delta(h + e_i), h + e_i \right) \tag{16}$$

and, with the initial condition $\bar{x}^\delta(\mathbf{1}) = 0$, the maximum punishment is given by

$$\bar{x}^\delta(h) = \max\{x \in [0, v(h)] : h \cdot R^O(v(h) - x, h) + x = v(h) - \delta J^*(h)\}. \tag{17}$$

This general characterization enables us to solve the takeover problem for any initial ownership structure explicitly. First, we present a recursive characterization of the maximum credible punishment the principal can impose at each action profile. Subsequently, we derive a closed-form solution to this recursive system, yielding an explicit formula for the level of credible punishment achievable through contingent contracts.

Lemma 3. *Suppose the existing contracts $\{R_i^O\}_i$ are equity cliams, defined by $R_i^O(w, h) = \alpha_i w$ for all h. The maximum credible dilution at action profile h satisfies the recursive relation*

$$\bar{x}^\delta(h) = (1 - \delta)v(h) + \delta \sum_{i \in \xi(h)} \alpha_i(v(h + e_i) - \bar{x}^\delta(h + e_i)) \quad \forall h \neq \mathbf{1} \tag{18}$$

subject to the boundary condition $\bar{x}^\delta(\mathbf{1}) = 0$, provided that either $\sum_{i=1}^N \alpha_i = 1$ or $v(\mathbf{1}) = 0$.

The maximum dilution the principal can credibly impose at h, denoted by $\bar{x}^\delta(h)$, is a convex combination of the payoff she can credibly give to the tendering agents at h and the total asset value, weighted by the discount rate.

(a) The first term $(1 - \delta)v(h)$ represents the deadweight loss associated with renegotiation: Since the principal dissipates a fraction $(1 - \delta)$ of the surplus whenever she renegotiates, she can credibly commit to transferring at least this amount to tendering agents (as doing so is weakly cheaper than the efficiency loss of renegotiation).

(b) The second term represents the discounted sum of the reservation values for each tendering agent, the minimum the principal has to offer.

The boundary condition states that no punishment is feasible when all agents hold out if either i) the agents collectively own the entire equity stake; or ii) the asset value is zero. Conversely, if a third party retains a fraction of the equity and the asset holds positive value, the principal can generate credible punishment even when all agents hold out by diverting value to this third-party stakeholder.

In the case of least commitment, $\delta = 1$, the maximum payoff that can be credibly promised to any tendering agent is exactly equal to their contractual claim on the residual asset value available upon deviation: $v(h + e_i) - \bar{x}^\delta(h + e_i)$.

Lemma 3 highlights an alternating structure in the punishment mechanism: a more severe punishment upon further deviation reduces the maximum credible punishment on the equilibrium path. The intuition is as follows: if the punishment at the deviation profile $h + e_i$ is more severe, the tendering agent A_i faces a lower reservation value (outside option) should they choose to hold out. Consequently, promising a high reward to A_i at h becomes less credible, as the principal faces a stronger temptation to renegotiate the offer down to this lower reservation level. Conversely, a higher asset value $v(h + e_i)$ at the deviation profile increases the maximum credible punishment at h. In this case, the tendering agents' outside options are higher; thus, they command higher compensation at h, which raises the threshold at which the principal would profitably renegotiate.

Thus, we obtain the closed-form solution in Section OA.4 of the Online Appendix

Proposition 9. *For equity contracts, the maximum credible punishment at action profile h takes the following alternating form*

$$\bar{x}(h) = (1 - \delta)v(h) + \sum_{k=1}^{|\xi(h)|} \frac{(-\delta)^{k+1}}{(|\xi(h)| - k)!} \sum_{\sigma \in \Sigma(\xi(h))} \left(\prod_{s=1}^{k} \alpha_{\sigma(s)} \right) v \left(h + \sum_{s=1}^{k} e_{\sigma(s)} \right) \qquad (19)$$

where $\Sigma(\xi(h))$ is the set of all the permutations on $\xi(h)$. Consequently, the highest payoff the principal can credibly obtain at $\mathbf{0}$ is

$$J(\mathbf{0}) = v(\mathbf{0}) + \sum_{k=1}^{N} \frac{(-\delta)^k}{(N - k)!} \sum_{\sigma \in \Sigma(\mathcal{N})} \left(\prod_{s=1}^{k} \alpha_{\sigma(s)} \right) v \left(\sum_{s=1}^{k} e_{\sigma(s)} \right). \qquad (20)$$

This result shows how the contractual structure and the asset value at each k-step deviation profile $h + \sum_{s=1}^{k} e_{\sigma(s)}$ affect the maximum possible credible punishment at h. The first component $(-\delta)^{k+1}$ captures the alternating structure. Since we only to count the k-step deviation path from h once, the sum over all the permutations on $\xi(h)$ over-count the number of paths since it also includes all the paths further deviating from the k-step deviation profile, and the term $\frac{1}{(|\xi(h)| - k)!}$ is used to offset the repeated counting.[50]

In Section OA.5 of the Online Appendix, we extend this analysis to the more complex case of existing debt contracts. That analysis reveals that the solution exhibits discontinuities and regions of non-responsiveness.

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[50]This is similar to the factorial in the Shapley value where all possible paths of length N are summed over. Differently, here we sum over all possible paths of length $N - k$ starting at a particular node with k tendering agents.

5 Property Rights

5.1 Modeling Property Rights

The preceding analysis relied on the assumption that all existing contracts are fully dilutable. In reality, property rights protection often insulates claims from such dilution.[51] For instance, secured debts are typically shielded from subordination by liens on collateral.[52] Similarly, in land assembly problems, a holdout landowner retains the standalone value of their property if they reject the developer's offer.[53] Crucially, whereas contractual rights offer protection only against the specific counterparty (the principal), property rights provide protection against third parties as well (Ayotte and Bolton, 2011). This section examines how the strength of property rights protection influences the resolution of holdout problems. Our main results demonstrate that while stronger property rights invariably impede restructuring under full commitment, they can, counterintuitively, facilitate restructuring under limited commitment. Nonetheless, for standard securities such as debt and equity, we find that a marginal increase in protection typically exacerbates the holdout problem.

The simplest way to model property rights protection is to introduce an additional term $\pi_i \geq 0$ in each agent A_i's payoff, called the "property value", if he holds out. This term is independent of other agents' action and does not come from the value creation of the project.[54] That is, the payoff at h with a dilution of x is $R_i^O(v(h) - x, h) + \pi_i$.[55] And consequently the

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[51]For classic references to the optimal allocation of property rights, see Segal and Whinston (2013); for recent developments, see Dworczak and Muir (2024).

[52]Secured interests can sometimes be primed in DIP financing or via *uptier transactions*. However, such maneuvers are subject to judicial scrutiny and are often difficult to execute. That said, in the landmark case LCM XXII Ltd. v. Serta Simmons Bedding, LLC, the court upheld the legality of a transaction where the debtor issued new tranches of debt senior to existing first-lien obligations.

[53]There are subtle distinctions between these two forms of property rights. In land assembly, the specific asset (the "house") is effectively destroyed once the owner accepts the offer, with the surplus generated by the developer's aggregation of the land. In secured lending, the collateral lien is simply released upon acceptance. However, these scenarios can be unified in our modeling framework by viewing the unencumbered collateral as the value created from the exchange. We will treat these properties as "houses" in the general definition, noting that this formulation encompasses "collateral" through appropriate normalization of the asset value.

[54]We exclude the issue of collective ownership, multiple liens, or state-contingent investor protection such as credit default swaps. Bolton and Oehmke (2011) identified an "empty creditor problem" with such protection.

[55]Note if the property is collateral and the value goes back to the firm when the creditor accepts the offer and is available to be paid to other agents, we could define an alternative value $\tilde{v}(h) := v(h) + (1 - h_i)\pi_i$ and replace the occurrence of v by $\tilde{v}$ in the formulation of the problem. We model this way because the notation is simpler.

problem to implement h can be written as[56]

$$\max_{R \in \mathcal{C}^\delta(h)} J(h|R) \quad \text{s.t.} \quad h_i \in \arg\max_{h_i' \in H_i} \left\{ u(h_i'|h_{-i}, R) + h_i'\pi_i \right\} \quad \forall i \in \mathcal{N} \tag{21}$$

I assume participation is efficient even when the properties are destroyed:[57]

Assumption A3 (Monotonicity with Property). $v(h_{-i}, 0) > v(h_{-i}, 1) + \pi_i, \forall h_{-i}, \forall i \in \mathcal{N}$.

Similar to Proposition 2, the principal is extremely powerful by deploying contingency: She can extract all the value unprotected by the property rights by creating contractual externalities. Thus, higher property rights protection hinders restructuring.

Proposition 10. *With full commitment, greater property rights protection exacerbates the holdout problem. More specifically, the principal's value at $\mathbf{0}$ is $J(\mathbf{0}) = v(\mathbf{0}) - \sum_{i=1}^N \pi_i$, which is always decreasing in π_i for all i.*

The underlying intuition is straightforward: under full commitment, the principal must only compensate each claim holder for the value specifically protected by their property rights. Any contractual claims in excess of this protected floor can be fully diluted through contractual externalities. Consequently, stronger property rights protection increases the mandatory compensation required to satisfy existing claimants, thereby reducing the residual value captured by the principal.

When commitment is limited, there is no guarantee that property rights help the agents. In fact, a negative example in Section OA.6 of the Online Appendix shows that more property rights can help the principal, weaponizing the protection of one agent against another. For empirical relevance, we focus on the case of debt and equity.

5.2 Effect of Property Rights with Equity Holdouts

When existing contracts are equities, no matter the structure, a higher property rights protection never leads to an easier resolution of the holdout problem.

Proposition 11 (Property rights hinder equity restructruring). *For any equity contracts $\{\alpha_i\}_i$, the prinicpal's value $J(\mathbf{0})$ under δ-credibility for any $\delta \in (0, 1]$ is decreasing in π_i for all $i \in \mathcal{N}$.*

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[56]The definition of the credible contracts is the same except the additional term π_i in the agent's payoff of holding out in the set of incentive-compatible contracts. The existence and uniqueness of credible contracts with property rights protection can be proved, *mutatis mutandis*, similarly to Proposition 7.

[57]Note if we use the other notation as in footnote 55, this is simply monotonicity of $\tilde{v}$: $\tilde{v}(h_{-i}, 0) > \tilde{v}(h_{-i}, 1)$.

The result says that despite the countervailing forces that greater property rights protection bolsters her commitment, this indirect force will nonetheless not exceed the direct force that makes restructuring harder. The reason is that each indirect effect is weighted by the equity dilution sensitivities $\{\alpha_j\}_{j\neq i}$ which also sum up less than 1. To see the force more clearly, let's look at a specific example. Let the existing contracts be equities $\alpha = \{\alpha_i\}_{i=1}^{3}$ such that $\langle \alpha, \mathbf{1} \rangle = 1$ and $\delta = 1, v(\mathbf{1}) = 0$.

Example 5.1 (Property rights hinder equity restructuring). *With limited commitment, the value function of the principal at $\mathbf{0}$ with equities outstanding is decreasing in each π_i,*

$$\frac{\partial}{\partial \pi_i} J(\mathbf{0}) = - \left(1 - \sum_{j\neq i, k \neq j,i} \alpha_i (1 - \alpha_k) \right) < 0 \quad \forall i. \tag{22}$$

The closed-form solution for the sensitivity of the principal's value to property rights protection illustrates the trade-off of the two forces. The direct effect is a one-to-one reduction in P's value and the indirect effect is summarized in the other term. This renegotiation channel is shadowed when equities are in place because higher protection of A_1 also makes punishing A_2 easier, but only at a rate smaller than 1: It is the equity sensitivity to the asset, α_2. Similarly, the effect of punishing A_3 is also dampened by the equity sensitivity α_3. Since the sum of all equity shares adds up to 1, the indirect effect is always smaller than one.

5.3   Effect of Property Rights with Debt Holdouts

The effect of property rights is more nuanced when existing securities are debt contracts. Any locally small increase in property rights protection always exacerbates the holdout problem, but a large increase could facilitate restructuring. I show the two effects in the next two propositions.

Proposition 12 (Property rights generically hinder debt restructruring). *For any debts contracts $\{D_i\}_i$, the prinicpal's value $J(\mathbf{0})$ under δ-credibility for any $\delta \in (0,1]$ is generically locally decreasing in π_i for all i. That is, $\frac{\mathrm{d}J(\mathbf{0})}{\mathrm{d}\pi_i} < 0$ at any differentiable points.*

When creditors are protected by property rights, the force that makes renegotiation harder for the principal does not get transmitted to the initial bargaining due to the fact that a holdout creditor is either repaid in full or not at all. Thus, the effect of a small change in the protection that increases the punishment does not get transmitted from the off path renegotiation since the maximum credible punishment has a discontinuity and is flat in each region. However, this effect only applies to a small increase in π_i away from the boundary.

When the existing contracts are debt, a non-locally-small increase in property rights protection could indeed facilitate debt restructuring. Let there be two agents: agent A_i has a debt value of $D_i = 1$ for all $i \in \{1, 2\}$. The asset value is $v(\mathbf{1}) = 0$, $v(e_i) = 2$ for all i and $v(\mathbf{0}) = 3$. And for simplicity, we assume $\delta = 1$. For the property value, we focus on the region where $\pi_i \in [1/2, 3/2]$ for all i.

Proposition 13. *With limited commitment, the principal's value in the 2-creditor example is $J(\mathbf{0}) = v(\mathbf{0}) - \sum_{i=1}^{2} \left[D_i \mathbb{1}_{\{v(e_i) \geq \pi_j + D_i\}} + \pi_i \right]$. Given the parameters above, the principal's value increases when the property right of A_j increases from any value $\pi_j \in (1/2, 1)$ to any $\pi_j + \Delta \pi_j \in (1, 3/2)$.*

This result says the effect is different when a change in property rights is large enough to "switch the regime". When π_j is small, the principal needs to pay A_i in full if he holds out because she cannot credibly pay more to A_j to punish A_i. But when π_j is slightly larger, above the threshold, she can more credibly pay A_j to punish A_i, which reduces her initial compensation to A_i.

These results echo the finding that higher creditor protection could facilitate or hinder restructuring in Donaldson et al. (2020). Both non-monotonicity stems from the principal's lack of commitment: She cannot commit to a renegotiation policy here and to a bankruptcy filing policy in theirs. Here, higher property rights protection of the creditors has a direct effect of making the restructuring harder but an indirect effect of making the principal more credible when punishing other creditors. In theirs, a more creditor-friendly policy has a direct effect of making priority more attractive but an indirect effect of making a bankruptcy filing less likely, reducing the appeal of priority.

6 Literature

The extensive literature on holdout problems has largely focused on the specific contractual forms of both existing and newly offered securities, while generally circumventing the issue of commitment. In a seminal study, Grossman and Hart (1980) analyzed the holdout problem in takeovers, Gertner and Scharfstein (1991) in debt restructuring, Bulow et al. (1988) in sovereign bond buyback. Much of the later work focuses on eliminating the holdout problems by allowing for mixed strategy (Holmström and Nalebuff, 1992), concentrated agent (Shleifer and Vishny, 1986), or legal institutions (Burkart et al., 2014) without much attention paid to the commitment issue of the principal, despite the wide acknowledgement in sovereign debt literature (Pitchford and Wright, 2012).

The paper falls broadly in the literature of mechanism design with limited commitment, with two notable distinctions. Most papers studying the limited commitment of the principal in mechanism design, such as Bester and Strausz (2000), Bisin and Rampini (2006) and Doval and Skreta (2022), focus on the issue of information leakage. Another feature of the model is that the outside option is endogenous and depends on the Principal's contracts, similar to the literature on the dissolution of partnership (Cramton et al., 1987), ratifiable mechanism (Cramton and Palfrey, 1995), contracting with externality (Jehiel et al., 1996) and partial mechanism design (Loertscher and Muir, 2022).

To the best of my knowledge, there is no paper associating the credibility of contracts with its dilution sensitivity. The non-monotonicity of commitment was derived in a bilateral repeated lending with a similar intuition: "just as commitment increases the lender's payoff in an optimal equilibrium, it increases his payoff from the most profitable deviation."(Kovrijnykh, 2013, p.2850) Higher commitment can backfire for a different reason: Donaldson et al. (2020a,b) proxies commitment with pledgeability (Proposition 1) and collateralizability (Proposition 4) and shows that both might lead to lower ex-ante payoff: higher pledgeability might hurt borrowers due to excessive power to dilute initial creditor at the interim financing stage, leading to the impossibility of lending ex ante; higher collateralizability could harm borrowers by over-collateralization, which leads to impossible interim financing.

7 Discussions

7.1 Discussions of Assumptions

Asset Value Microfoundation   The paper assumes the asset value is decreasing in the holdout profile but is silent about why. I present several canonical ways of microfounding this assumption here, based on agency theory, costly default, and liquidity injection.

Imagine first the case of takeovers where each initial shareholder has a share of α_i. After acquiring the firm, the raider could exert an effort $e \in \mathbb{R}_+$ to improve the asset value from 1 to e, which incurs a quadratic cost e^2. Given the holdout profile h, the raider has a fraction $1 - h^\top \alpha$, and he optimally chooses the effort to maximize his payoff from his equity shares, i.e., $\max_e (1 - h^\top \alpha)e - e^2$. The optimal effort and the corresponding asset value is $v(h) = e^* = 1 - h^\top \alpha$, a decreasing function of h as I assumed earlier.

Imagine a debt restructuring case where each creditor A_i holds a debt with a face value of D_i. There is an underlying asset whose value e follows a distribution G, independent of the capital structure. There is a chance for the firm to file bankruptcy, which destroys a fraction $1 - \lambda$ of the asset value, but the firm can obtain a fraction β of the remaining asset value. So

the firm files if and only if $\lambda \beta e \geq e - h^\top D \iff e \leq (1 - \lambda\beta)^{-1} h^\top D$. The expected value before the underlying asset value realization is thus also decreasing in h

$$v(h) = \mathbb{E}[e] - \int_0^{(1-\lambda\beta)^{-1} h^\top \boldsymbol{D}} \lambda v \mathrm{d}G(v). \tag{23}$$

In a DIP financing scenario, the firm offers securities to existing creditors in exchange for liquidity injection. Let l_i be the liquidity the A_i injects into the firm and $\boldsymbol{l} = (l_1, \cdots, l_N)$; then the asset value would be $v(h) = v(\boldsymbol{0}) + (\boldsymbol{1} - h)^\top \boldsymbol{l}$, a linear decreasing function of h.

Sequential Renegotiation An alternative way to model multilateral bargaining is to specify a sequential protocol. There are multiple ways to specify an extensive game in which bargaining or renegotiation occurs sequentially: i) Shaked's unanimity game, where players propose in order, and any player can veto. The problem with this is that it has many perfect equilibria, and any feasible agreement can be implemented; ii) Legislative Bargaining models where proposers are randomly selected and a binding decision can be confirmed by a less-than-unanimous consent. This approach is plagued with impossibility results like the Condorcet paradox and that the majority core can be empty (Eraslan and Evdokimov, 2019); iii) The exit games considered in Lensberg (1988) where any agent satisfied with his share can leave the bargaining table. This approach requires the consistency axiom I employed in this paper. Krishna and Serrano (1996) showed that the equivalence between Nash's axiomatic solution and Rubinstein's alternating bargaining model extends to the multilateral case given this consistency axiom.

Regenotiation-Proofness The most commonly used notion is the two-sided renegotiation-proofness: That is, the principal cannot propose an alternative contract that Pareto dominates the current one, i.e., nobody objects to the alternative offer, and some agent or the principal is strictly better off under this new hypothetical offer. But such a requirement would be too strong as it can be difficult to achieve in reality for various reasons. For example, i) the holdouts typically are tough to handle, and they usually are not negotiated away so the size of the pie can not be increased, and ii) some laws may prohibit preferential treatment of the holdouts. E.g., in takeovers, the *best-price rule*, or sometimes called *all-holders rule* or *Rule 14D-10*.[58] Therefore, I confine the alternative proposals to the contracts that are incentive compatible with the deviation profile, i.e., that the tendering agents still have an incentive to

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[58]This is Code of Federal Regulations §240.14d-10, which can be traced back to the 1968 Williams Act Betton et al. (2008). See https://www.law.cornell.edu/cfr/text/17/240.14d-10. SEC also provides a detailed discussion of this rule and possible exemptions in *17 CFR PARTS 200 and 240*. See https://www.sec.gov/rules/final/2006/34-54684.pdf

tender under the potential alternative proposal, and the holdouts are not enticed to tender.

Put differently, similar to Hart and Tirole (1988) I am implicitly assuming that the principal can unilaterally renege on the proposed offer whenever any agent deviates, and no agent can hold her accountable. Otherwise, the principal can threaten to give the entire firm to a tendering agent, who would block any alternative offer. Consequentially, the full-value extraction in Proposition 2 would be credible. Readers can also view the protocol in the model as if the principal called off the entire deal and re-proposed an new deal to the tendering agents so that the old proposal does not constrain her.

Renegotiation with Tendering Agents   In the potential renegotiation and the formal definition of credibility in Section 4, the renegotiation protocol I laid out on possible punishments via "dilution" is effectively a renegotiation with the tendering agents instead of with the holdouts. It's meant to capture the principal's lack of commitment to the punishment.

Empirically, holdouts are usually not easily renegotiated away and they extract significant value from sticking to their initial contracts. As mentioned above, holdouts in Greek debt restructuring are paid in full. In *Elliott Associates, L.P. v. Banco de la Nacion and The Republic of Peru*, the holdout creditor purchased bonds with a total face value of 21 million for 11 million and received 58 million in settlement for the principal and accrued interests. Moreover, renegotiation with the holdouts could be illegal. In applications like takeovers, providing additional compensation to the holdouts would violate the best-price rule (Exchange Act Rule 10d-10, see 17 CFR § 240.14d-10 - Equal treatment of security holders.).

Will renegotiation with the holdouts alter the outcome? Not without new information: The principal will offer the same; otherwise, she would have already offered it initially. Indeed, how credibly the principal can punish the holdout is determined by the renegotiation with the tendering agents, not with the holdout. Thus, whether we allow for an explicit renegotiation with the holdout would not alter the outcome.

7.2   Discussions of Empirical Relevance

Relevance of the Holdout Problems   Despite many attempts to solve the holdout problems at the institutional level, they remain of first-order concern in all aspects of the economy. In the sovereign bond restructuring case, the IMF proposed adding Collective Action Clauses (CACs) to the new issuance. It has been proven effective in solving the holdout problems within series but not across series (Gelpern and Heller, 2016; Fang et al., 2021). Also, there is a bulk of existing sovereign debts without it. *Squeeze-out* procedures are adopted for takeovers in both the US and EU, which allow the acquirer to gain the full stake of the target when she obtains a majority stake, thus "squeezing out" the holdouts.

But the legitimacy has been contested and the holdout can resort to legal remedies such as *"action of avoidance"* and *"price fairness"*. Similarly, the once-popular two-tier tender offer[59] also received great legal challenges. The possibility of litigation restores the incentive to hold out. Therefore, a better understanding of the holdout problem and its solutions would still have first-order relevance in the current state. In other jurisdictions, for example, in Colombia, where the legal system follows a civil law tradition, Holland (2022) documented strong property rights protection worsens the holdout problems and curbs city development. In land acquisition for oil drilling, the "*rule of capture*" allows the oil drilling companies to acquire the land adjacent to the holdout block and utilize the oil extracted from a common pool, weakening the bargaining power of the holdout and strengthening the tendering land owners. Yet, the adoption of these legal theories varies across states. For example, in Texas, the land owner has a *possessory interest* in the substances beneath the land. In *Geo Viking, Inc. v. Tex-Lee Operating CO*, the Supreme Court of Texas has ruled a fracture across the property line, as a result of *fracking*, a subsurface trespass.

Empirical Relevance of Limited Commitment   The key assumption, limited commitment, is reflected in a multitude of empirical evidence, e.g., in Pitchford and Wright (2012). It is well-documented that sovereigns lack the commitment to debt repayment, new debt issuance, and, in particular, to the negotiated outcome due to both the doctrine of sovereign immunity and the lack of a statutory regime. For example, Argentina filed with the SEC not to pay anything to the holdout creditors in 2004 and passed the Lock Law not to reopen a new exchange offer in 2005. Yet, Congress suspended the Lock Law in 2009, and the government offered a new exchange offer in 2010. In the Greek debt crisis, Greece opted to pay 435 million euros ($552 million) to the holdout creditors in full in order not to trigger the cross-default clauses and be dragged into litigation, even though it announced in the earlier exchange offer that the holdout would not get anything. Meanwhile, the majority (97%) of the tendering creditors only received cents on the euro.[60]

Legality of Certain Solutions   Currently, there are no laws prohibiting the use of unanimity. In takeovers, typically, the acceptance of the tendered shares is "contingent on the delivery of a certain number of shares" (Cohen, 1990, p.116), which can be set to

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[59]A two-tier tender offer typically offers a high price to purchase shares until the raider obtains a controlling stake and purchases the remaining shares at a lower price. A similar practice is a partial tender offer where the raider only buys a fraction of outstanding shares. Both create a coercive force for the shareholders to tender. The main form of tender offers now is any-and-all, where the bidder promises to buy any shares of the target firm.

[60]See https://www.reuters.com/article/us-greece-bond/in-about-face-greece-pays-bond-swap-holdouts-idUSBRE84E0MY20120515

100%,[61] the optimal threshold in Holmström and Nalebuff (1992). Typically, the raider can include a *bidder termination provision*[62] which gives the raider a real option to terminate the transaction at a fee to implement the unanimity rule.

The Extreme Gouging result might raise concerns about "fraudulent conveyance" when the firm pays certain creditors too much to avoid paying other known creditors (See 11 U.S. Code § 548). But this only applies i) when there is an imminent bankruptcy and ii) if the payments exceed the face value of the liabilities, not the market value. Since in bankruptcy, the firm's assets are not enough to pay off all creditors in full; it is also unlikely to exceed the total debt of the tendering creditors when one holds out.

Another concern is whether such offers violate certain covenants, such as the pari-passu clause and fair-dealing/good-faith provisions. Pari-passu clauses are unlikely to be violated as the offers the principal proposed here *is* symmetric: The allocation is only asymmetric after some creditors reject the offer, which is the case for any other offers. Traditionally, the clause is also interpreted in a very narrow sense: Ratable payment, prior to an innovative reading by the Brussels Court of Appeal in *Elliott Associates, L.P. v. Banco de la Nacion* which prevented Chase Manhattan from facilitating the interest payment of Peru's Brady bond. Typically, in a sophisticated court like New York, textualist judges often interpret any arrangement consistent with the text of the contracts as good faith, even when it looks exploitative to outsiders.

Dilutability of Existing Securities   The baseline model assumes that all existing securities are dilutable, e.g., via senior debt. When existing debts are protected by collateral, they can still be diluted in bankruptcy through *priming lien*, typically in Debtor-In-Possession (DIP) financing to raise new liquidity under Section 364(d). The firm in bankruptcy is also allowed to use *roll-up provisions* to draw the DIP financing to repay some of the creditors' (usually DIP lenders') pre-petition indebtedness, converting these debts to post-petition supersenior debt.[63] And absent *de jure* seniority structure, sovereign debts issued under foreign law sometimes have priority under the judge's discretion. In the *Elliot Management vs. Argentina*, the Southern District of New York court judge Thomas Griesa issued an injunction preventing the Bank of New York Mellon from forwarding the payment to the

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[61]Grossman and Hart (1980) argues the absence of unanimity is due to the sleepy investor problem. We are not particularly concerned with the issue of inability to find all the agents as most takeover offers are widely publicized (Cohen, 1990) and the holdouts are often well-known hedge funds, e.g., Elliot Management in the debt restructuring of Argentina, Peru, Panama; Oppenheimer, Franklin, and Aurelius Capital in Puerto Rico's debt crisis; Dart Management in the debt crisis of Brazil, Argentina, and Greece.

[62]The bidder also has a fiduciary termination right, which allows the raider to terminate when itself receives a takeover offer, and a regulatory termination trigger when it fails to pass the antitrust review.

[63]*Up-tier exchanges* and *drop-down transactions* are also similar tools commonly used in DIP financing to gain priority.

restructured creditors or new creditors, creating a *de facto* seniority of the holdout's debt. Currently, New York is considering a bill to rule with sovereign,[64] which effectively lowers the seniority of the holdouts' debt. And Schlegl et al. (2019) finds sovereigns implement a *de facto* seniority by selectively defaulting on certain creditors.

8   Conclusion

The holdout problem is pervasive in our economy and extensively studied in finance research. Despite decades of research, however, the literature has not sufficiently recognized that a meaningful discussion of holdout problems requires relaxing both the contracting space and the commitment assumption. While it is generally understood that limited commitment exacerbates the holdout problem, how it limits the contractual solutions remains underexplored. Conversely, studying general mechanisms under the assumption of full commitment proves unfruitful: when commitment is absolute, the holdout problem becomes trivial to solve. Unanimity suffices.

The paper uncovers two effects of commitment: First, it will interact with the dilution sensitivity of the initial set of contracts and determine the credibility of the dilution mechanism and, in turn, the optimal exchange offer; second, the commitment has a non-monotone effect through the renegotiation channel. When the securities in place are equity-like, not fully sensitive to dilutions, contingent securities cannot do any better than a non-contingent contract like cash. The model explains why senior debts, so dominantly used in debt restructuring, are not seen in the takeover. Similar to repeated games, the non-monotonic effect of commitment emerges in static multilateral bargaining with potential sequential deviations. Furthermore, the same intuition suggests a surprising result regarding property rights: strengthening property rights protection for current claimants does not necessarily benefit them. Such protection can be "weaponized" against other claimants.

Despite this progress, several avenues remain for future research. This paper does not address issues of asymmetric information. For instance, an emerging concern in the sovereign debt market is the lack of transparency between debtors and non-Paris Club creditors. Analyzing dynamic multilateral bargaining under private information will inevitably require solving an interim informed principal problem—a significant challenge for future work.

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[64]The Assembly Bill A2970 can be found here https://www.nysenate.gov/legislation/bills/2023/A2970, and it has received a strong rebuttal from Credit Roundtable, ICMA, IIF, ICI, ACLI, LICONY.

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A Proofs for Section 3 (Optimal Exchange Offer with Full Commitment)

Proof of Proposition 1. We need to show that there's no SPNE in which the principal can find a non-contingent cash transfer $t_i(h_i)$ and every agent accepts. Suppose such an equilibrium exists, for A_i not to hold out, it must be that $t_i(0) \geq t_i(1) + R_i^O(v(e_i), e_i)$ and since lowest possible payment when A_i holds out is $t_i(1) = 0$, the principal has to pay at least $t_i(0)_{\min} := R_i^O(v(e_i), e_i)$. But under Assumption A1, the principal is better off not initiating the transaction. So this cannot be an equilibrium. □

Proof of Proposition 2. Consider the following offer: If $\xi(h) = \mathcal{N}$, $R_i(v(h), h) = \frac{\varepsilon}{N}$. If instead $\xi(h) = \varnothing$, we let $R_{\underline{j}}(v(h), h) = v(h)\mathbb{1}_{\{j=j^*\}}$ where $\underline{j} := \min\{i \in \mathcal{N} : v(1 - e_i) > 0\}$ and $j^* := \min\{i \in \mathcal{N} : i \neq \underline{j}\}$. If $\xi(h)$ is neither $\varnothing$ nor $\mathcal{N}$, we let $R_j(v(h), h) = \frac{v(h)}{|\xi(h)|}\mathbb{1}_{\{j \in \xi(h)\}}$.

Clearly, $h = \mathbf{0}$ is an equilibrium: If A_i deviates to 1, his payoff will be reduced to 0 from ε/N, so no one wants to deviate. To see why $h = \mathbf{0}$ is unique, first, let's check $\mathbf{1}$ is not an equilibrium: only A_{j^*} gets the full project value $v(\mathbf{1})$ while others get nothing. It's strictly profitable for agent $A_{\underline{j}}$ to accept since this deviation would result in an increase of his payoff by $v(\mathbf{1} - e_{\underline{j}}) > 0$. Second, let's consider an action profile h such that $\xi(h) \neq \mathcal{N}$, then for any agent $i \notin \xi(h)$, he gets 0 in the action profile while deviating to $h_i = 0$ would give him a positive payoff $\frac{v(h_{-i}, 0)}{N - |\xi(h_{-i}, 0)|} > 0$. □

B Proofs for Section 4 (Optimal Exchange Offer with Limited Commitment)

Proof of Lemma 1. Let $J(h|\mathcal{R})$ be attained at $\hat{R}$ with $\hat{x} = x(\hat{R}) \equiv \sum_{i \in \xi(h)} \hat{R}_i(v(h), h)$. We have $g(v(h)) = 0 \leq \delta J(h|\mathcal{R})$ and $g(\hat{x}) = J(h|\mathcal{R}) \geq \delta J(h|\mathcal{R})$. So by continuity of g, a solution to the equation $g(x) = \delta J(h|\mathcal{R})$ must exist. In addition, the pre-image of a continuous function $g^{-1}(\delta J(h|\mathcal{R}))$ is a closed set, and it is also bounded in $[\underline{x}(h), v(h)]$, so it is a compact set and the supremum can be attained.

By Rademacher's theorem, Lipschitz continuity of $h \cdot R^O(\cdot, h)$ implies that g is absolutely continuous and differentiable almost everywhere, and we take the left first-order derivatives $g'(x) = -1 + S(v(h) - x; h) \leq 0$ *a.e.*, so the function g is weakly decreasing. Therefore, $\mathcal{X}$ must be a closed and connected set, which can only be a closed interval or a singleton. The optimality implies $g'(x) = 0$ and thus $S(v(h) - x; h) = 1$ almost everywhere. And since $S(\cdot; h)$ is a derivative, which cannot have jump or removable discontinuity by Darboux's theorem, and is a constant almost everywhere, it must be a constant everywhere.

Again, the continuity of g implies $g^{-1}([\delta J(h|\mathcal{R}), +\infty))$ is a closed set bounded in $[\underline{x}(h), v(h)]$ so the supremum can be attained. And since g is weakly decreasing, the supremum is attained when $g(x) = \delta J(h|\mathcal{R})$. Moreover, the equation $g(x) = \delta g(\hat{x})$ can be rewritten as

$$\int_{\hat{x}}^{x} g'(s)\mathrm{d}s + (1 - \delta)g(\hat{x}) = 0 \tag{24}$$

Using the fact that $g(\hat{x}) = J(h|R)$ and $g'(s) = -S_0(s; h)$ we have

$$(x - \hat{x})S_0([v(h) - x, v(h) - \hat{x}]; h) = (1 - \delta)J(h|\mathcal{R}). \tag{25}$$

And taking $x = \bar{x}(h; \mathcal{R})$ we have the characterization in the lemma.

Lastly, when $\delta = 1$, the RHS $(1 - \delta)J(h|\mathcal{R})$ is zero so at least one of the two terms on the LHS is zero. In particular, if $\bar{x} > \underline{x}$, $S([v(h) - \bar{x}, v(h) - \underline{x}]; h) = 1$ and since $S(v(h) - x; h) \leq 1$ by 1-Lipschitzness and thus it must be identically 1 everywhere, (a derivative cannot be less than 1 on a set of measure zero) which implies $\bar{x}(h; \mathcal{R}) \leq \inf\{x \geq \underline{x}(h; \mathcal{R}) : S(v(h) - x; h) < 1\}$. But it cannot be strictly smaller since we could otherwise increase the dilution, so it has to be equality. $\square$

Proof of Lemma 2. I first construct an incentive compatible contract $\tilde{R}$ that delivers a payoff of $v(e_i) - R_i^O(v(e_i), e_i)$ to the principal. The construction is similar to that in Proposition 2. Let $\tilde{R}_i(v(h), h) = 0$ for all h and for $j \neq i$,

$$\tilde{R}_j(v(h), h) = \begin{cases} \varepsilon/N & \text{if } h = e_i \\ 0 & \text{if } h = \mathbf{1} \text{ or } \mathbf{0} \text{ or } (h \neq e_i, \mathbf{1}, \mathbf{0} \text{ and } j \notin \xi(h)) \\ \frac{v(h) - \varepsilon}{|\xi(h)|} & \text{if } h \neq e_i, \mathbf{1}, \mathbf{0} \text{ and } j \in \xi(h) \end{cases} \tag{26}$$

I will now show that with this proposal, for sufficiently small $\varepsilon \geq 0$, e_i is an equilibrium, and when $\varepsilon > 0$ and $R_i^O(\cdot, h)$ has a strictly positive right derivative at 0 for all h, the equilibrium is unique.

- For agent A_i, as long as $h \neq e_i, \mathbf{0}$ or $\mathbf{1}$, the total payment to the tendering agents is $v(h) - \varepsilon$ tendering results in a payoff of 0 while holding out yields a payoff of $R_i^O(\varepsilon, h)$, so holding out is strictly better if $\varepsilon > 0$ and $R_i^O(\cdot, h)$ has a strictly positive payoff. When everyone else holds out, holding out yields a payoff of $R_i^O(v(\mathbf{1}), \mathbf{1})$ while tendering gives him nothing.

- For any other agent A_j, non-tendering gives a payoff of zero, and tendering gives a payoff of either ε/N if everyone else other than A_i tenders, or $\frac{v(h) - \varepsilon}{|\xi(h)|}$ otherwise, which is positive for sufficiently small $\varepsilon > 0$.

Thus, we proved $R^{O|R}$ is incentive compatible with e_i.

For any arbitrary contract $\hat{R} \in \mathcal{I}(e_i)$, let $x(e_i; \hat{R}) = \sum_{k \in \xi(e_i)} R_k(v(e_i), e_i)$ be the payment to the tendering agents and thus the total payment is $x(e_i; \hat{R}) + R_i^O(v(e_i) - x(e_i; \hat{R}), e_i)$.

Suppose the principal wants to find another contract $\hat{R}$ to minimize the total payment. Under Assumption A2, $R_i^O(\cdot, e_i)$ is weakly increasing and 1-Lipschitz, by Lemma 1, the solution to the minimization problem above is obtained at $x = 0$, which is achieved by $\tilde{R}$ when $\varepsilon = 0$. And the principal cannot obtain a higher payoff than $v(e_i) - R_i^O(v(e_i), e_i)$. □

Proof of Proposition 3. To prove this result, I first show that when $S_i(v(e_i); e_i) < 1$ for all$i$, the contract R is strongly credible if and only if the off-path punishment at e_i is $x(e_i) := \sum_{j \neq i} R_j(v(e_i), e_i) = 0$. Then, I calculate the value function of the principal and show that it equals the value function when offering cash. Lastly, I show that the principal can do strictly better when the condition $S_i(v(e_i); e_i) < 1$. is violated.

First, from Lemma 2, we know that at the deviation profile e_i the principal was able to obtain $v(e_i) - R_i^O(v(e_i), e_i)$ using an incentive compatible contract. Therefore, the credibility constraint at e_i is

$$v(e_i) - \sum_{k \neq i} R_k(v(e_i), e_i) - R_i^O \left(v(e_i) - \sum_{k \neq i} R_k(v(e_i), e_i), e_i \right) \geq \delta \left[v(e_i) - R_i^O(v(e_i), e_i) \right] \quad (27)$$

Rearranging the terms, we obtain

$$x(e_i; R) + R_i^O(v(e_i) - x(e_i; R), e_i) \leq (1 - \delta)v(e_i) + \delta R_i^O(v(e_i), e_i) \quad (28)$$

where $x(e_i; R) = \sum_{k \neq i} R_k(v(e_i), e_i)$. When $\delta = 1$, using Lemma 1, the unique solution is $x(e_i; R) = 0$ when the first partial derivative $R_i^O(v(e_i), e_i)$ is strictly smaller than 1 at $v(e_i)$. Since any punishment would be renegotiated away and the holdout would be paid $R_i^O(v(e_i), e_i)$, in order to persuade the agent to tender, the principal has to pay at least this much to A_i, leaving at most $v(\mathbf{0}) - \sum_{i=1}^N R_i^O(v(e_i), e_i)$ to the principal, which is equivalent to offering cash. This is lower than c under Assumption A1 and restructuring is infeasible. □

Proof of Proposition 4. To prove this, we first show that the maximum credible punishment is $\bar{x}^\delta(e_i) = (1 - \delta)(v(e_i) - D_i)$. This is obtained by finding the maximum x such that

$$x + \min\{v(e_i) - x, D_i\} \leq v(e_i) - \delta [v(e_i) - \min\{v(e_i), D_i\}] \quad (29)$$

When $v(e_i) \leq D_i$, the RHS is simplified to $v(e_i)$, while the LHS is always smaller than $v(e_i)$ as $x + \min\{v(e_i) - x, D_i\} \leq \min\{v(e_i), D_i + x\} \leq v(e_i)$. So the maximum punishment is $\bar{x}^\delta(e_i) = v(e_i)$. The holdout A_i doesn't get paid anything.

When $v(e_i) > D_i$, the LHS ranges from D_i to $v(e_i)$ while the RHS $(1 - \delta)v(e_i) + \delta D_i$ is a value strictly in between. So the maximum possible value is given by $\bar{x}^\delta(e_i) = (1-\delta)(v(e_i)-D_i)$. And the holdout is paid $\min\{v(e_i) - \bar{x}^\delta(e_i), D_i\} = D_i$.

Thus, at $h = \mathbf{0}$, the principal has to pay D_i to any agent A_i such that $D_i < v(e_i)$ since he could otherwise hold out and get paid in full; but nothing to other agents. This confirms the value function of the principal in the proposition. □

Proof of Proposition 5. To prove this, I calculate the principal's value function ignoring the sunk cost. First, note that the maximum credible dilution at e_i is $x(e_i; R) = (1 - \delta)v(e_i)$. This is obtained by substituting the functional form $R_i^O(x, e_i) = \alpha_i x$ into Equation (28), which becomes $x(e_i; R) + \alpha_i(v(e_i) - x(e_i; R)) \leq (1-\delta)v(e_i) + \delta\alpha_i v(e_i)$. Rearranging the terms shows that the maximum punishment that can be imposed on A_i is $x(e_i) = (1 - \delta)v(e_i)$.

Therefore, the principal has to pay at least $\alpha_i(v(e_i) - x(e_i)) = \alpha_i \delta v(e_i)$ on path to A_i. The firm's value function is $J(\mathbf{0}) = v(\mathbf{0}) - \sum_{i=1}^N \delta\alpha_i v(e_i)$ which is decreasing in δ. □

Proof of Proposition 6. I first prove the maximum punishment $\bar{x}^\delta(e_i)$, given by finding the largest x subject to the inequality

$$x + R_i^O(v(e_i) - x, e_i) \leq v(e_i) - \delta(v(e_i) - R_i^O(v(e_i), e_i)), \tag{30}$$

is decreasing in δ for any e_i. I prove this auxiliary statement by contradiction. Suppose there exists $\delta_1 < \delta_2$ and $\bar{x}^{\delta_1}(e_i) < \bar{x}^{\delta_2}(e_i)$ for some e_i. Then we have

$$\bar{x}^{\delta_2}(e_i)+R_i^O(v(e_i)-\bar{x}^{\delta_2}(e_i), e_i) \leq v(e_i)-\delta_2(v(e_i)-R_i^O(v(e_i), e_i)) < v(e_i)-\delta_1(v(e_i)-R_i^O(v(e_i), e_i)) \tag{31}$$

where the first inequality is given by the definition of $\bar{x}^{\delta_2}(e_i)$ and the second is by $\delta_2 > \delta_1$. Thus $\bar{x}^{\delta_2}(e_i)$ is a feasible value of x when $\delta = \delta_1$ in Equation (30). This contradicts the optimality of $\bar{x}^{\delta_1}(e_i)$! Thus, it must be $\bar{x}^{\delta_1}(e_i) \geq \bar{x}^{\delta_2}(e_i)$.

The principal's value function $J(\mathbf{0}) = v(\mathbf{0}) - \sum_{i=1}^N R_i^O(v(e_i) - \bar{x}^\delta(e_i), e_i)$ is increasing in $\bar{x}^\delta(e_i)$ for each e_i since $R_i^O(\cdot, e_i)$ is increasing for each e_i. Combining these two facts, we conclude that $J(\mathbf{0})$ is weakly decreasing in δ for any R^O. □

Proof of Lemma 3. We first calculate the initial condition at $h = \mathbf{1}$. Since credibility constraint matters at $\mathbf{1}$, the principal obtains her highest value by paying every agent his holdout payoff $J(\mathbf{1}) = v(\mathbf{1}) - \mathbf{1} \cdot R^O(v(\mathbf{1}), \mathbf{1})$. To solve for $\bar{x}^\delta(\mathbf{1})$, I solve the equation $x + \mathbf{1} \cdot R^O(v(\mathbf{1}) - x, \mathbf{1}) = (1 - \delta)v(\mathbf{1}) + \delta\mathbf{1} \cdot R^O(v(\mathbf{1}), \mathbf{1})$ which, in the equity case, after rearranging, can be written as $(1 - \langle\mathbf{1}, \alpha\rangle)x = (1 - \delta)(1 - \langle\mathbf{1}, \alpha\rangle)v(\mathbf{1})$.

If $\langle \mathbf{1}, \alpha \rangle \neq 1$, the only solution is $\bar{x}^\delta(\mathbf{1}) = (1-\delta)v(\mathbf{1}) = 0$ using the normalization $v(\mathbf{1}) = 0$. If instead $\langle \mathbf{1}, \alpha \rangle = 1$, the equation is reduced to an identity that always holds regardless of the choice of x. Thus, the largest possible solution is $\bar{x}^\delta(\mathbf{1}) = v(\mathbf{1}) = 0$.

Now, I show the iterative relation. When $\bar{x}^\delta(h + e_i)$ is known, I can write the value function at h as

$$J^*(h) = v(h) - (1 - \langle h, \alpha \rangle) \sum_{i \in \xi(h)} \alpha_i \left(v(h + e_i) - \bar{x}^\delta(h + e_i) \right) - \langle h, \alpha \rangle v(h) \qquad (32)$$

Then in order to find $\bar{x}^\delta(h)$, we solve the equation $\langle h, \alpha \rangle (v(h) - x) + x = v(h) - \delta J^*(h)$. Substitute in $J^*(h)$, use the fact $\langle h, \alpha \rangle \neq 1$ for all $h \neq \mathbf{1}$, and we obtain

$$\bar{x}^\delta(h) = (1 - \delta)v(h) + \delta \sum_{i \in \xi(h)} \alpha_i \left(v(h + e_i) - \bar{x}^\delta(h + e_i) \right). \qquad (33)$$

$\square$

C   Proofs for Section 5 (Property Rights)

Proof of Proposition 10. When A_i deviates, the principal could promise to give the entire asset to other tendering agents, and the holdout A_i still enjoys a value of π_i by retaining his property. Thus, to convince A_i to tender, he must be paid π_i on path. Therefore, the value at $\mathbf{0}$ is the asset value minus the sum of property values. $\square$

Proof of Proposition 11. We first show that the maximum punishment satisfies the recursion

$$\bar{x}(h) = \sum_{i \in \xi(h)} \left[\alpha_i (v(h + e_i) - \bar{x}(h + e_i)) + \pi_i \right] \qquad (34)$$

with the initial condition $\bar{x}(\mathbf{1}) = 0$. This is because given $\bar{x}(h + e_i)$, at h, each tendering agent A_i could have otherwise obtained a value of $\alpha_i(v(h + e_i) - \bar{x}(h + e_i)) + \pi_i$ were he to hold out. Thus, the value function of the principal is $J(h) = v(h) - \underline{x}(h) - \langle h, \alpha \rangle (v(h) - \underline{x}(h))$ where $\underline{x}(h) = \sum_{i \in \xi(h)} \left[\alpha_i(v(h + e_i) - \bar{x}(h + e_i)) + \pi_i \right]$. And solving for the maximum x such that $x + \langle h, \alpha \rangle (v(h) - x) \leq v(h) - J(h)$ yields $(1 - \langle h, \alpha \rangle)x \leq \langle h, \alpha \rangle \underline{x}(e_i)$, which gives $\bar{x}(h) = \underline{x}(h)$ whenever $h \neq \mathbf{1}$ and $\bar{x}(h) = v(h)$ otherwise. From the recursive relation of $\bar{x}$, we obtain

$$\frac{d\bar{x}(h)}{d\pi_i} = \mathbb{1}_{\{i \in \xi(h)\}} - \sum_{j \in \xi(h)} \alpha_j \frac{d\bar{x}(h + e_j)}{d\pi_i} \qquad (35)$$

with the initial condition $\frac{d\bar{x}(\mathbf{1})}{d\pi_i} = 0$ since $\bar{x}(\mathbf{1}) = 0$. To solve $\frac{dJ(\mathbf{0})}{d\pi_i}$, we establish two lemmata:

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Lemma 4. *For any h and any i such that $i \notin \xi(h)$, $\frac{\mathrm{d}\bar{x}(h)}{\mathrm{d}\pi_i} = 0$.*

Proof. I prove the lemma by induction. For any h such that $|\xi(h)| = 0$, i.e., $h = \mathbf{1}$, we have the obvious case $\frac{\mathrm{d}\bar{x}(\mathbf{h})}{\mathrm{d}\pi_i} = 0$.

Now I show that if the statement is true for any h such that $i \notin \xi(h)$ and $|\xi(h)| = n$, it is also true for any h such that $i \notin \xi(h)$ and $|\xi(h)| = n + 1$. First notice that if $i \notin \xi(h)$, then for any $j \in \xi(h)$, $j \notin \xi(h + e_j)$. And $|\xi(h + e_j)| = |\xi(h)| - 1$. Then, we have

$$\frac{\mathrm{d}\bar{x}(h)}{\mathrm{d}\pi_i} = -\sum_{j \in \xi(h)} \alpha_j \frac{\mathrm{d}\bar{x}(h + e_j)}{\mathrm{d}\pi_i} = 0 \tag{36}$$

where the first equality holds because $i \notin \xi(h)$ and the second by induction hypothesis. $\square$

Lemma 5. *For any h and any i such that $i \in \xi(h)$, $0 < \frac{\mathrm{d}\bar{x}(h)}{\mathrm{d}\pi_i} \leq 1$*

Proof. I prove the lemma by induction. For any h such that $|\xi(h)| = 1$, i.e., $h = \mathbf{1} - e_i$, we have the obvious case $\frac{\mathrm{d}\bar{x}(\mathbf{h})}{\mathrm{d}\pi_i} = 1$.

Now I show that if the statement is true for any h such that $i \in \xi(h)$ and $|\xi(h)| = n$, it is also true for any h such that $i \in \xi(h)$ and $|\xi(h)| = n + 1$. First notice that if $i \in \xi(h)$, then for any $j \in \xi(h) : j \neq i$, $j \in \xi(h + e_j)$. And $|\xi(h + e_j)| = |\xi(h)| - 1$. Thus, the recursive relation could be written as $\frac{\mathrm{d}\bar{x}(h)}{\mathrm{d}\pi_i} = 1 - \sum_{j \in \xi(h):j \neq i} \alpha_j \frac{\mathrm{d}\bar{x}(h + e_j)}{\mathrm{d}\pi_i}$ since $\frac{\mathrm{d}\bar{x}(h + e_i)}{\mathrm{d}\pi_i}$ is zero. Since by induction hypothesis, each $\frac{\mathrm{d}\bar{x}(h + e_j)}{\mathrm{d}\pi_i}$ is in $(0, 1]$, we have $0 < \frac{\mathrm{d}\bar{x}(h)}{\mathrm{d}\pi_i} < 1$ since $\sum_{j \in \xi(h):j \neq i} \alpha_i < 1$. Thus, it holds for all h such that $i \in \xi(h)$. $\square$

Using $\frac{\mathrm{d}J(h)}{\mathrm{d}\pi_i} = -(1 - \langle h, \alpha \rangle) \frac{\mathrm{d}\bar{x}(h)}{\mathrm{d}\pi_i}$, I obtain $\frac{\mathrm{d}J(\mathbf{0})}{\mathrm{d}\pi_i} = -\frac{\mathrm{d}\bar{x}(\mathbf{0})}{\mathrm{d}\pi_i} \in [-1, 0)$. Thus, a higher property rights protection always undermines restructuring for equities. $\square$

Proof of Example 5.1. We first show that the maximum punishment satisfies the recursion

$$\bar{x}(h) = \sum_{i \in \xi(h)} [\alpha_i(v(h + e_i) - \bar{x}(h + e_i)) + \pi_i] \tag{37}$$

with the initial condition $\bar{x}(\mathbf{1}) = 0$. This is because given $\bar{x}(h + e_i)$, at h, each tendering agent A_i could have otherwise obtained a value of $\alpha_i(v(h + e_i) - \bar{x}(h + e_i)) + \pi_i$ were he to hold out. Thus the value function of the principal is $J(h) = (1 - \langle h, \alpha \rangle)(v(h) - \bar{x}(h))$ where $\underline{x}(h) = \sum_{i \in \xi(h)} [\alpha_i(v(h + e_i) - \bar{x}(h + e_i)) + \pi_i]$. And solving for the maximum x from $x + \langle h, \alpha \rangle(v(h) - x) \leq v(h) - J(h)$ yields $\bar{x}(h) = \underline{x}(h)$ whenever $h \neq \mathbf{1}$ and $\bar{x}(h) = v(h)$ otherwise. Using this recursion with the parameters specified, we obtain $\bar{x}(\mathbf{1} - e_i) = \pi_i \quad \forall i$ and

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$\bar{x}(e_i) = \sum_{j\neq i} [\alpha_j(v(e_i + e_j) - \pi_k) + \pi_j] \quad \forall k \neq i, j \quad \forall i$. The value function of the principal is

$$J(\mathbf{0}) = v(\mathbf{0}) - \sum_{i=1}^{3} \alpha_i v(e_i) + \sum_{i=1}^{3}\sum_{j\neq i} \alpha_i\alpha_j v(e_i + e_j) - \sum_{i=1}^{3}\left(1 - \sum_{j\neq i}\alpha_i(1 - \alpha_k)\right)\pi_i \quad (38)$$

Taking partial derivatives yields the expression in the proposition.

Without loss of generality, look at the coefficient of π_1. Even if I ignore the constraint $\langle \mathbf{1}, \alpha \rangle = 1$, the coefficient $1 - \alpha_2 - \alpha_3 + 2\alpha_2\alpha_3$ is minimized at $\alpha_2 = \alpha_3 = 1/2$ with a minimum value of $1/2$. Thus, all coefficients of π_i are positive. $\qquad\square$

Proof of Proposition 12. Consider the deviation profile e_i, let $X(e_i)$ be the total payments to the tendering creditors according to an optimal δ-credible contract, potentially a function of $\{\pi_i\}_i$. The principal's value at e_i is $J(e_i) = v(e_i) - X(e_i) - \min\{D_i, v(e_i) - X(e_i)\}$ and solving $x + \min\{D_i, v(e_i) - x\} \leq v(e_i) - J(e_i)$ yields the maximum punishment

$$\bar{x}(e_i) = \begin{cases} v(e_i) & v(e_i) - X(e_i) \leq D_i \\ (1 - \delta)(v(e_i) - D_i) + \delta X(e_i) & v(e_i) - X(e_i) \geq D_i \end{cases} \quad (39)$$

Thus, the principal's value is $J(\mathbf{0}) = v(\mathbf{0}) - \sum_{i=1}^{N}\left[D_i\mathbb{1}_{\{v(e_i)\geq X(e_i)+D_i\}} + \pi_i\right]$ because whenever $v(e_i) - X(e_i) \leq D_i$, $\bar{x}(e_i) = v(e_i)$ and thus $\min\{D_i, v(e_i) - \bar{x}(e_i)\} = 0$; In contrast, when $v(e_i) - X(e_i) > D_i$, we have $v(e_i) - \bar{x}(e_i) = \delta(v(e_i) - X(e_i) - D_i) + D_i > D_i$ so $\min\{D_i, v(e_i) - \bar{x}(e_i)\} = D_i$. In either case, the payment to each tendering agent is independent of the renegotiation off-path. Thus $\frac{\partial J(\mathbf{0})}{\partial \pi_i} = -1 \quad \forall i$, which implies a locally small increase in property rights protection always hinders restructuring. $\qquad\square$

Proof of Proposition 13. At every e_i, the principal only needs to compensate A_j at most π_j for him to tender so the principal's value is $J(e_i) = v(e_i) - \pi_j - \min\{v(e_i) - \pi_j, D \cdot e_i\}$. Solviong $x + \min\{v(e_i) - x, D \cdot e_i\} \leq v(e_i) - J(e_i)$, we get the maximum credible dilution

$$\bar{x}(e_i) = \begin{cases} v(e_i) & \text{if } v(e_i) \leq \pi_j + D \cdot e_i \\ \pi_j & \text{otherwise.} \end{cases} \quad (40)$$

The principal's value at $\mathbf{0}$ is then $J(\mathbf{0}) = v(\mathbf{0}) - \sum_{i=1}^{2}\left[D_i\mathbb{1}_{\{v(e_i)\geq\pi_j+D_i\}} + \pi_i\right]$. When $\pi_j \in (1/2, 1)$, given that $D_i = 1$ and $v(e_i) = 2$, we have $v(e_i) > \pi_j + D_i$; In contrast, when $\pi_j \in (1, 3/2)$, we have $v(e_i) \leq \pi_j + D_i$, so the change in the principal's value is $D_i - \Delta\pi_j > 0$ since $\Delta\pi_j < 3/2 - 1/2 = 1$. $\qquad\square$